INL/EXT-14-33156

Electric Vehicle Preparedness Task 3: Detailed Assessment of Charging Infrastructure for Plug-in Electric Vehicles at Joint Base Lewis McChord

Stephen Schey
Jim Francfort

October 2014

Idaho National Laboratory

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Electric Vehicle Preparedness Task 3: Detailed Assessment of Charging Infrastructure for Plug-in Electric Vehicles at Joint Base Lewis McChord

Stephen Schey
Jim Francfort[2]

[1]Stephen Schey, Project Manager, Infrastructure Planning and Analysis, Intertek Testing Services, North America, Phoenix, AZ
[2]Jim Francfort, Vehicle Systems Principal Investigator, Idaho National Laboratory operated by Battelle Energy Alliance, Idaho Falls, ID

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Idaho National Laboratory
Idaho Falls, Idaho 83415

http://avt.inl.gov

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ABSTRACT

Battelle Energy Alliance, LLC, managing and operating contractor for the U.S. Department of Energy's Idaho National Laboratory, is the lead laboratory for U.S. Department of Energy Advanced Vehicle Testing. Battelle Energy Alliance, LLC contracted with Intertek Testing Services, North America (Intertek) to conduct several U.S. Department of Defense base studies to identify potential U.S. Department of Defense transportation systems that are strong candidates for introduction or expansion of plug-in electric vehicles (PEVs).

Task 2 selected vehicles for further monitoring and involved identifying the daily operational characteristics of these select vehicles. Data logging of vehicle movements was initiated in order to characterize the vehicle's mission. Individual observations of these selected vehicles provide the basis for recommendations related to PEV adoption and whether a battery electric vehicle or plug-in hybrid electric vehicle (collectively PEVs) can fulfill the mission requirements. The report also provides observations related to placement of PEV charging infrastructure.

The Task 3 vehicle utilization report (INL/EXT-14-33337) provided the results of the data analysis and observations related to the replacement of current vehicles with PEVs. This report provides an assessment of charging infrastructure required to support the suggested PEV replacements.

Intertek acknowledges the support of Idaho National Laboratory and Joint Base Lewis McChord fleet managers and personnel for participation in this study.

Intertek is pleased to provide this report and is encouraged by enthusiasm and support from Joint Base Lewis McChord personnel.

EXECUTIVE SUMMARY

Federal agencies are mandated[a] to purchase alternative fuel vehicles, increase use of alternative fuels, and reduce the consumption of petroleum used for transportation. Available plug-in electric vehicles (PEVs) provide an attractive option in the selection of alternative fuel vehicles. PEVs, which consist of both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), have significant advantages over internal combustion vehicles in terms of energy efficiency, reduced petroleum consumption, and reduced production of greenhouse gas (GHG) emissions, and they provide performance benefits with quieter, smoother operation. This study evaluated the extent to which Joint Base Lewis McChord (JBLM) could convert part or all of their fleet of vehicles from petroleum-fueled vehicles to PEVs.

BEVs provide the greatest benefit when it comes to fuel and emissions savings because all motive power is provided by the energy stored in the onboard battery pack. These vehicles use no petroleum and emit no pollutants at their point of use. PHEVs provide similar savings when their battery provides the motive power, but they also have the ability to extend their operating range with an onboard internal combustion engine. Because a PHEV can meet all transportation range needs, the adoption of a PHEV will be dependent on its ability to meet other transportation needs such as cargo or passenger carrying. Operation of PHEVs in battery-only mode can be increased with opportunity charging at available charging stations. However, it should be noted that not all PHEVs have a mode in which the battery provides all motive power at all speeds. The Task 3 report on vehicle utilization (INL/EXT-14-33337) focused on the mission requirements of the fleet of vehicles. The objective was to identify vehicles that may be replaced with PEVs, with emphasis on BEVs because they provide maximum benefit. This report follows that vehicle use analysis with an evaluation of the electric vehicle charging infrastructure required to support those PEVs.

The Task 3 report on vehicle utilization observed that a mix of BEVs and PHEVs are capable of performing most of the required missions. Replacing vehicles in the current fleet could result in significant reductions in the emission of greenhouse gases and in petroleum use, as well as reduced fleet operating costs. PEVs that currently are commercially available cannot replace certain vehicles and missions, such as those requiring heavy-duty trucks, passenger vans, and specialty usage vehicles., However, based on data collected for the monitored vehicles, the 60-vehicle fleet subset could possibly consist of two conventional heavy-duty trucks, 11 conventional passenger vans, 28 BEVs, and 19 PHEVs. Additional replacement may be possible as more PEVs of different types become commercially available. This report shows that 20 alternating current (AC) Level 2 and 27 AC Level 1 charging stations should be sufficient to support these PEVs.

[a] Energy Policy act of 1992, Energy Policy Act of 2005, Executive Order 13423, and Energy Independence and Security Act of 2007.

The monitored vehicles represent 60 of the 1,382 on-road rated vehicles in these represented fleets. Assuming that the balance of these fleets operate in a manner similar to those monitored and without consideration of specific cargo or other mission requirements not previously identified, Intertek suggests the total fleet composition could consist of 111 conventional heavy-duty trucks, 263 conventional passenger vans, 57 conventional buses, five conventional specialty vehicles, 573 BEVs, and 373 PHEVs. This report suggests that 432 AC Level 2 and 514 AC Level 1 charging stations should be sufficient to support these PEVs.

Installation of PEV charging stations requires pre-planning; this report provides some highlighted area of interest in this preparation. In general, electrical supply is not a concern; however, location relative to that supply is a significant cost factor for installation. Several potential sites were identified for charging station locations.

The information presented in this report and the prior Task 3 report (INL/EXT-14-33337) on vehicle utilization will be considered in the Task 4 effort to identify a potential replacement schedule with budget information.

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ACRONYMS

AC	alternating current
BEV	battery electric vehicle
DC	direct current
DCFC	DC fast charger
DOD	U.S. Department of Defense
EVSE	electric vehicle supply equipment
Intertek	Intertek Testing Services, North America
JBLM	Joint Base Lewis McChord
PEV	plug-in electric vehicle (includes BEVs and PHEVs, but not hybrid electric vehicles)
PHEV	plug-in hybrid electric vehicle
POV	privately owned vehicle
SUV	sports utility vehicle
V2G	vehicle to grid

Electric Vehicle Preparedness Task 3: Detailed Assessment of Charging Infrastructure for Plug-in Electric Vehicles at Joint Base Lewis McChord

1. INTRODUCTION

The U.S. Department of Energy and the U.S. Department of Defense (DOD) signed a memorandum of understanding on July 22, 2010, to strengthen the coordination of efforts for enhancing national energy security and demonstrating federal government leadership in transitioning the United States to a low-carbon economy. The memorandum of understanding included efforts in the areas of energy efficiency, fossil fuels, alternative fuels, efficient transportation technologies and fueling infrastructure, grid security, smart grid, and energy storage.

In support of the memorandum of understanding , Idaho National Laboratory, with funding provided by the U.S. Department of Energy's Vehicle Technologies Office and Federal Energy Management Program, contracted with Intertek Testing Services, North America (Intertek) to conduct several DOD base studies to identify potential transportation systems that are strong candidates for introduction or expansion of plug-in electric vehicles (PEVs). Intertek previously has conducted similar fleet, city, state, and countrywide studies using the micro-climate assessment process, which consists of the following four main tasks:

- Task 1: Conduct a fleet and infrastructure assessment
- Task 2: Develop target electrification vehicles
- Task 3: Perform detailed assessment of target electrification vehicles and charging infrastructure
- Task 4: Perform economic analysis of target electrification.

An assessment of the potential for replacing fleet vehicles at Joint Base Lewis McChord (JBLM; in Tacoma, Washington) with PEVs starts with an assessment of the fleet vehicles' missions and vehicle characteristics. This assessment was conducted through a written survey, collection of data on vehicle use, and field interviews. The Task 1 report provided a summary and assessment of General Services Administration data and survey results.

PEVs generally are classified into two vehicle types: battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). A BEV contains an onboard battery that provides all motive power. PHEVs also have an onboard battery that provides some motive power through an onboard battery, but this onboard battery is supplemented by another power source (such as a gasoline engine). Collectively, BEVs and PHEVs are PEVs.

The Task 1 effort led to identification of fleet vehicles that appear to be good candidates for replacement by PEVs. Task 2 selected a number of vehicles within the candidate groups for further monitoring and analysis through addition of vehicle data loggers. The data loggers were installed and data collected on the use of these selected vehicles. The Task 3 report on vehicle utilization provided a summary and details of that data collection. This report assesses the electric vehicle charging infrastructure necessary to support the recommended electric vehicle replacements.

The infrastructure recommendations depend on the type of PEV to be charged, time available for charging, locations of typical vehicle parking, fleet management attention, and electrical power availability. Other considerations (such as providing charging opportunities for assigned military, base employees, or visitors) may be of interest. While vehicle-to-grid (V2G) power transfer capabilities are currently under study at military facilities, this topic will be discussed but is not evaluated as part of this report.

2. FLEET VEHICLE PLUG-IN ELECTRIC VEHICLE RECOMMENDATIONS

JBLM identified 60 vehicles for further study; this study was completed and reported in the Task 3 vehicle utilization report (INL/EXT-14-33337). In summary, this subset of vehicles contains eight sedans, seven minivans, four sports utility vehicles (SUV), 20 pickup trucks, seven cargo vans, 11 passenger vans, and three heavy-duty trucks. This distribution is intended to be representative of the entire non-tactical fleet.

PEVs that currently are commercially available cannot replace certain vehicles and missions, such as those requiring heavy-duty trucks, passenger vans, and specialty usage vehicles. However, the Task 3 vehicle utilization report (INL/EXT-14-33337) suggested that, based on the data collected for the monitored vehicles, the 60-vehicle fleet subset could possibly consist of two conventional heavy-duty trucks, 11 conventional passenger vans, 28 BEVs, and 19 PHEVs. Table 1 shows the replacement summary. Additional replacement may be possible as more PEVs of different types become commercially available.

Table 1. Monitored vehicle replacement summary.

Vehicle	Sedan Compact/ Sub Com	Sedan Midsize/ Large	Mini-van	SUV	Specialty	Cargo Van	Pass Van	Pickup or LD Truck	HD Truck	Bus	Total
ICE	0	0	0	0	0	0	11	0	2	0	13
BEV	1	4	4	3	0	5	0	11	0	0	28
PHEV	0	3	3	1	0	2	0	10	0	0	19
Total	1	7	7	4	0	7	11	21	2	0	60

The monitored vehicles represent 60 of the 1,382 on-road rated vehicles in these represented fleets. Assuming that the balance of these fleets operate in a manner similar to those monitored and without consideration of specific cargo or other mission requirements not previously identified, Intertek suggests the total fleet composition could consist of 111 conventional heavy-duty trucks, 263 conventional passenger vans, 57 conventional buses, five conventional specialty vehicles, 573 BEVs, and 373 PHEVs. Table 2 shows this replacement summary.

Table 2. Total fleet replacement summary.

Vehicle	Sedan Compact/ Sub Com	Sedan Midsize/ Large	Mini-van	SUV	Specialty	Cargo Van	Pass Van	Pickup or LD Truck	HD Truck	Bus	Total
ICE	0	0	0	0	5	0	263	0	111	57	436
BEV	29	65	60	73	1	81	0	264	0	0	573
PHEV	13	43	43	55	0	59	0	160	0	0	373
Total	42	108	103	128	6	140	263	424	111	57	1382

Figure 1 illustrates the final suggested vehicle summary.

The Task 3 report suggested that some inventory reduction might be possible. Task 4 of this study will consider that possibility. This report focuses on the charging infrastructure that would be required to support the PEV replacements.

The 60 vehicles monitored in the study at JBLM belong to four different fleet managers: 6th MP Group, DCA Support Group, Public Works Group, and Motor Transport Branch. PEV replacements are separated by these groups, as are the recommendations for the total 1,382 vehicle replacements. Specific analyses by fleet groups follow in Section 4.

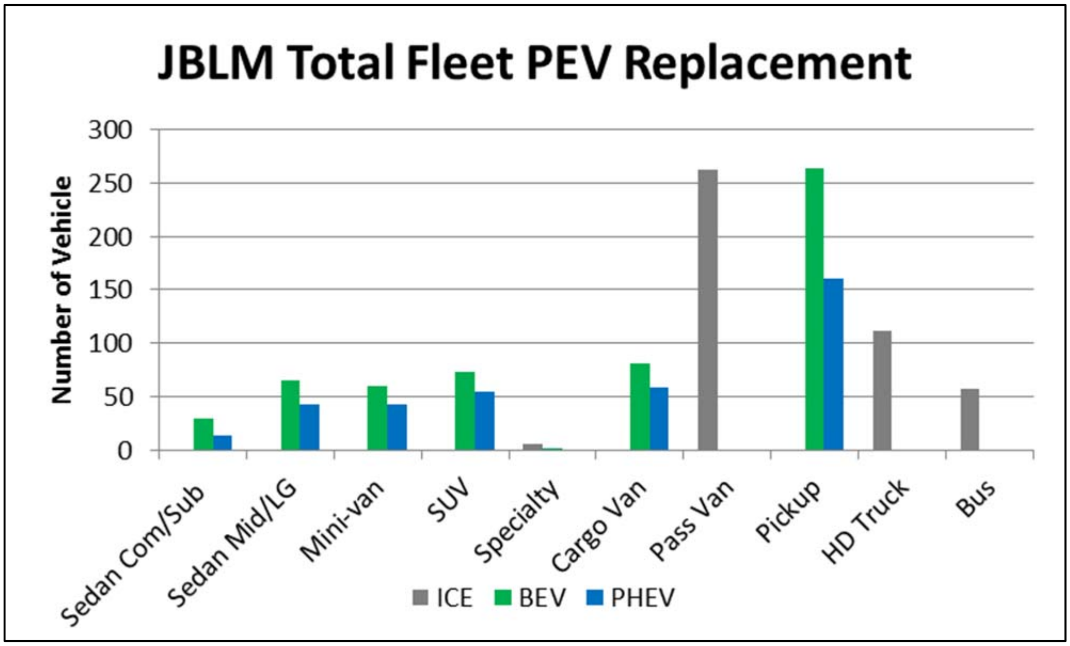

Figure 1. Vehicle type distribution for all vehicles.

3. PLUG-IN ELECTRIC VEHICLE CHARGING

Refueling of electric vehicles presents some challenges and some opportunities not encountered when refueling petroleum-fueled vehicles. Recharging the battery of a PHEV follows the same methodology as that for BEVs. This section provides basic information on recharging PEVs.

3.1 Electric Vehicle Supply Equipment Design

3.1.1 Charging Components

Electric vehicle supply equipment (EVSE) stations deliver electric power from the electric grid to the applicable charge port on the vehicle. Figure 2 illustrates the primary components of a typical EVSE, which the figure is an alternating current (AC) Level 2.

The electricity grid delivers AC to the charging location. The conversion from AC to direct current (DC) electricity is necessary for battery charging to occur either on or off board the vehicle. Further explanation of the different EVSE configurations follows in the next subsection. For onboard conversion, AC current flows through the PEV inlet to the onboard charger. The charger converts AC to DC current required to charge the battery. A connector attached to the EVSE inserts into a PEV inlet to establish an electrical connection to the PEV for charging and information/data exchange. Offboard conversion, also known as DC charging, proceeds in a similar manner except that the AC to DC conversion occurs in a charger that is off board the vehicle and, thus, bypasses any onboard charger. For both AC and DC charging, the PEV’s battery management system on board the vehicle controls the battery rate of charge, among other functions. All current PEVs have an onboard charger; some BEVs (but currently no PHEVs) accommodate DC charging.

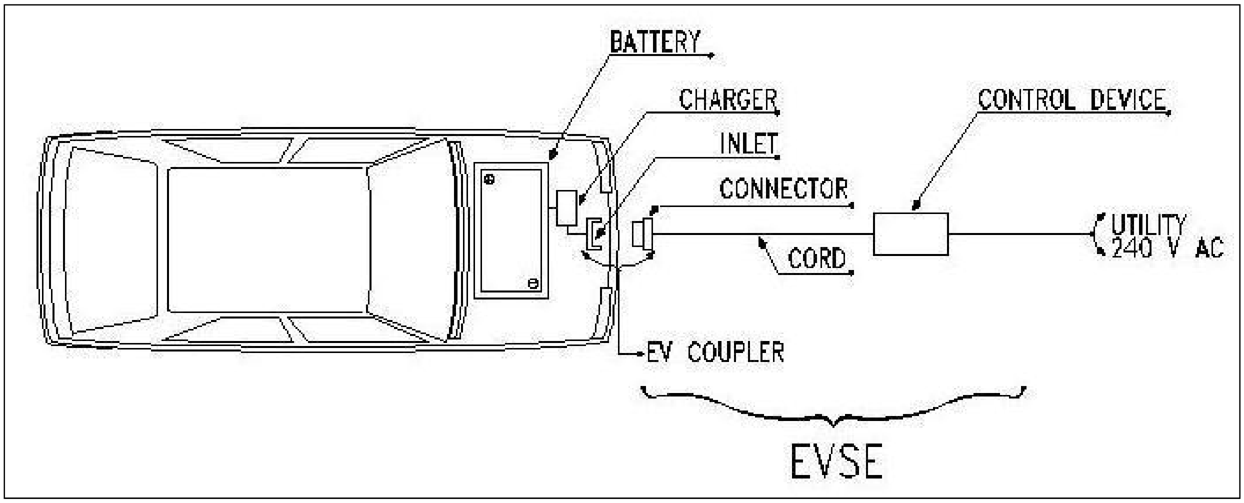

Figure 2. AC Level 2 charging diagram[b].

3.1.2 Charging Configurations and Ratings

The Society of Automotive Engineers standardized the requirements, configurations, and equipment followed by most PEV suppliers in the United States in the J1772 standard. Figure 3 summarizes these attributes and the estimated recharge times. Actual recharge times depend on the onboard equipment, including the charger, battery, and battery management system.

Most PEV manufacturers supply an AC Level 1 cordset with the vehicle, which provides sufficient capabilities for some drivers, but more typically provides a portable emergency backup capability because of the longer recharge times. AC recharging capabilities found in the public arena more typically are AC Level 2. Figure 4 depicts a typical J1772-compliant inlet and connector for both AC Levels 1 and 2.

The J1772 standard also identifies requirements for DC charging. For PEVs that accept both AC and DC inputs, the Society of Automotive Engineers approved a single connector and inlet design. Figure 5 shows this connector, which is colloquially known as the J1772 “combo connector.”

Some PEVs delivered in the United States prior to the approval of the J1772 standard for DC charging employed the CHAdeMO standard for connector and inlet design. Figure 6 shows this connector. EVSE units that are either J1772-compliant or CHAdeMO-compliant are both known as DC fast chargers (DCFCs).

Tesla Motors has developed a charge connector unique to their vehicles. An adapter is provided to allow the use of public charging stations using the J1772 standard for AC Level 2. Tesla has also developed a network of “superchargers” for use with their vehicles that provide up to 120 kW of power.[c]

The presence of the two separate standards for DC charging (along with the unique Tesla connector) presents challenges for vehicle owners to ensure that the EVSE accessed provides the appropriate connector for their vehicle inlet. Not all PEV suppliers include DC charging options. BEV suppliers more typically provide DC inlets than PHEV suppliers do, because the rapid recharging provides opportunities for expanded vehicle range with minimal operator wait times. PHEV operators can rely on the gasoline drive in the event they deplete the vehicle’s battery; at present, no PHEV on the market or near commercialization has DC charging capability (although the Mitsubishi Outlander PHEV is rumored to

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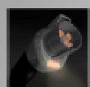
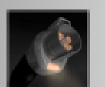
[b] http://www.theevproject.com/downloads/documents/Electric%20Vehicle%20Charging%20Infrastructure%20Deployment%20Guidelines%20for%20the%20Greater%20Phoenix%20Area%20Ver%203.2.pdf [accessed January 15, 2014].

[c] http://www.teslamotors.com/supercharger [accessed August 25, 2014].

be offering DC charging capability as an option). It is noted that DC Level 1 and DC Level 2 charging are commonly combined and labeled “DC fast charging.”

SAE International — **SAE Charging Configurations and Ratings Terminology**

AC level 1 (SAE J1772™)	PEV includes on-board charger	*DC Level 1	EVSE includes an off-board charger
	120V, 1.4 kW @ 12 amp 120V, 1.9 kW @ 16 amp		200-450 V DC, up to 36 kW (80 A)
	Est. charge time:		Est. charge time (20 kW off-board charger):
	PHEV: 7hrs (SOC* - 0% to full)		PHEV: 22 min. (SOC* - 0% to 80%)
	BEV: 17hrs (SOC – 20% to full)		BEV: 1.2 hrs. (SOC – 20% to 100%)
AC level 2 (SAE J1772™)	PEV includes on-board charger (see below for different types)	*DC Level 2	EVSE includes an off-board charger
	240 V, up to 19.2 kW (80 A)		200-450 V DC, up to 90 kW (200 A)
	Est. charge time for 3.3 kW on-board charger		Est. charge time (45 kW off-board charger):
	PEV: 3 hrs (SOC* - 0% to full)		PHEV: 10 min. (SOC* - 0% to 80%)
	BEV: 7 hrs (SOC – 20% to full)		BEV: 20 min. (SOC – 20% to 80%)
	Est. charge time for 7 kW on-board charger		
	PEV: 1.5 hrs (SOC* - 0% to full)	*DC Level 3 (TBD)	EVSE includes an off-board charger
	BEV: 3.5 hrs (SOC – 20% to full)		200-600V DC (proposed) up to 240 kW (400 A)
	Est. charge time for 20 kW on-board charger		Est. charge time (45 kW off-board charger):
	PEV: 22 min. (SOC* - 0% to full)		BEV (only): <10 min. (SOC* - 0% to 80%)
	BEV: 1.2 hrs (SOC – 20% to full)		
*AC Level 3 (TBD)	> 20 kW, single phase and 3 phase		

*Not finalized
Voltages are nominal configuration voltages, not coupler ratings
Rated Power is at nominal configuration operating voltage and coupler rated current
Ideal charge times assume 90% efficient chargers, 150W to 12V loads and no balancing of Traction Battery Pack

Notes:
1) BEV (25 kWh usable pack size) charging always starts at 20% SOC, faster than a 1C rate (total capacity charged in one hour) will also stop at 80% SOC instead of 100%
2) PHEV can start from 0% SOC since the hybrid mode is available. Developed by the SAE Hybrid Committee ver. 031611

Copyright SAE 2011

Figure 3. Society of Automotive Engineers charging configurations and ratings terminology.[d]

Figure 4. J1772 connector and inlet.[e]

[d] http://www.sae.org/smartgrid/chargingspeeds.pdf [accessed January 15, 2014].

Figure 5. J1772-compliant combo connector.[f]

Figure 6. CHAdeMO-compliant connector.[g]

Because the battery of a BEV is typically much larger than that of a PHEV, recharge times are longer (see Figure 3). BEVs that see daily mileage near the limits of the advertised range do better when recharged using AC Level 2 EVSE or DCFC, because AC Level 1 recharge times are usually extensive. On the other hand, PHEVs generally can use AC Level 1 EVSE for overnight charging to ensure a fully charged battery at the start of daily use. AC Level 2 EVSE units provide greater range in the shortest amount of time when intermediate or opportunity charging. DCFC provides the fastest recharge capability for those vehicles equipped with DCFC inlets.

3.2 Electric Vehicle Supply Equipment Stations

AC Level 2 charging is the predominant rating of publicly accessible EVSE because of its wide acceptance by auto manufacturers and faster recharge times than AC Level 1. Purchase and installation costs are more manageable than DCFCs and less space is required. There are several manufacturers of AC Level 2 equipment and the agency should review brands for comparison purposes. Figure 7 provides an example of a public AC Level 2 EVSE unit.[h] The unit shown is known as a "pedestal" unit because it is a self-standing unit. Wall or post-mounted models are also available from several suppliers.

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[e] http://carstations.com/types/j09 [accessed January 15, 2014].

[f] http://www.zemotoring.com/news/2012/10/sae-standardizes-j1772-fast-dc-charging-up-to-100-kw [accessed January 15, 2014].

[g] https://radio.azpm.org/p/azspot/2012/5/10/1632-electric-cars/ [accessed January 15, 2014].

[h] www.eaton.com/ [accessed January 29, 2014].

Figure 7. AC Level 2 unit.

DCFCs also are available from several manufacturers. Figure 8 illustrates one such charger.[i] This particular unit uses the CHAdeMO connector standard.

Figure 8. Public DCFC.

In general, installation costs are higher for DCFCs because of the higher voltage requirements and the inclusion of the AC to DC converter and other safety and design features. Installation costs for both types are highly dependent on site characteristics such as distance to the nearest power source, asphalt or concrete cutting and repair, conduit requirements, and payment systems, if any.

Payment and equipment control systems included by some suppliers provide the potential for use by privately owned vehicles for a fee, but allow agency fleet vehicle use without direct payment. These systems allow for accurate record keeping of vehicle charging requirements.

EVSE designs also include dual port or multi-port options that allow charging of vehicles simultaneously or sequentially depending on design.

[i] http://evsolutions.avinc.com/products/public_charging/public_charging_b [Accessed April 16, 2014].

At times, fleet vehicles obtain benefits from using public charging infrastructure. Figure 9 displays the availability of public charging for the JBLM area at the time of this writing. The green-colored sites are AC sites, indicating either AC Level 1 and Level 2 public locations, and the orange-colored sites are DCFCs.

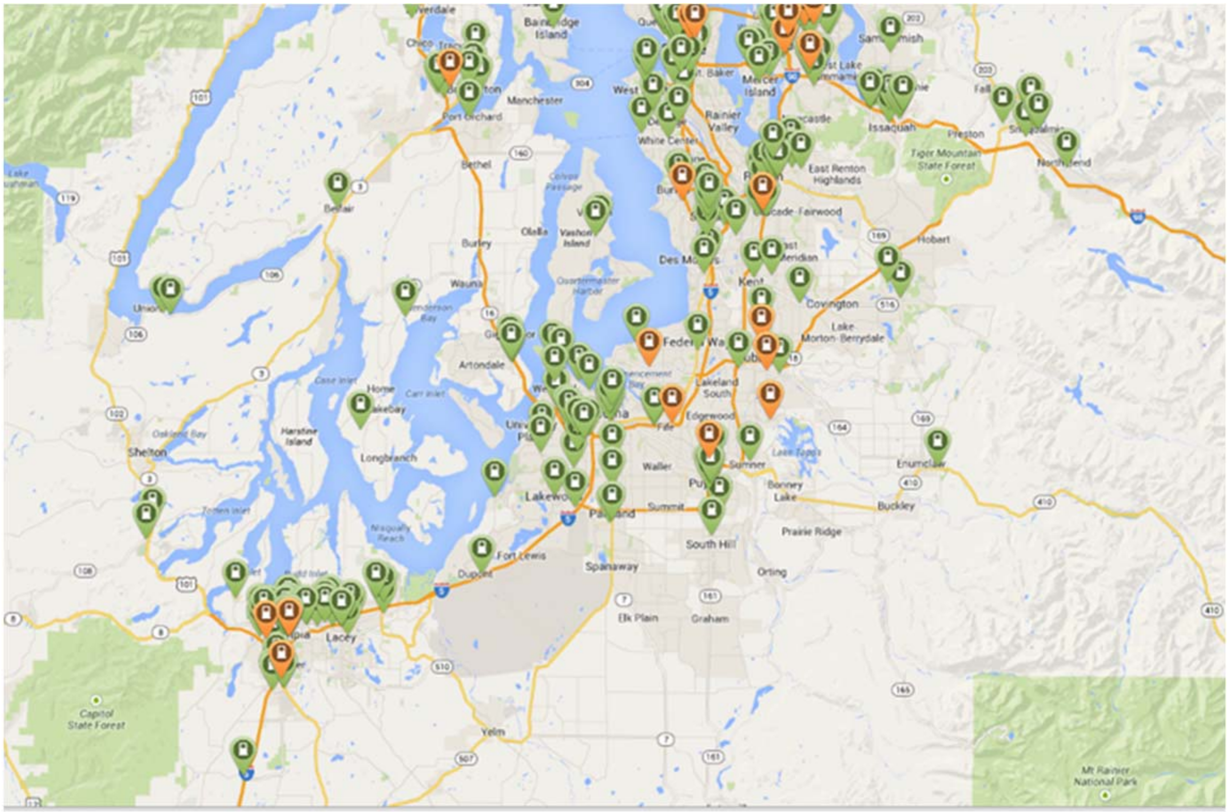

Figure 9. Public EVSE in JBLM region.[j]

The high density of publicly accessible EVSE reflects the high local interest and adoption of PEVs. It also illustrates the high potential for adoption of PEVs by JBLM attached military, civilian employees, and local contractors who may be interested in PEV charging locations.

3.3 Electric Vehicle Supply Equipment Installation

Numerous factors must be considered before installation of EVSE can occur. The *Electric Vehicle Charging Infrastructure Deployment Guidelines* document by The EV Project[k] provides specific information related to commercial fleet charging. While military bases may not be required to address all of these considerations, this information may be of use in site selection. Figure 10 provides a flowchart of installation considerations for fleet applications.

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[j] http://www.plugshare.com/ [accessed June 19, 2014].

[k] http://www.theevproject.com/downloads/documents/Electric%20Vehicle%20Charging%20Infrastructure%20Deployment%20Guidelines%20for%20the%20Greater%20San%20Diego%20Area%20Ver%203.2.pdf [accessed August 8, 2014].

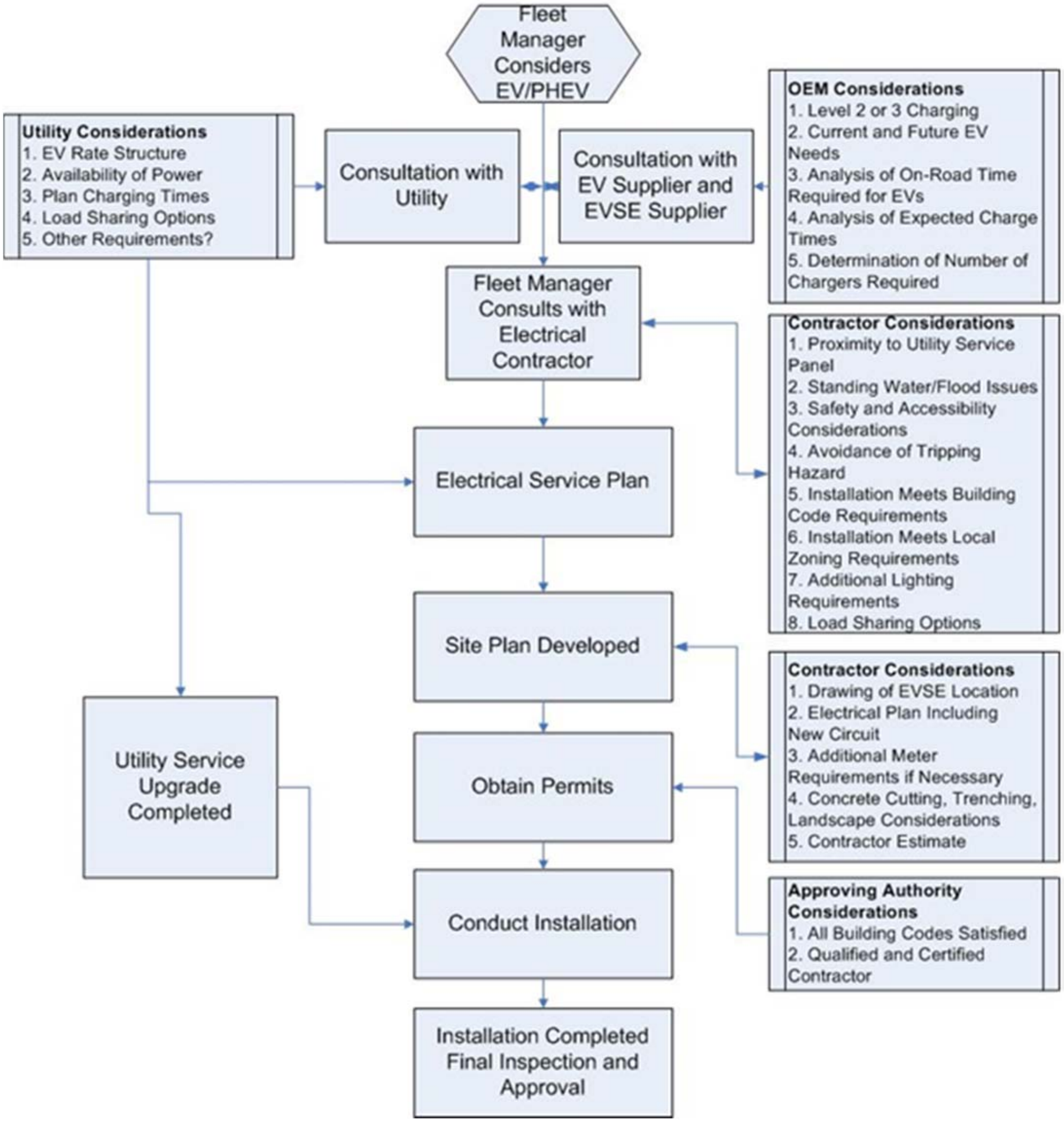

Figure 10. Installation process for commercial fleet operation.[1]

Specific considerations include the following:

1. AC Level 1, Level 2 or DCFC units:

   The Task 3 vehicle utilization report (INL/EXT-14-33337) provided recommendations related to the power level needs of the associated vehicles. These will be discussed in detail in Section 4.

2. Proximity to power supply connections:

   Installation of EVSE in a commercial facility typically will consist of installing new dedicated branch circuits from the central meter distribution panel to a Level 2 EVSE. In a commercial fleet, there usually are many such EVSE units in adjacent parking stalls. Proximity to the electrical service is an

[1] ibid

important factor in locating this parking area. The length of the circuit run and the number of EVSE units will have a significant impact on the cost.[m]

In addition, the cost for installation will be influenced by whether concrete or asphalt cuts will be required, along with restoration of these surfaces. Conduit runs through landscaped areas will be less expensive.

Consideration should be given to the potential for adding PEVs in the future. Installing additional conduit and conductors to feed future EVSE units reduces future costs, while not adding significantly to current costs.

3. Parking space restrictions:

   Determination should be made in advance whether the EVSE parking space will be restricted to PEVs only. If so, the dedication of these spaces may reduce the availability of spaces for conventional vehicles. This may affect the functional needs of the existing operation. On the other hand, non-PEVs parking in charging locations will inhibit the recharge ability of the PEVs and may interfere with their mission. Intertek recommends dedicating charging stations to PEV charging only.

4. Americans with Disabilities Act considerations:

   The Americans with Disabilities Act provides requirements on accessibility for many situations, but does not directly address PEV charging stations. The EV Project provided recommendations to maximize compliance within the specific restraints and constraints of PEV operation. While the exact requirements may not be applicable to military bases, the recommendations may present best practices for JBLM consideration.[n]

5. Physical protection of the equipment:

   Unless de-energized by the local disconnect, EVSE is considered electrically energized equipment. Because it operates above 50 volts, Part 19, "Electrical Safety," of the Occupational Health and Safety Regulation requires guarding live parts. EVSE may be positioned in a way that requires a physical barrier for its protection. Frequently, wheel stops, curbs, or bollards are used to provide physical protection.

6. Accessibility and usage:

   EVSE units typically will be powered from the electrical grid near the parking location. The base provides this electrical supply for general use to carry out its mission. The power delivered to fleet vehicles supports the DOD mission. However, federal restrictions do not allow use of federally provided electrical power to be utilized by privately owned vehicles (POVs). Therefore, for each EVSE installed, the installing agency fleet must decide whether access to the EVSE will be restricted to fleet vehicle only or whether POVs will be allowed to utilize these units.

   Restricting use to agency fleet vehicles can be accomplished by physically segregating the charging infrastructure to restricted parking locations that can be fenced and gated or by electronically segregating the usage by use of access control cards. Several EVSE suppliers provide access cards that are capable of allowing usage only by authorized cardholders.

   Another option may allow for use by POV drivers using access cards that assess a fee for the charging opportunity. Under this option, the fleet drivers' cards allow access without the fee but the POV driver is charged the fee. The fee structure can be based on the cost of electrical energy dispensed or by the amount of time connected. EVSE suppliers have options related to these structures. Fleet

[m] ibid

[n] http://www.theevproject.com/downloads/documents/EV%20Project%20-%20Accessibility%20at%20Public%20EV%20Charging%20Locations%20(97).pdf [accessed August 8, 2014]

managers will need to monitor EVSE usage to ensure their fleet vehicles have priority in charging to complete their mission.

7. Data acquisition and reporting:

   It is likely that accounting for the electrical energy used for recharging vehicles will be required. Typically, the electrical energy supplied to a building is a facility cost; however, energy delivered to PEVs will be fuel costs. While supply to EVSE can be metered, Intertek suggests the use of “smart” EVSE that are capable of data collection and transmittal can be very useful to identify usage associated with specific vehicles and thus enhance fleet management.

8. Base cyber security;

   Smart EVSE are likely to collect data locally in the EVSE or network of EVSE and transmit via internet or cellular communications to an offsite data center. Transmittal of the data back to the DOD facility may create issues with cyber security for the facility. Local transmittal to the appropriate fleet manager could be a benefit.

Figure 11 shows a fleet EVSE installation showing a significant number of stations with physical protection barriers. This site is not accessible to the public or for use by POVs.

Figure 11. Typical fleet charging installation.[o]

EVSE installations intended for use by POVs may be required to follow other requirements. Figure 12 shows a public installation site complying with the Americans with Disabilities Act requirements. Note the accessible EVSE and parking location on the right.

The General Services Administration provides information and guides related to PEVs. The Installation Guide linked on their website provides specific installation instructions for the ChargePoint Networked Charging Station.[p] These instructions apply once all other site conditions have been resolved and provide the detailed systematic instruction for installing a ChargePoint-brand EVSE.

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[o] http://www.theevproject.com/downloads/documents/Electric%20Vehicle%20Charging%20Infrastructure%20Deployment%20Guidelines%20for%20the%20Greater%20San%20Diego%20Area%20Ver%203.2.pdf [accessed August 8, 2014].

[p] http://gsa.gov/portal/mediaId/184507/fileName/Charging_Station_Installation_Guide.action [accessed August 8, 2014].

Figure 12. Publicly accessible EVSE.[q]

3.4 Electric Vehicle Supply Equipment Advanced Design Considerations

Several other charging topics may be of interest to JBLM in evaluating EVSE designs.

3.4.1 Public Charging Access

Figure 9 identifies the local public charging infrastructure in the JBLM region. The high local interest and adoption of PEVs supports this public infrastructure. For vehicles that travel off base, this infrastructure can provide backup support for charging vehicles. Because PHEVs provide their own backup motive power, this feature may be more important for BEV drivers. JBLM may wish to consider obtaining access to these public chargers.

3.4.2 Electric Utility Demand Charges

Tacoma Power provides the electrical supply to JBLM. While the supply is contracted separately from other users, industrial schedules provided by Tacoma Power include electrical supply demand charges. The demand charge is billed at the highest measured demand for the month. Not only is the energy (kWh) consumed billed to JBLM, but the power (kW) delivered is also billed. PEV charging costs are impacted by this demand charge.

Figure 3 identifies the power requirements for EVSE charging. Up to 19.2 kW of power are identified for AC Level 2. The power is controlled by the PEV's onboard battery management system and the capability of the onboard charger, which are typically rated at 3.6 or 7.2 kW. The power required by DCFC is up to 90 kW; however, typical DCFC installed in the JBLM area deliver up to 60 kW; again this is controlled by the vehicle's battery management system.

Tacoma Power's demand charge for Schedule HVG[r] is $3.86/kW. There is a cost impact for the operation of both AC Level 2 and DCFC. The impact of DCFC is up to eight times that of AC Level 2, although the simultaneous operation of AC Level 2 can have the same impact.

The electric vehicle industry is concerned with this impact, especially for those EVSE installed in public locations by retailers. Methods are being tested to mitigate the impact of these demand charges. Options for AC Level 2 may include the following:

- Staggering the EVSE start times – This avoids all EVSE operating at high power at the same time.

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[q] https://www.flickr.com/photos/blinknetwork1/page3/ [accessed August 8, 2014].

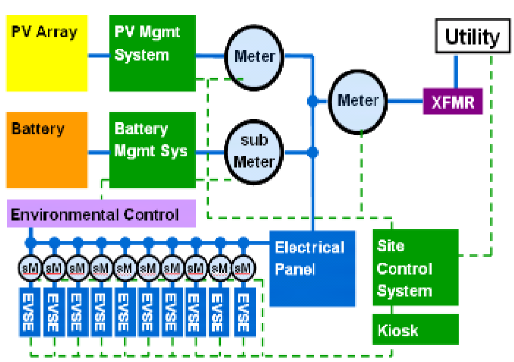
[r] http://www.mytpu.org/customer-service/rates/power-rates/power-rates-schedules.htm [accessed August 9, 2014].

- Shifting EVSE start times to evening and night hours – The highest usage by JBLM would typically occur during the daytime hours; therefore, the charging peak would not add to the non-charging peak.
- Limiting the power delivered by EVSE – However, this also reduces the energy returned to the PEVs, resulting in longer recharge times, which defeats many of the benefits of fast charging.
- Augmenting EVSE supply power – Storage-assisted recharging is one method for reducing the demand from the utility and is discussed further in Section 3.4.3.
- Smart grid charging – Some EVSE are equipped with features, including communications with the electric utility. Automatic controls can be set to reduce or curtail charging upon specific signals from the utility related to overall demand. Such features could also be integrated with the site power to assist in lowering charging demand.

All features designed to mitigate power demand may affect the recharging of vehicles because the power is interrupted or curtained in response, thus influencing the actual power delivered to the PEV.

3.4.3 Storage-Assisted Recharging

Storage-assisted recharging utilizes a storage battery to augment power delivered from the electric grid to provide the PEV recharge energy. Figure 13 provides a conceptual sketch of such a system. This system may be available for AC Level 2 or DCFC charging stations. The local storage battery is discharged during the PEV charging operation at a rate that limits the power demand from the electric utility and thus limits the demand charges. The battery may be recharged using renewable energy sources (i.e., wind or solar) or directly from the grid during non-charging operations. System design will depend on the number and ratings of the EVSE, as well as the availability of the renewable energy sources and anticipated PEV charging requirements.



Sample System Parameters	
(values are per parking space)	
Solar PV Array	2kW
Battery Storage	5kW/5kWhr
Vehicle Charging	240V, 32A (7.68kW)

Figure 13. Conceptual design storage-assisted recharging.[s]

3.4.4 Vehicle to Grid

V2G technology is the transfer of energy from the PEV's onboard storage battery to the electrical grid. The uses for this electrical energy include the following:

- Installation peak power shaving
- Frequency regulation/power regulation
- Voltage and VAR optimization
- Voltage regulation

[s] http://et.epri.com/Charging_Vehicles_with_Solar_Power_and_Energy_Storage_2011.html [accessed August 9, 2014]

- Spinning reserve functionality
- Emergency back-up power
- Installation microgrid connectivity and support.[t]

Figure 14 illustrates some of the opportunities for V2G benefits.

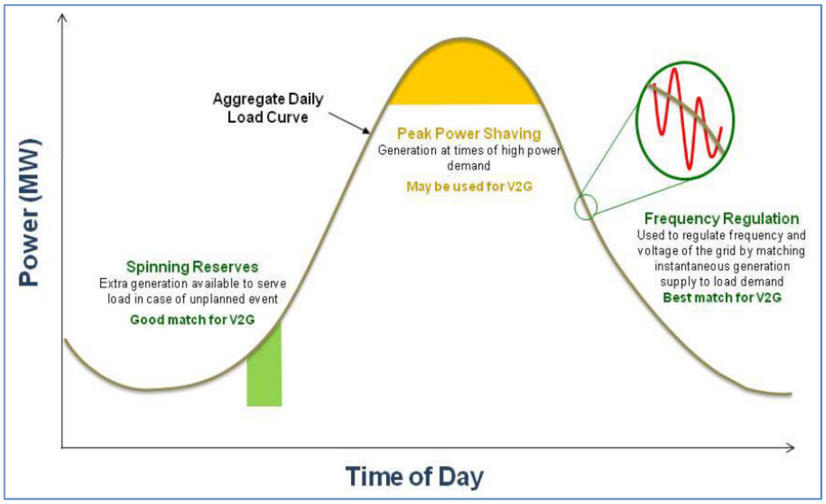


Figure 14. V2G applications.[u]

The electric load for the electric utility typically follows the aggregate daily load curve shown in Figure 14, where peak power demands occur during the daylight hours and low power demand occurs in the evening and night hours. Utilities match this load by adding or removing generators in their supply. Typically, an electric utility will "base load" generation with their least cost generation capabilities (such as hydroelectric and nuclear). "Spinning reserve" generation is operational and ready to take grid load as the demand increases and "peaking" generation covers the peak daily demands with generators that are easier to start and stop (gas) and that are typically more costly to run. If sufficient power is available from the storage batteries of the PEVs and that energy can be transferred to the grid, the utility may be able to avoid generation. This saves utility generation costs for which the utility may be disposed to compensate the V2G supplier. In a similar manner, electric utilities may be interested in the other potential benefits noted above.

The U.S. DOD is interested in V2G as a potential technology to provide financial support in the adoption of PEVs at DOD facilities and for support of DOD energy security in establishing the facility microgrid. The microgrid isolates the facility in the event of a sustained loss of utility-supplied power and the facility provides its own generation for strategic and tactical missions.

The Smart Power Infrastructure Demonstration for Energy Reliability and Security Program was initiated to address the energy security issues in several phases. Each phase increases the size and complexity of the microgrid as renewable energy sources and V2G are added.[v]

In order to support bi-directional power flow from the vehicle, the vehicle must have the ability to transfer power from the onboard battery off board to the EVSE. The EVSE must be able to accept the reverse power flow and supply to the local grid. Control systems must be in place to monitor and direct

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[t] Statement of Work for Grid Services Demonstration – U.S. Army-TARDEC_NAC April 2, 2012.

[u] ibid

[v] Smart Power Infrastructure Demonstration for Energy Reliability and Security presentation, USPACOM/USNORTHCOM, May 2012.

the process, as well as employ safety and security systems in handling electrical energy and internet/communications systems.

The V2G capabilities can be realized with either AC or DC charging equipment. A few DCFC can provide significant power (if the vehicle can support the battery discharge) and the aggregated energy from several AC Level 2 EVSE can also be effective.

V1G capabilities refer to the single-directional power control afforded by controlling the charge rate to the connected PEVs. Rather than reverse power to the grid, grid peak and frequency is controlled by regulating the power to the connected PEVs.

Should JBLM be interested in possessing V2G or V1G capability, several other design considerations need to be studied, as well as selecting the supplier of the smart EVSE capable of providing the bi-directional services.

4. FLEET VEHICLE CHARGING ANALYSIS

Sixty vehicles, belonging to four different fleet managers, were included in the study at JBLM. The specific requirements of each fleet manager necessitates that these data be analyzed by fleet rather than aggregating across all vehicles. The Task 3 vehicle utilization report (INL/EXT-14-33337) provides recommendations for PEV substitution for internal combustion engine vehicles by these fleets. Several terms were defined in the data collection process and included in that report. Topics directly related to the vehicle charging infrastructure are emphasized here followed by the analysis by fleet.

4.1 Analysis Background

Non-intrusive data loggers were installed into the monitored vehicle’s onboard diagnostic port to collect and transmit the relevant data. Data consist of key-on events, key-off events, and position updates logged every minute while the vehicle is keyed-on.

From these data points, the following information was available for evaluation:

- Trip start and stop time and location
- Trip distance and duration
- Idle start time, location, and duration
- Stop start time, location, and duration.

For charging analysis, the stop locations and durations are the most significant because most recharging will occur at the vehicle’s home base.

It is important to define other terms used in the analysis. Figure 15 illustrates a vehicle outing, which is comprised of trips, stops, and idle events, that may occur over one day or several days. The following list provides a definition of these terms:

- **Outing**: An outing is the combination of trips and stops that begin at the home base and includes all travel until the vehicle returns home.
- **Trip**: A trip begins with a key-on event and ends with the next key-off event.
- **Vehicle stop**: A vehicle stop includes a key-off/key-on event pair.
- **Idle time**: Idle time is the amount of time a vehicle spends stationary after a key-on event when the vehicle is not moving for a period of 3 minutes or longer.
- **Trip travel time**: Trip travel time is the amount of time required to complete a trip, excluding stops but including idle time.

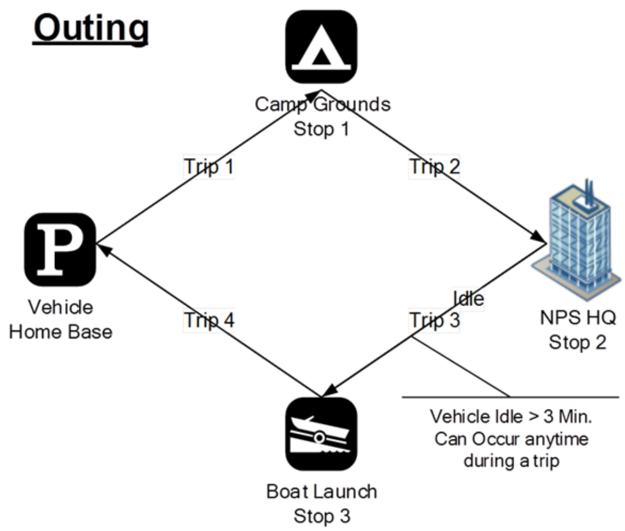


Figure 15. Vehicle outing.

The vehicle's mission influences the PEV recommendations. Based on fleet information gathered, Intertek has established the following seven mission/vehicle categories for analysis. They are listed as follows and examples are depicted in Figure 16:

- **Pool vehicles:** A pool vehicle is any automobile (other than the low-speed vehicles identified below) manufactured primarily for use in passenger transportation, with not more than 10 passengers.
- **Enforcement vehicles:** Vehicles specifically approved in an agency's appropriation act for use in apprehension, surveillance, police, or other law enforcement work. This category also includes site security vehicles, parking enforcement, and general use, but the vehicles are capable of requirements to support enforcement activities. Appendix A provides further definition.
- **Support vehicles:** Vehicles assigned to a specific work function or group to support the mission of that group. Vehicles are generally passenger vehicles or light-duty pickup trucks and may contain after-market modifications to support the mission.
- **Transport vehicles:** Light, medium, or heavy-duty trucks used to transport an operator and tools or equipment of a non-specific design or nature. The vehicle's uses include repair, maintenance, or delivery.
- **Specialty vehicles:** Vehicles designed to accommodate a specific purpose or mission (such as ambulances, mobile cranes, and handicap controls).
- **Shuttles/buses:** Vehicles designed to carry more than 12 passengers and further outlined in 49 CFR 532.2.
- **Low-speed vehicle:** Vehicles that are legally limited to roads with posted speed limits up to 45 mph and that have a limited load-carrying capability.

Figure 16. Vehicle missions.

4.2 Plug-In Electric Vehicle Charging Analysis Results – 6th MP Group

This section summarizes and aggregates the data collection for the 6th MP Group. The details of each vehicle monitored are included in Appendix B of the Task 3 vehicle utilization report (INL/EXT-14-33337).

4.2.1 6th MP Group Recommended Plug-In Electric Vehicles for Monitored Vehicles

The Task 3 vehicle utilization report recommended replacement of the monitored vehicles with those identified in Table 3. See that report for the vehicle analysis. All vehicles in the fleet are pool vehicles.

Table 3. 6th MP Group-monitored vehicle replacements.

Vehicle Index						
Log	**Fleet Vehicle Id**	**Make**	**Model**	**EPA Class**	**Replacement PEV**	**Mission**
82	G61-0546L	GMC	Terrain	SUV	Toyota RAV4 EV	Pool
86	G61-0689A	Ford	Ranger	Pickup Truck	Via Motors VTRUX	Pool
103	G41-5433B	Dodge	Gr Caravan	Minivan	Nissan Leaf	Pool

4.2.2 6th MP Group Available Charge Time

The Task 3 vehicle utilization report also identified the aggregated travel time summary for these monitored vehicles. The relevant section from that report is provided in Table 4.

The average daily usage is just over 1 hour per day. The peak daily usage was just over 6 hours. The peak outing time was higher because of overnight trips away from the home base. The distribution of daily travel times is shown in Figure 17, with 25% of daily travel time being 20 minutes or less in duration.

Table 4. Pool vehicle travel time summary.

Pool Vehicle Travel Time Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Time (Minutes)	69.6/361	35.6/443	14.2/181	6,477
Idle Time (Minutes)	13.6/NA	7.0/NA	2.8/NA	1,269

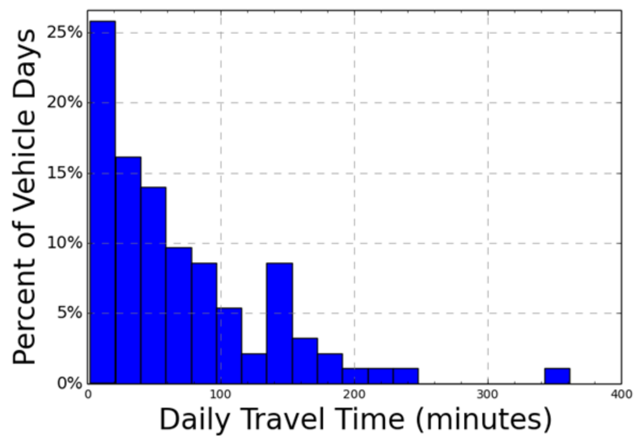


Figure 17. Pool vehicle daily travel time.

The average daily usage for each vehicle was also identified in the Task 3 vehicle utilization report and is provided in Table 5.

Table 5. Vehicle utilization.

Logger	Vehicle	Mission	Vehicle Class	Percent Days Used	Avg Daily Travel Time (Hrs)
82	G61-0546L	PL	SUV	73%	1.2
86	G61-0689A	PL	Pickup	53%	1.2
103	G41-5433B	PL	Minivan	80%	1.1
			Average	69%	1.2

In general, the vehicles are used on frequent days, but average usage per day is quite low.

4.2.3 6th MP Group Electric Vehicle Supply Equipment Type Information

As reported in the Task 3 vehicle utilization report, AC Level 2 overnight charging of BEVs is typical, whereas overnight charging of PHEVs can usually be accomplished with AC Level 1 charging. This would result in a typical recommendation to provide two AC Level 2 EVSE for the BEVs and one AC Level 1 EVSE for the PHEV. However, daily travel time and distance are typically so low that the time for recharge is not a concern.

4.2.4 6th MP Group Electric Vehicle Supply Equipment Charging Locations

The home bases of the three monitored vehicles reported by JBLM and recorded by instrument are shown in Table 6.

Table 6. 6th MP Group pool vehicles home base.

Log	Fleet Vehicle Id	Replacement PEV	Home Base
82	G61-0546L	Toyota RAV4 EV	Bldg 4291
86	G61-0689A	Via Motors VTRUX	Bldg 4291
103	G41-5433B	Nissan Leaf	Bldg 4291

All vehicles are home based in the same location. Figure 18 maps the home base location.

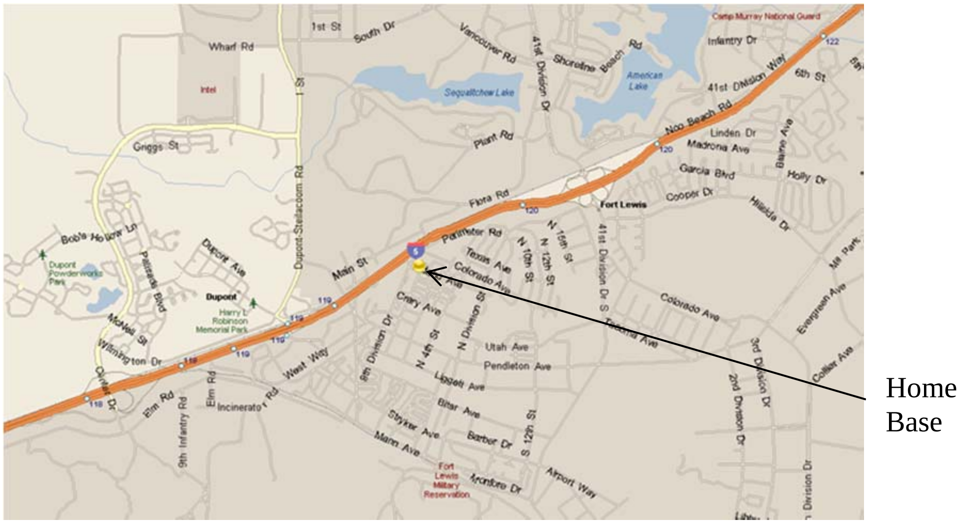


Figure 18. 6th MP Group home base.

The vehicles for the 6th MP Group typically park overnight at their home base. At times, PEVs benefit from additional charge opportunities if EVSE are located in areas where they frequently stop. Figure 19 shows locations where these vehicles parked for more than 2 hours. The size of the symbol indicates the length of time parked at that location capped at 1 week's duration.

Figure 19. 6th MP Group stop locations by duration.

Figure 20 shows locations where these vehicles parked for more than 2 hours. In this map, the size of the symbol indicates the number of times the vehicles parked at that location during the study period.

Figure 20. 6th MP Group stop locations by count.

Figures 19 and 20 show that although the vehicles may have parked for significant time away from the home base, the number of times are insignificant compared to home-base parking.

4.2.5 6th MP Group Electric Vehicle Supply Equipment Observations for Monitored Vehicles

Data show that the recommended PEVs should have sufficient time daily for recharging at the home base. The infrequent nature of the away-from-home base charging suggests that such would not be of much benefit. Thus, home-base charging only is suggested.

Two BEVs and one PHEV suggest that two AC Level 2 and one AC Level 1 EVSE would be appropriate. However, utilization of these vehicles suggests that one AC Level 2 EVSE and two AC Level 1 EVSE ports will be sufficient and result in lower cost. Some management attention will be required to ensure the vehicles are effectively rotated on the AC Level 2 EVSE for charging and dispatched based on the battery state of charge. It is likely that such attention is already employed when assigning pool vehicles. Connecting the vehicles overnight should provide sufficient recharge time for all vehicles.

4.2.6 6th MP Group Fleet Summary

This study provides observations for the vehicles monitored and for the entire non-tactical fleet of vehicles identified within the 6th MP Group.

The fleet of pool vehicles in this study included one SUV, one minivan, and one pickup truck. Intertek suggests that replacing these three vehicles with two BEVs and one PHEV would meet current mission requirements and that one AC Level 2 and two AC Level 1 EVSE ports should be sufficient for recharging.

Considering a full complement of 20 pool vehicles in the 6th MP Group fleet, Intertek suggests a fleet of one conventional passenger van, 12 BEVs, and 7 PHEVs conservatively meets vehicle travel requirements. All 6th MP Group vehicles have a pool mission and, assuming that the full fleet operates in a manner similar to those monitored, it is likely that six AC Level 2 and thirteen AC Level 1 EVSE will provide the necessary recharge capabilities with typical management attention.

These suggestions will be factored into further observations and suggestions related to the business case and the schedule for any replacements in the 6th MP Group. These observations will be addressed in Task 4 of this project.

4.3 Analysis Results – DCA Group

This section summarizes and aggregates data collection for the Directorate of Community Activities (DCA) Group. The details of each vehicle monitored are included in Appendix C of the Task 3 vehicle utilization report (INL/EXT-14-33337).

4.3.1 Directorate of Community Activities Support Group Recommended Plug-In Electric Vehicles for Monitored Vehicles

The Task 3 vehicle utilization report recommended replacement of the monitored vehicles with those identified in Table 7 (see that report for the vehicle analysis). Two vehicles had a pool mission and two were support vehicles.

Table 7. DCA Group-monitored vehicle replacements.

Vehicle Index						
Log	Fleet Vehicle Id	Make	Model	EPA Class	Replacement PEV	Mission
83	G41-74299	Ford	Ranger	Pickup	Via Motors VTRUX PU	Support
94	G71-0684A	Chevrolet	C6500 Stake	Truck HD	Via Motors VTRUX Van	Pool
96	G43-1195H	Chevrolet	15 Pas Van	Pass Van	N/A	Support
99	G42-0289G	Chevrolet	G1300	Cargo Van	Nissan eNV200	Pool

4.3.2 Directorate of Community Activities Support Group Available Charge Time

The Task 3 vehicle utilization report also identified the aggregated travel time summary for these monitored vehicles. The relevant sections from that report for pool and support vehicles are provided in Tables 8 and 9.

Average daily usage for the pool vehicles is 40 minutes per day. The peak daily usage was just over 2 hours. The peak outing time was higher because of overnight trips away from the home base.

Table 8. Pool vehicles travel summary.

Pool Vehicles Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Time (Minutes)	40.1/123.0	28.7/133.0	8.3/55.0	1,926.0
Idle Time (Minutes)	9.1/NA	6.5/NA	1.9/NA	435.0

Table 9. Support vehicle travel summary

Support Vehicle Travel Summary

	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Time (Minutes)	108.0/544.0	53.6/544.0	21.7/222.0	8,208
Idle Time (Minutes)	11.5/NA	2.3/NA	2.3/NA	872

The average daily usage for support vehicles is under 2 hours per day. The longest daily travel was 9 hours.

The distribution of daily travel times is shown in Figure 21. The figure shows that the support vehicles are used for longer durations.

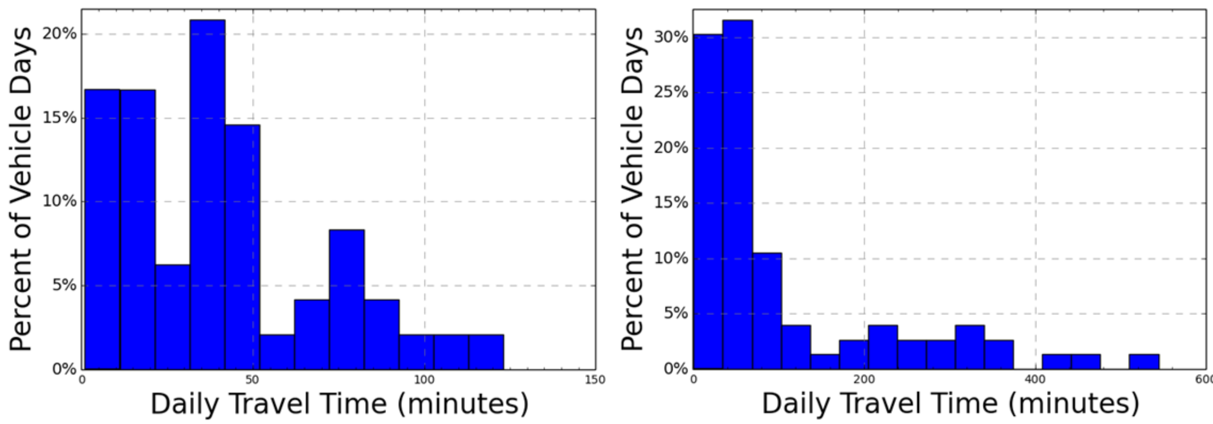


Figure 21. Pool and support vehicle daily travel minutes (all vehicles).

The average daily usage for each vehicle was also identified in the Task 3 vehicle utilization report and is provided in Table 10. SU and PL are abbreviations for support and pool, respectively.

Table 10. Vehicle utilization.

Logger	Vehicle	Mission	Vehicle Class	Percent Days Used	Avg Daily Travel Time (Hrs)
83	G41-74299	SU	Pickup	98%	0.8
94	G71-0684A	PL	Truck HD	56%	0.8
96	G43-1195H	SU	Van - Pass	71%	3.1
99	G42-0289G	PL	Van - Cargo	51%	0.6
			Average	69%	1.3

This table shows that the passenger van was the primary contributor to the longer daily travel time for the support vehicles. In general, the other vehicles are used on frequent days, but average usage per day is quite low.

4.3.3 Directorate of Community Activities Group Electric Vehicle Supply Equipment Type Recommendation

As reported in the Task 3 vehicle utilization report, AC Level 2 overnight charging of BEVs is typical, whereas overnight charging of PHEVs can usually be accomplished with AC Level 1 charging.

This would result in a typical recommendation to provide one AC Level 2 EVSE for the BEV and two AC Level 1 EVSE for the PHEVs.

4.3.4 Directorate of Community Activities Group Electric Vehicle Supply Equipment Charging Locations

The home bases of the four monitored vehicles reported by JBLM and recorded by the instruments are shown in Table 11.

Table 11. DCA Support Group pool vehicles' home base.

Log	Fleet Vehicle Id	Replacement PEV	Home Base
83	G41-74299	Via Motors VTRUX PU	Bldg 8050
94	G71-0684A	Via Motors VTRUX Van	Bldg 2057
96	G43-1195H	NA	Bldg 8050
99	G42-0289G	Nissan eNV200	Bldg 2057

Figure 22 shows the home base locations. The vehicles for the DCA Support Group typically park overnight at their home base. At times, PEVs benefit from additional charge opportunities if EVSE are located in areas where they frequently stop. Figure 23 shows locations where these vehicles parked for more than 2 hours. The size of the symbol indicates the length of time parked at that location, capped at 1 week's duration.

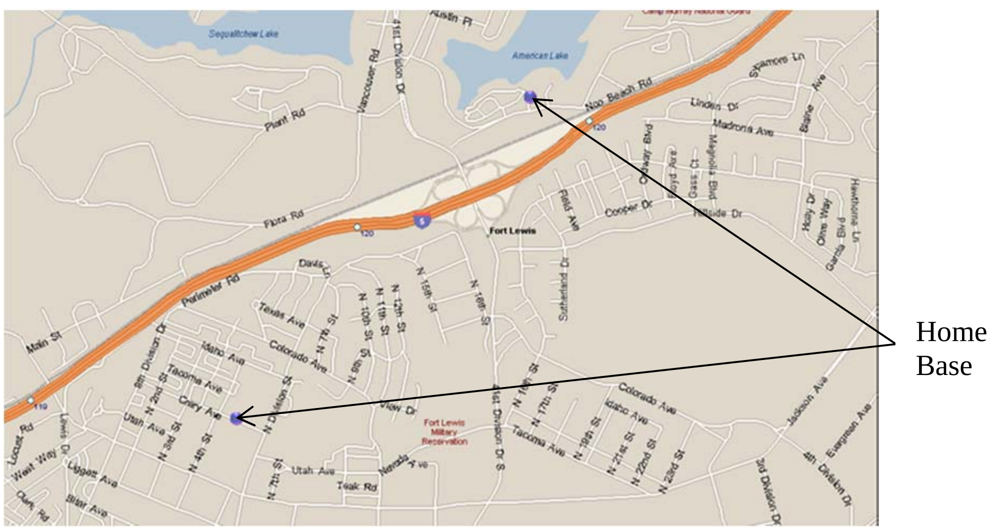


Figure 22. DCA Support Group home base locations.

Figure 24 shows locations where these vehicles parked for more than 2 hours. On this map, the size of the symbol indicates the number of times the vehicles parked at that location during the study period.

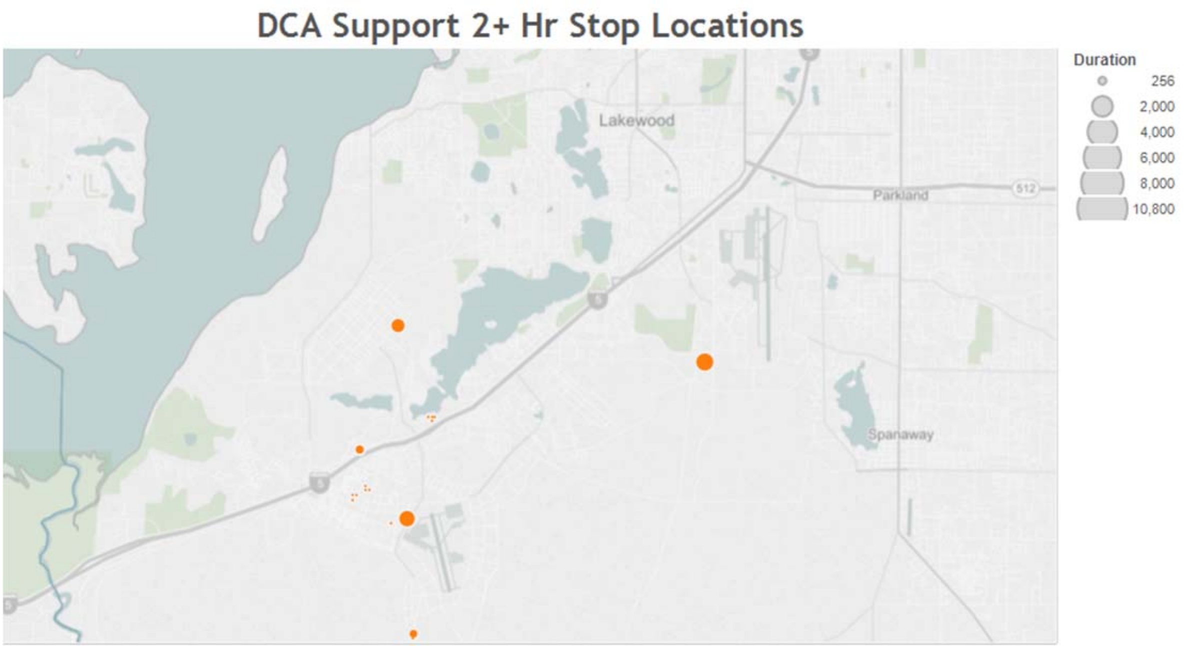


Figure 23. DCA Support Group stop locations by duration.

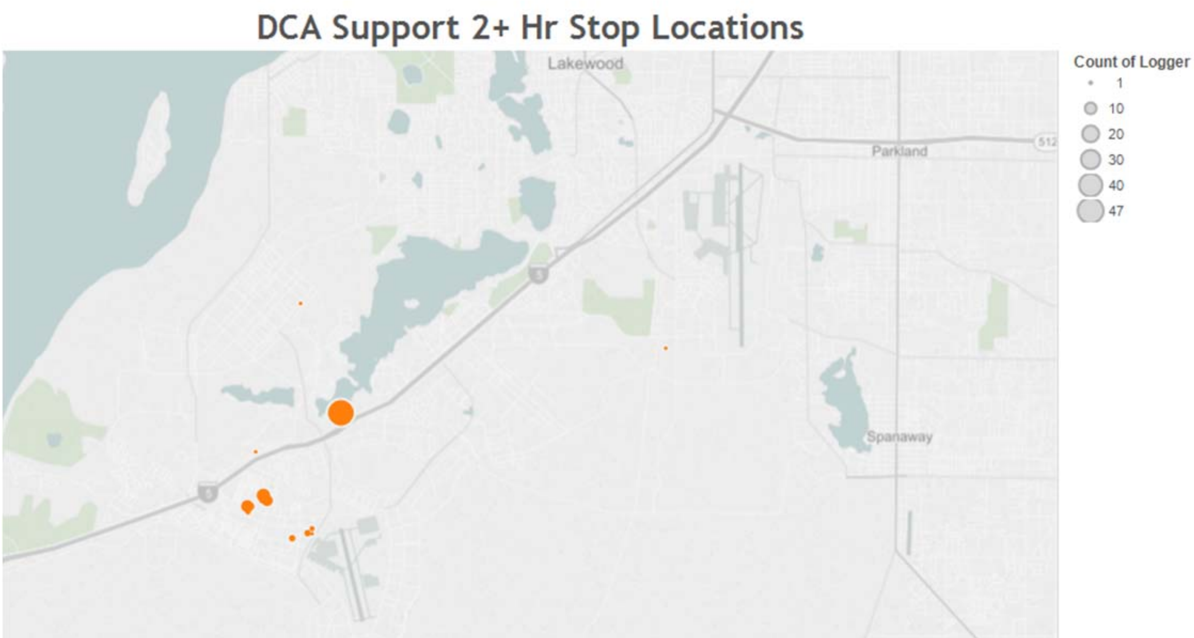


Figure 24. DCA Support Group stop locations by count.

4.3.5 Directorate of Community Activities Support Group Electric Vehicle Supply Equipment Observation

Data show that the recommended PEVs should have sufficient time daily for recharging at the home base. The infrequent nature of the away-from-home base charging suggests that this would not be much of a benefit. Thus, home-base charging only is suggested.

For the DCA Support Group, the vehicles involved in the support mission have higher utilization and travel times than the pool mission vehicles.

One BEV and two PHEVs suggest that one AC Level 2 and two AC Level 1 EVSE would be appropriate. However, utilization of these vehicles suggests that the one AC Level 2 EVSE could be of benefit for other vehicles as well. Connecting the vehicles overnight should provide sufficient recharge time for all vehicles.

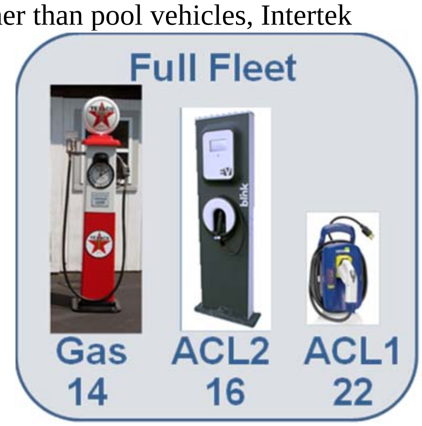
4.3.6 Directorate of Community Activities Support Group Summary

This study provides observations for the vehicles monitored and for the entire non-tactical fleet of vehicles identified with the DCA Support Group.

The vehicles monitored in this study included one cargo van, one passenger van, one pickup truck, and one heavy-duty truck. Intertek suggests that retention of the conventional passenger van and replacement of three vehicles with one BEV and two PHEVs would meet current mission requirements and that one AC Level 2 and two AC Level 1 EVSE ports should be sufficient for recharging.

Considering a full complement of 52 vehicles in the DCA Support Group fleet, 12 are involved in the pool mission and 40 in the support mission. Intertek suggests that a pool mission fleet consisting of six conventional vehicles, four BEVs, and two PHEVs should meet mission objectives. Because utilization of these vehicles is low, Intertek suggests two AC Level 2 and four AC Level 1 EVSE should meet recharging requirements. Some management attention will be required to ensure the vehicles are effectively rotated on the AC Level 2 EVSE for charging and dispatched based on the battery state of charge. It is likely that such attention is already employed when assigning pool vehicles. Connecting the vehicles overnight should provide sufficient recharge time for all vehicles.

In the full fleet, 40 vehicles are involved in the support mission. Intertek suggests a mixed pool mission fleet consisting of eight conventional vehicles, 20 BEVs, and 12 PHEVs should meet mission objectives. Because utilization of these vehicles is low but slightly higher than pool vehicles, Intertek suggests that 14 AC Level 2 and 18 AC Level 1 EVSE should meet recharging requirements. Some management attention will be required to ensure the vehicles are effectively rotated on the AC Level 2 EVSE for charging and dispatched based on the battery state of charge. It is likely that such attention is already employed when assigning pool vehicles. Connecting the vehicles overnight should provide sufficient recharge time for all vehicles.



In summary, the full fleet of DCA Support vehicles could contain 14 conventional vehicles, 24 BEVs, and 14 PHEVs. Charging equipment could consist of 16 AC Level 2 and 22 AC Level 1 EVSE. These suggestions should be factored into further observations and suggestions related to the business case and the schedule for any replacements for the DCA Support Group. Those observations will be addressed in Task 4 of this project.

4.4 Analysis Results – Public Works Group

This section summarizes and aggregates data collection for the Public Works Group. The details of each vehicle monitored are included in Appendix D of the Task 3 vehicle utilization report (INL/EXT-14-33337).

4.4.1 Public Works Group Recommended Plug-In Electric Vehicles for MONITORED VEHICLES

The Task 3 vehicle utilization report recommended replacement of the monitored vehicles with those identified in Table 12. See the report for vehicle analysis. Eight vehicles had a pool mission and six were support vehicles.

Table 12. Public Works Group-monitored vehicle replacements.

Vehicle Index						
Log	**Fleet Vehicle Id**	**Make**	**Model**	**EPA Class**	**Replacement PEV**	**Mission**
1	G42-0658K	Ford	F150	Pickup	Via Motors VTRUX PU	Pool
2	G42-1054F	Ford	F150	Pickup	Toyota Rav4	Pool
3	G71-0133L	Ford	E450	Pass van	NA	Pool
4	G43-0944G	Chevrolet	G3500	Pass van	NA	Pool
5	G43-0822G	Ford	F350	Pickup	Toyota Rav4	Support
84	G41-1100K	Dodge	GR Caravan	Minivan	Mitsubishi Outlander	Pool
87	G42-0619K	Chevrolet	C1500	Pickup	Toyota Rav4	Pool
88	G41-1180K	Dodge	GR Caravan	Minivan	Nissan Leaf	Pool
90	G43-1892H	Chevrolet	C2500HD	Pickup	Nissan eNV200	Support
91	G43-1961H	Chevrolet	C3500	Pickup	Toyota Rav4	Support
92	G42-0505A	Chevrolet	G1300	Pass van	NA	Support
95	G43-1155L	Ford	F350	Pickup	Via Motors VTRUX PU	Support
98	G41-1605L	Dodge	Dakota	Pickup	Toyota Rav4	Support
100	G42-0610K	Chevrolet	C1500	Pickup	Nissan eNV200	Pool

4.4.2 Public Works Group Available Charge Time

The Task 3 Vehicle Utilization report also identified the aggregated travel time summary for these monitored vehicles. The relevant sections from that report for pool and support vehicles are provided in Tables 13 and 14.

Table 13. Pool vehicles travel summary.

Pool Vehicles Travel Summary				
	Per Day Average/Peak	**Per Outing Average/Peak**	**Per Trip Average/Peak**	**Total**
Travel Time (Minutes)	59.2/297.0	23.0/247.0	9.3/139.0	15,563
Idle Time (Minutes)	17.5/NA	6.9/NA	2.7/NA	4,595

The average daily usage for the pool vehicles is about 1 hour per day. The peak daily usage was just about 5 hours.

Table 14. Support vehicle travel summary.

Support Vehicle Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Time (Minutes)	88.1/585	26.2/628	11.6/215	18,053
Idle Time (Minutes)	18.2/NA	5.4/NA	2.4/NA	3,722

The average daily usage for support vehicles is about 1.5 hours per day. The longest daily travel was just under 10 hours. The peak outing time was higher due to overnight trips away from the home base.

The distribution of daily travel times is shown in Figure 25. As with the 6th MP Group, the support vehicles are used for longer durations as shown.

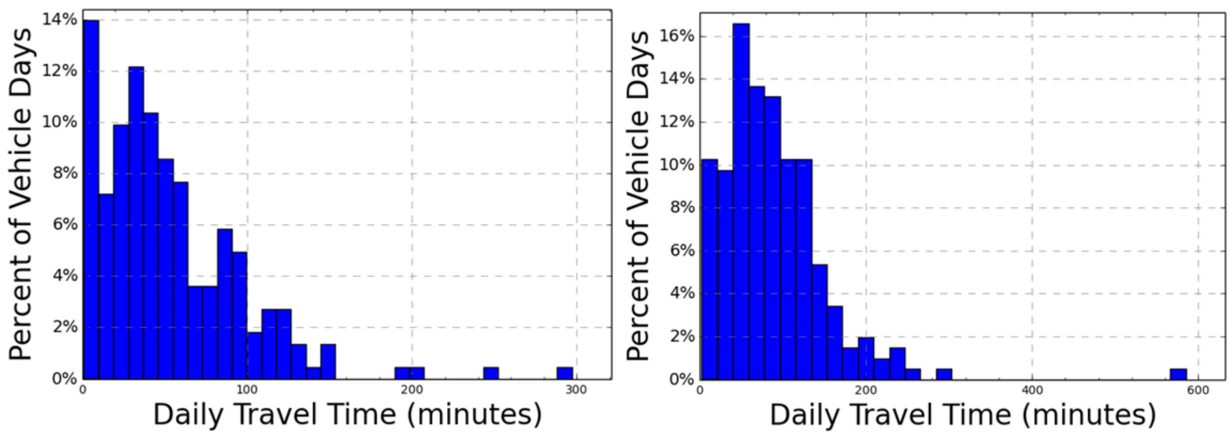


Figure 25. Pool and support vehicle daily travel minutes (all vehicles).

The average daily usage for each vehicle was also identified in the Task 3 vehicle utilization report and is provided in Table 15.

Table 15. Vehicle utilization

Logger	Vehicle	Mission	Vehicle Class	Percent Days Used	Avg Daily Travel Time (Hrs)
1	G42-0658K	PL	Pickup	82%	1.2
2	G42-1054F	PL	Pickup	78%	1.0
3	G71-0133L	PL	Van - Pass	91%	1.6
4	G43-0944G	PL	Van - Pass	76%	1.3
5	G43-0822G	SU	Pickup	100%	1.3
84	G41-1100K	PL	Minivan	62%	0.7
87	G42-0619K	PL	Pickup	67%	0.5
88	G41-1180K	PL	Minivan	84%	0.6
90	G43-1892H	SU	Pickup	96%	1.5
91	G43-1961H	SU	Pickup	91%	1.7
92	G42-0505A	SU	Van - Pass	78%	0.9
95	G43-1155L	SU	Pickup	78%	2.2
98	G41-1605L	SU	Pickup	13%	0.4
100	G42-0610K	PL	Pickup	44%	0.7
			Average	74%	1.1

In general, the vehicles are used on frequent days, but average usage per day is quite low.

4.4.3 Public Works Group Electric Vehicle Supply Equipment Type Recommendation

As reported in the Task 3 vehicle utilization report, AC Level 2 overnight charging of BEVs is typical, whereas overnight charging of PHEVs can usually be accomplished with AC Level 1 charging. This would result in a typical recommendation to provide eight AC Level 2 EVSE for the BEVs and three AC Level 1 EVSE for the PHEVs.

4.4.4 Public Works Group Electric Vehicle Supply Equipment Charging Locations

The home bases of the 14 monitored vehicles reported by JBLM and recorded by the instruments are shown in Table 16.

Table 16. Public Works Group pool vehicle home base.

Log	Fleet Vehicle Id	Replacement PEV	Home Base
1	G42-0658K	Via Motors VTRUX PU	Bldg 2044
2	G42-1054F	Toyota Rav4	Bldg 2044
3	G71-0133L	NA	Bldg 2063
4	G43-0944G	NA	Bldg 2044
5	G43-0822G	Toyota Rav4	Bldg 2044
84	G41-1100K	Mitsubishi Outlander	Bldg 2012
87	G42-0619K	Toyota Rav4	Bldg 555/Lincoln Blvd
88	G41-1180K	Nissan Leaf	Bldg 540
90	G43-1892H	Nissan eNV200	Bldg 300/6th St SW
91	G43-1961H	Toyota Rav4	Bldg 300/6th St SW
92	G42-0505A	NA	Bldg 555/ Bldg 2012
95	G43-1155L	Via Motors VTRUX PU	Bldg 2044
98	G41-1605L	Toyota Rav4	Bldg 2044
100	G42-0610K	Nissan eNV200	Bldg 2044

Figure 26 illustrates these home base locations.

The vehicles for the Public Works Group typically park overnight at their home base. At times, PEVs benefit from additional charge opportunities if EVSE are located in areas where they frequently stop. Figure 27 shows locations where these vehicles parked for more than 2 hours. The size of the symbol indicates the length of time parked at that location, capped at 1 week’s duration.

Figure 28 shows locations where these vehicles parked for more than 2 hours. In this map, the size of the symbol indicates the number of times the vehicles parked at that location during the study period.

Stops greater than 2 hours occur at only a few locations and, although some may be for a significant time, they were very infrequent.

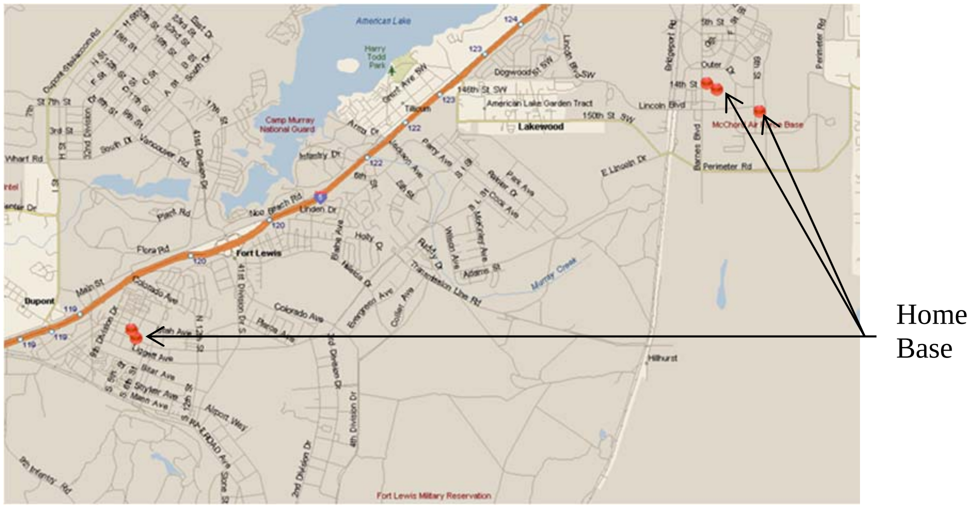


Figure 26. Public Works Group home locations.

Figure 27. Public Works Group stop locations by duration.

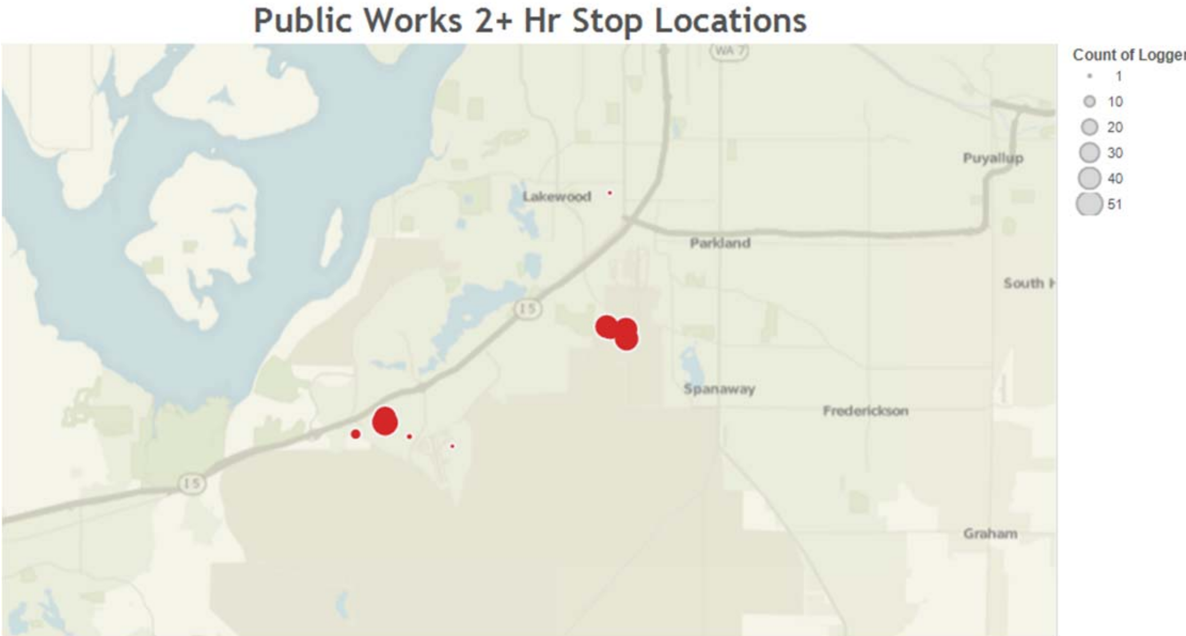


Figure 28. Public Works Group stop locations by count.

4.4.5 Public Works Group Electric Vehicle Supply Equipment Observation

Data show that the recommended PEVs should have sufficient time daily for recharging at the home base. The infrequent nature of the away-from-home base charging suggests that this would not be of much benefit. Thus, home-base charging only is suggested.

For the Public Works group, the vehicles involved in the support mission have higher utilization and travel times than the pool mission vehicles.

As noted above, eight AC Level 2 and three AC Level 1 EVSE typically would be recommended. However, the low utilization of these vehicles suggests that fewer AC Level 2 can be sufficient. Intertek suggests that six AC Level 2 EVSE and five AC Level 1 EVSE should meet mission commitments. Connecting the vehicles overnight should provide sufficient recharge time for all vehicles.

4.4.6 Public Works Group Summary

This study provides observations for the vehicles monitored and for the entire non-tactical fleet of vehicles identified with the Public Works Group.

The vehicles monitored in this study included three conventional passenger vans, nine pickup trucks, and two minivans. Intertek suggests that retention of the conventional passenger vans and replacement of the remaining vehicles with eight BEV and three PHEVs would meet current mission requirements. Further, six AC Level 2 and five AC Level 1 EVSE ports should be sufficient for recharging.

Considering a full complement of 250 vehicles in the Public Works Group fleet, 107 are involved in the pool mission, 117 in the support mission, and 25 in the transport mission. Intertek suggests that a pool mission fleet consisting of 35 conventional vehicles, 57 BEVs, and 15 PHEVs should meet mission objectives. Because utilization of these vehicles is low, Intertek suggests 35 AC Level 2 and 37 AC Level 1 EVSE should meet recharging requirements.

In the full fleet, 117 vehicles are involved in the support mission. Intertek suggests that a mixed pool mission fleet consisting of 33 conventional vehicles, 67 BEVs, and 17 PHEVs should meet mission objectives. Because utilization of these vehicles is low but slightly higher than pool vehicles, Intertek suggests that 52 AC Level 2 and 32 AC Level 1 EVSE should meet recharging requirements.

In the full fleet, 35 vehicles are involved in the transport mission. Intertek suggests that a mixed pool mission fleet consisting of 17 conventional heavy-duty trucks, four BEVs, and four PHEVs should meet mission objectives. Assuming utilization similar to the rest of the fleet, Intertek suggests that two AC Level 2 and six AC Level 1 EVSE should meet recharging requirements.

In summary, the full fleet of Public Works vehicles could contain one conventional specialty vehicle, 52 conventional passenger vans, 33 conventional heavy-duty trucks, 128 BEVs, and 36 PHEVs. Charging equipment could consist of 89 AC Level 2 and 75 AC Level 1 EVSE.

Some management attention will be required to ensure the vehicles are effectively rotated on the AC Level 2 EVSE for charging and are dispatched based on the battery state of charge. It is likely that such attention is already employed when assigning pool vehicles. Connecting the vehicles overnight should provide sufficient recharge time for all vehicles.

These suggestions should be factored into further observations and suggestions related to the business case and schedule for any replacements for the Public Works Group. Those observations will be addressed in Task 4 of this project.

4.5 Analysis Results – Motor Transport Branch

This section summarizes and aggregates data collection for the Motor Transport Branch. The details of each vehicle monitored are included in Appendix E of the Task 3 vehicle utilization report (INL/EXT-14-33337).

4.5.1 Motor Transport Branch Recommended Plug-In Electric Vehicles for Monitored Vehicles

The Task 3 vehicle utilization report recommended replacement of the monitored vehicles with those identified in Table 17 (see that report for the vehicle analysis). Twenty-three vehicles had a pool mission, eleven were support, and six were transport.

Table 17. Motor Transport Branch-monitored vehicle replacements.

Vehicle Index						
Log	**Fleet Vehicle Id**	**Make**	**Model**	**EPA Class**	**Replacement PEV**	**Mission**
6	G43-0875K	Ford	E350	Cargo Van	Nissan eNV200	Pool
7	G41-1288A	Ford	Sport Trac	Pickup Truck	Toyota Rav4 EV	Pool
8	G43-4937A	Ford	E350	Cargo Van	Nissan eNV200	Pool
9	G10-7664F	Dodge	Avenger	Comp Sedan	Ford Focus	Pool
10	G41-65991	Dodge	Dakota	Pickup Truck	Via Motors VTRUX PU	Pool
11	G11-2676G	Chevrolet	Impala	Large Sedan	Nissan Leaf	Pool
12	G43-3717A	Ford	E350	Cargo Van	Via Motors VTRUX Van	Pool
13	G11-0678K	Chevrolet	Impala	Large Sedan	Nissan Leaf	Support
14	G62-4526H	Chevrolet	Tahoe	SUV	Mitsubishi Outlander	Support

Vehicle Index						
Log	Fleet Vehicle Id	Make	Model	EPA Class	Replacement PEV	Mission
15	G42-0698K	Chevrolet	C1500	Pickup Truck	Via Motors VTRUX PU	Support
16	G11-0493L	Chevrolet	Impala	Large Sedan	Ford Fusion	Support
17	G71-0062G	Ford	F750	Stake Truck	NA	Transport
18	G62-1094L	Chevrolet	Avalanche	SUV	Nissan Leaf	Support
19	G41-1395G	Chevrolet	Uplander	Minivan	Toyota Rav4 EV	Pool
20	G61-1155D	Ford	Escape HYB	SUV	Toyota Rav4 EV	Pool
81	G10-2878L	Chevrolet	Malibu	Mid. Sedan	Nissan Leaf	Pool
84	G41-1100K	Dodge	GR Caravan	Minivan	Mitsubishi Outlander	Pool
85	G62-0979G	Dodge	1500	Pickup Truck	Via Motors VTRUX PU	Pool
89	G71-0674A	Ford	F650 18'BO	Cargo Van	Via Motors VTRUX Van	Transport
93	G41-1373G	Dodge	Dakota	Pickup Truck	Mitsubishi Outlander	Support
97	G41-1367G	Dodge	Dakota	Pickup Truck	Toyota Rav4 EV	Pool
101	G43-0792K	Chevrolet	CG3300	Pass Van	NA	Pool
102	G43-0801K	Chevrolet	CG3300	Pass Van	NA	Pool
104	G42-0988F	Chevrolet	Express 13	Cargo Van	Nissan eNV200	Support
105	G43-0860G	Chevrolet	CG3300	Pass Van	NA	Pool
106	G43-1389K	Chevrolet	CG3300	Pass Van	NA	Pool
107	G41-1180G	Chevrolet	Uplander	Minivan	Mitsubishi Outlander	Support
108	G11-2675G	Chevrolet	Impala	Large Sedan	Chevrolet Volt	Pool
109	G43-1191L	Chevrolet	CG3300	Pass Van	NA	Pool
110	G12-0662H	Ford	Fusion HEV	Mid Sedan	Ford Fusion	Pool
111	G63-0271A	Ford	F350STAKE	Stake Truck	Via Motors VTRUX PU	Transport
112	G41-1392G	Chevrolet	Uplander	Minivan	Mitsubishi Outlander	Support
113	G43-3881H	Ford	E350	Pass Van	NA	Pool
114	G43-25839	Ford	F350	Pickup Truck	Toyota Rav4 EV	Transport
115	G41-1376G	Dodge	Dakota	Pickup Truck	Nissan eNV200	Support
116	G41-1161G	Chevrolet	Uplander	Minivan	Toyota Rav4 EV	Pool
117	G43-0790K	Chevrolet	CG3300	Pass Van	NA	Pool
118	G82-0509A	Ford	F650 STAKE	Stake Truck	NA	Transport
119	G10-6379L	Dodge	Avenger	Mid Sedan	Nissan Leaf	Support
120	G42-3471A	Chevrolet	G2300	Cargo Van	Nissan eNV200	Transport

4.5.2 Motor Transport Branch Available Charge Time

The Task 3 vehicle utilization report also identified the aggregated travel time summary for these monitored vehicles. The relevant sections from that report for pool, support, and transport vehicles are provided in Tables 18, 19, and 20.

Table 18. Pool vehicles travel summary.

Pool Vehicles Travel Summary				
	Per Day Average/Peak	**Per Outing Average/Peak**	**Per Trip Average/Peak**	**Total**
Travel Time (Minutes)	103.1/777.0	34.8/1897	12.7/257.0	69,499
Idle Time (Minutes)	27.8/NA	9.4/NA	3.4/NA	18,748

The average daily usage for the pool vehicles is about 1 hour 40 minutes per day. The peak daily usage was just about 13 hours. The peak outing was greater because it involved overnight travel away from the home base.

Table 19. Support vehicle travel summary.

Support Vehicle Travel Summary				
	Per Day Average/Peak	**Per Outing Average/Peak**	**Per Trip Average/Peak**	**Total**
Travel Time (Minutes)	274.8/1,502	78.0/1,440	30.8/512.0	113,202
Idle Time (Minutes)	58.2/NA	16.5/NA	6.5/NA	59,355

The average daily usage for support vehicles is about 4.5 hours per day. The longest daily travel was involved in overnight trips away from the home base.

Table 20. Transport vehicle travel summary.

Transport Vehicles Travel Summary				
	Per Day Average/Peak	**Per Outing Average/Peak**	**Per Trip Average/Peak**	**Total**
Travel Time (Minutes)	237.9/669.0	102.5/673.0	29.2/218.0	8,090
Idle Time (Minutes)	136.6/NA	58.8/NA	16.8/NA	4,643

The average daily usage for support vehicles is about 2 hours per day. The longest daily travel was about 11 hours.

The distribution of daily travel times is shown in Figure 29. The support vehicles are used for longer durations as shown.

The average daily usage for each vehicle was also identified in the Task 3 vehicle utilization report and is provided in Table 21.

Overall, the vehicles are used on frequent days, but other than the vehicle with logger #15, average usage per day is quite low.

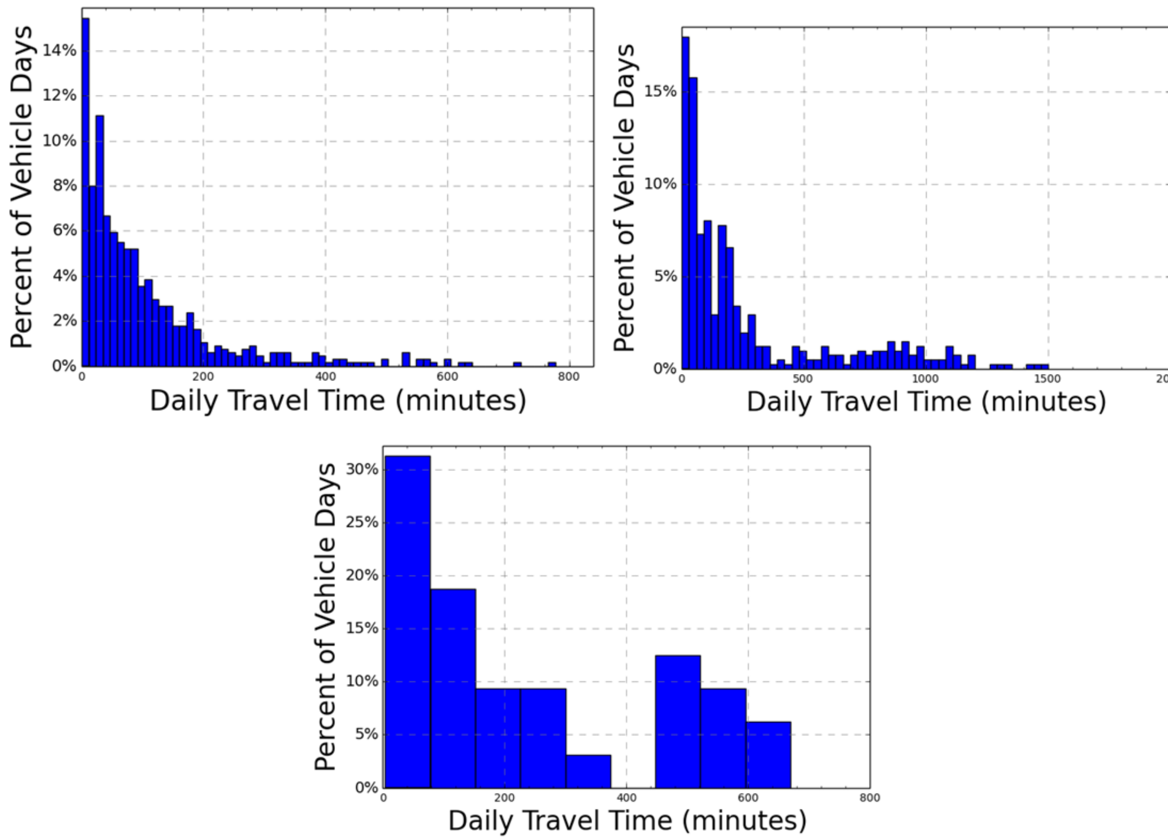


Figure 29. Pool, support, and transport vehicle daily travel minutes (all vehicles).

Table 21. Vehicle utilization.

Logger	Vehicle	Mission	Vehicle Class	Percent Days Used	Average Daily Travel Time (Hrs)
6	G43-0875K	PL	Van - Cargo	76%	3.7
7	G41-1288A	PL	Pickup	98%	0.3
8	G43-4937A	PL	Van - Cargo	20%	1.4
9	G10-7664F	PL	Sedan - Compact	56%	0.4
10	G41-65991	PL	Pickup	89%	2.0
11	G11-2676G	PL	Sedan - Large	33%	0.7
12	G43-3717A	PL	Van - Cargo	29%	0.8
13	G11-0678K	SU	Sedan - Large	87%	1.0
14	G62-4526H	SU	SUV	91%	1.8
15	G42-0698K	SU	Pickup	100%	15.5
16	G11-0493L	SU	Sedan - Large	100%	7.9
17	G71-0062G	TR	Truck HD	No data	No data
18	G62-1094L	SU	SUV	67%	0.8
19	G41-1395G	PL	Minivan	82%	0.4
20	G61-1155D	PL	SUV	53%	0.8
81	G10-2878L	PL	Sedan - Midsize	82%	1.9
84	G41-1100K	PL	Minivan	62%	0.7

85	G62-0979G	PL	Pickup	73%	1.6
89	G71-0674A	TR	Van - Cargo	No data	No data
93	G41-1373G	SU	Pickup	100%	2.9
97	G41-1367G	PL	Pickup	100%	1.2
101	G43-0792K	PL	Van - Pass	98%	2.1
102	G43-0801K	PL	Van - Pass	76%	2.4
104	G42-0988F	SU	Van - Cargo	89%	3.1
105	G43-0860G	PL	Van - Pass	91%	2.3
106	G43-1389K	PL	Van - Pass	76%	3.0
107	G41-1180G	SU	Minivan	36%	0.7
108	G11-2675G	PL	Sedan - Large	18%	0.8
109	G43-1191L	PL	Van - Pass	82%	2.0
110	G12-0662H	PL	Sedan - Midsize	60%	1.6
111	G63-0271A	TR	Pickup	49%	5.2
112	G41-1392G	SU	Minivan	44%	1.8
113	G43-3881H	PL	Van - Pass	76%	4.3
114	G43-25839	TR	Pickup	No data	No data
115	G41-1376G	SU	Pickup	67%	0.5
116	G41-1161G	PL	Minivan	64%	0.7
117	G43-0790K	PL	Van - Pass	No data	No data
118	G82-0509A	TR	Truck HD	No data	No data
119	G10-6379L	SU	Sedan - Midsize	42%	2.1
120	G42-3471A	TR	Van - Cargo	22%	1.7
			Average	68%	2.3

4.5.3 Motor Transport Branch Electric Vehicle Supply Equipment Type Recommendation

As reported in the Task 3 vehicle utilization report, AC Level 2 overnight charging of BEVs is typical, whereas overnight charging of PHEVs can usually be accomplished with AC Level 1 charging. For the 40 vehicles in this study, this would result in a typical recommendation to provide 18 AC Level 2 EVSE for the BEVs and 13 AC Level 1 EVSE for the PHEVs.

4.5.4 Motor Transport Branch Electric Vehicle Supply Equipment Charging Locations

The home bases of the 40 monitored vehicles reported by JBLM and recorded by the instruments are shown in Table 22.

Table 22. Motor Transport Branch vehicle home bases.

Log	Fleet Vehicle Id	Replacement PEV	Home Base
6	G43-0875K	Nissan eNV200	Near J Ramp/Levitow Blvd
7	G41-1288A	Toyota Rav4 EV	Bldg 100/Col. Joe Jackson Blvd
8	G43-4937A	Nissan eNV200	C Ramp/7th St NE
9	G10-7664F	Ford Focus	Bldg 100/ Westcott Hills

Log	Fleet Vehicle Id	Replacement PEV	Home Base
10	G41-65991	Via Motors VTRUX PU	Bldg 100/Barrack St or 2nd St
11	G11-2676G	Nissan Leaf	Bldg 9190/Sansone St
12	G43-3717A	Via Motors VTRUX Van	Bldg 2027/N 8th St
13	G11-0678K	Nissan Leaf	Bldg 100/2nd St NW
14	G62-4526H	Mitsubishi Outlander	Bldg 2007/Pendleton Ave
15	G42-0698K	Via Motors VTRUX PU	Near D Ramp/2nd St NW
16	G11-0493L	Ford Fusion	Bldg 2007/Pendleton Ave
17	G71-0062G	NA	NA
18	G62-1094L	Nissan Leaf	Bldg 4074/Kaufman Ave
19	G41-1395G	Toyota Rav4 EV	Bldg R9641/Rainier Dr
20	G61-1155D	Toyota Rav4 EV	Bldg 4074/Kaufman Ave
81	G10-2878L	Nissan Leaf	Bldg R1407/West Way
84	G41-1100K	Mitsubishi Outlander	Bldg 2012/1210
85	G62-0979G	Via Motors VTRUX PU	Bldg 1210/Mann Ave
89	G71-0674A	Via Motors VTRUX Van	Bldg R9641/Perry Ave
93	G41-1373G	Mitsubishi Outlander	Bldg R9654/Perry Ave
97	G41-1367G	Toyota Rav4 EV	Bldg R9641/Rainier Dr
101	G43-0792K	NA	NA
102	G43-0801K	NA	NA
104	G42-0988F	Nissan eNV200	Bldg 9040/Fitzsimmons
105	G43-0860G	NA	NA
106	G43-1389K	NA	NA
107	G41-1180G	Mitsubishi Outlander	Bldg 9040/Fitzsimmons
108	G11-2675G	Chevrolet Volt	Bldg 9040/9900
109	G43-1191L	NA	NA
110	G12-0662H	Ford Fusion	Bldg R9641/3674
111	G63-0271A	Via Motors VTRUX PU	Camp Murray/Yakima
112	G41-1392G	Mitsubishi Outlander	Bldg R9641/Bldg 3017
113	G43-3881H	NA	NA
114	G43-25839	Toyota Rav4 EV	Bldg R9641
115	G41-1376G	Nissan eNV200	Bldg R9640/Perry Ave
116	G41-1161G	Toyota Rav4 EV	Bldg 9040A/Fitzsimmons
117	G43-0790K	NA	NA
118	G82-0509A	NA	NA
119	G10-6379L	Nissan Leaf	Bldg 9040/Gardner Loop RD
120	G42-3471A	Nissan eNV200	Bldg 690

Figure 30 illustrates these home base locations. These vehicles are based in several distinct locations.

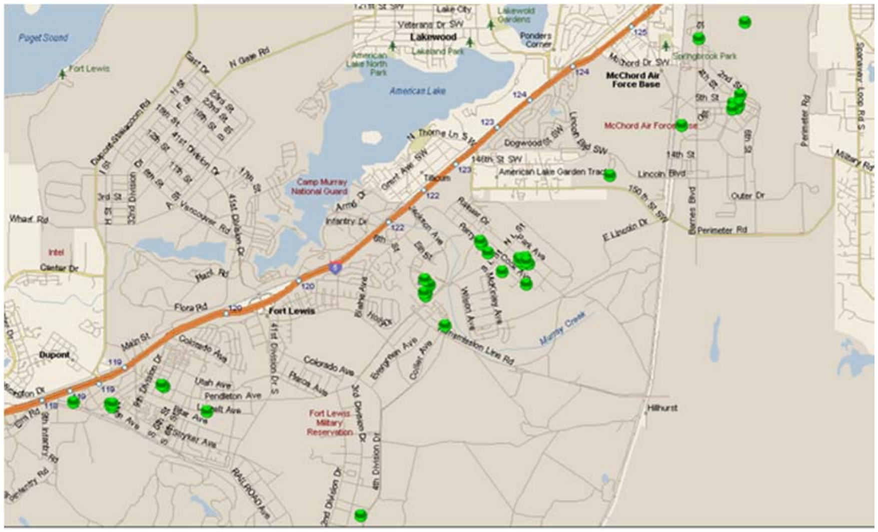


Figure 30. Motor Transport Branch home base locations.

The vehicles for the Motor Transport Branch typically park overnight at their home base. At times, PEVs may benefit from additional charge opportunities if EVSE are located in areas where they frequently stop. Figure 31 shows locations where these vehicles parked for more than 2 hours. The size of the symbol indicates the length of time parked at that location, capped at 1 week's duration.

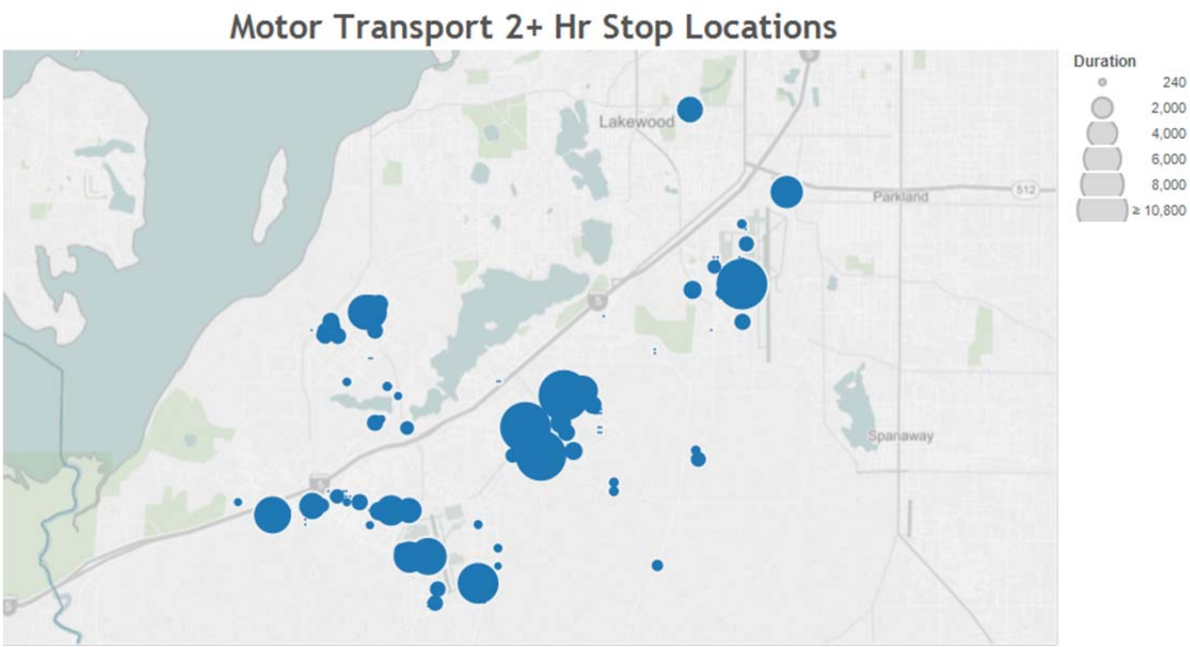


Figure 31. Motor Transport Branch stop locations by duration.

Figure 32 shows locations where these vehicles parked for more than 2 hours. In this map, the size of the symbol indicates the number of times the vehicles parked at that location during the study period.

Motor Transport 2+ Hr Stop Locations

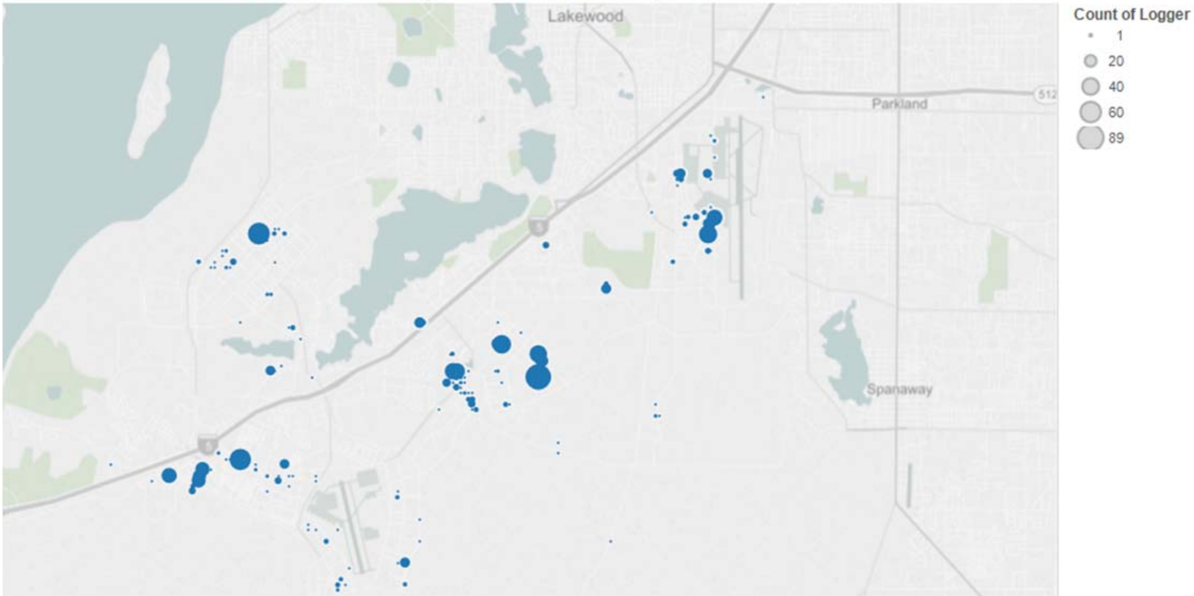


Figure 32. Motor Transport Branch stop locations by count.

There do not appear to be many locations other than the home bases where the vehicles park frequently for long durations.

4.5.5 Motor Transport Branch Electric Vehicle Supply Equipment Observation

Data show that the recommended PEVs should have sufficient time daily for recharging at the home base. The infrequent nature of the away-from-home base charging suggests that this would not be of much benefit. Thus, home-base charging only is suggested.

For the Motor Transport Branch, the vehicles involved in the support mission have higher utilization and travel times than the pool mission vehicles.

As noted above, 18 AC Level 2 EVSE are needed for the BEVs and 13 AC Level 1 EVSE are needed for the PHEVs. However, low utilization of these vehicles suggests that fewer AC Level 2 can be sufficient and Intertek suggests that 12 AC Level 2 EVSE and 19 AC Level 1 EVSE should meet mission commitments. Connecting the vehicles overnight should provide sufficient recharge time for all vehicles.

4.5.6 Motor Transport Branch Summary

This study provides observations for the vehicles monitored and for the entire non-tactical fleet of vehicles identified within the Motor Transport Branch.

The vehicles monitored in this study included eight sedans, five minivans, three SUVs, six cargo vans, seven passenger vans, nine pickup trucks, and two heavy-duty trucks. Intertek suggests retaining the conventional passenger vans and heavy-duty trucks and that replacing the remaining vehicles with 18 BEVs and 13 PHEVs would meet current mission requirements. Further, 12 AC Level 2 and 19 AC Level 1 EVSE ports should be sufficient for recharging.

Considering a full complement of 1,060 vehicles in the Motor Transport Branch fleet, 495 vehicles are involved in the pool mission, 301 in the support mission, 204 in the transport mission, and 60 in the specialty and bus missions. Intertek suggests that a pool mission fleet consisting of 168 conventional vehicles, 196 BEVs, and 131 PHEVs should meet mission objectives. Because utilization of these vehicles is low, Intertek suggests 142 AC Level 2 and 185 AC Level 1 EVSE should meet recharging requirements.

In the full fleet, 301 vehicles are involved in the support mission. Intertek suggests that a mixed pool mission fleet consisting of 18 conventional vehicles, 155 BEVs, and 128 PHEVs should meet mission objectives. Because utilization of these vehicles is low but slightly higher than pool vehicles, Intertek suggests that 141 AC Level 2 and 142 AC Level 1 EVSE should meet recharging requirements.

In the full fleet, 204 vehicles are involved in the transport mission. Intertek suggests that a mixed pool mission fleet consisting of 89 conventional vehicles, 58 BEVs, and 57 PHEVs should meet mission objectives. Assuming utilization similar to the rest of the fleet, Intertek suggests that 38 AC Level 2 and 77 AC Level 1 EVSE should meet recharging requirements.

In summary, the full fleet of Motor Transport Branch vehicles could contain four conventional specialty vehicles, 202 conventional passenger vans, 56 conventional buses, and 73 conventional heavy-duty trucks for now and a suggested fleet of 409 BEVs and 316 PHEVs for the balance of the fleet. Charging equipment could consist of 321 AC Level 2 and 404 AC Level 1 EVSE.

Some management attention will be required to ensure the vehicles are effectively rotated on the AC Level 2 EVSE for charging and dispatched based on the battery state of charge. It is likely that such attention is already employed when assigning pool vehicles. Connecting the vehicles overnight should provide sufficient recharge time for all vehicles.

These suggestions should be factored into further observations and suggestions related to the business case and the schedule for any replacements for the Motor Transport Branch. These observations will be addressed in Task 4 of this project.

4.6 Other Potential Joint Base Lewis McChord Electric Vehicle Supply Equipment Locations

4.6.1 Fleet Stop Locations

Figure 33 shows the stop locations for all monitored vehicles with the size of the symbol indicating the length of time parked at that location, capped at 1 week's duration.

Figure 34 shows locations where these vehicles parked for more than 2 hours. In this map, the size of the symbol indicates the number of times the vehicles parked at that location during the study period.

There appear to be no common or overlapping stop locations for the four monitored fleets of vehicles. In addition, all locations, with the exception of the Madigan Health Care System at Building 9040, the McChord Medical Clinic, and the Wescott Hills Housing area, appear to be of little interest to POV drivers. This means that these locations should appeal to the fleet vehicles and others on military business, but are not destinations for non-military functions.

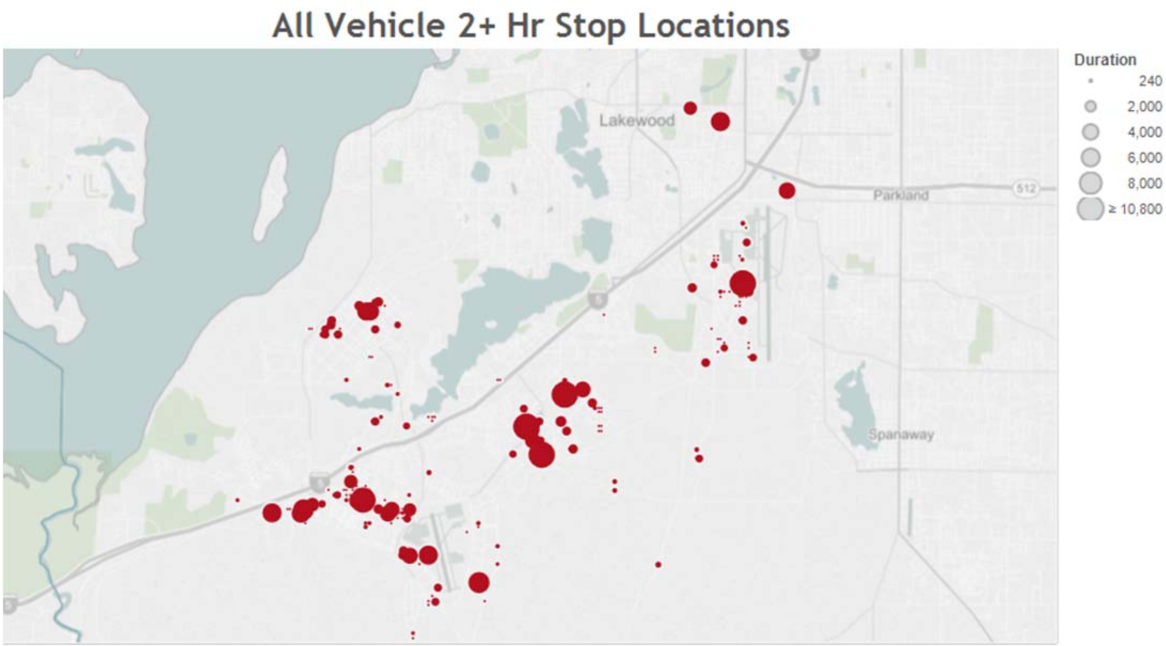


Figure 33. All monitored vehicle stop locations by duration.

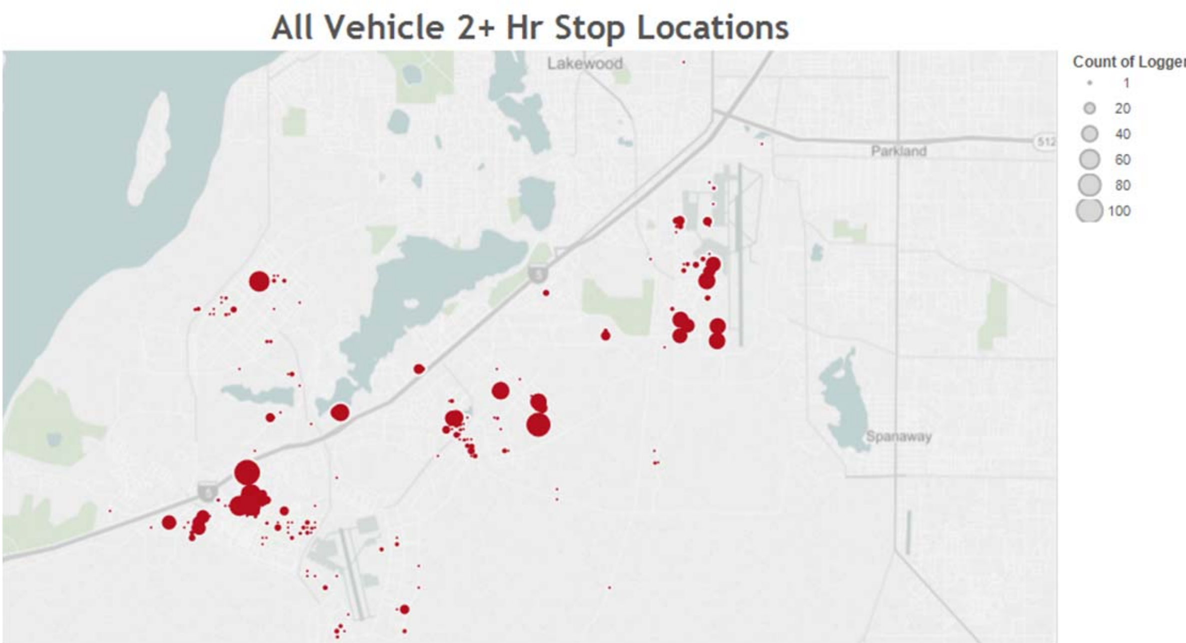


Figure 34. All monitored vehicle stop locations by count.

4.6.2 Public Charging Locations

The EVSE recommended in the previous sections are intended for fleet operations. Should JBLM be interested in providing charging stations to support charging of POVs, specific destination locations should be considered (i.e., identify facilities that attract the drivers of POVs). Some of the points of interest identified on the base map should be attractions. These include the commissaries, theaters, gyms/fitness centers, medical facilities, thrift store, bowling lanes, education center, legal assistance, PX/main shopping mall, chapels, post office, McChord BX, clubs, etc. However, base access would be required to access these locations.

Interstate 5 travels through JBLM, with several exits leading to base gates, with the visitor's center and main gate at Exit 120. Public charging stations outside the perimeter fence at this location, including DCFC, could be of benefit to assigned military, base employees, and contractors, as well as I-5 travelers extending their range while traveling between Olympia and Tacoma.

5. JOINT BASE LEWIS MCCHORD ELECTRIC POWER AND ELECTRIC VEHICLE SUPPLY EQUIPMENT LOCATION DETAILS

5.1 Background

Section 3.3 provides guidance on site selection and installation of EVSE. The availability of electrical power near the desired EVSE location is the most important factor affecting installation costs. Locations nearer the electrical supply will result in shorter conduit and conductor runs to minimize costs. Locations near landscaped areas reduce costs by reducing the amount of asphalt or concrete cuts to install the conduit. At the same time, the location for fleet vehicles should not be in the most ideal of parking locations for the facility if they are to be restricted for PEV charging only, because the EVSE are not likely to be available to POVs and other non-fleet vehicles.

Section 5.2 provides some suggested locations for the majority of the monitored fleet vehicle EVSE. In most cases, parking areas near the buildings will produce the least distance from the power center. However, for some buildings that area will be ideal destinations for POVs and business other than the fleet vehicles; therefore, site selection may not be the closest building approach.

5.2 Joint Base Lewis McChord Electrical Distribution and Electric Vehicle Supply Equipment Locations

JBLM provided the Electrical Map Book 2010-2011 for use with this study. It identifies substations, electrical vaults, boxes, etc. related to the electrical distribution. References to electrical distribution are obtained from this Map Book. Google Earth[w] provides the pictorial maps.

5.2.1 6th MP Group Home Base Power and Electric Vehicle Supply Equipment Locations

Table 6 identifies the home base locations for the 6th MP Group-monitored vehicles on Idaho Avenue near Building 4291. Electrical distribution is shown on Sheet: 11-1. The area is served by transformer SV-13J-91 from transformer T03531. It is suggested that the EVSE be installed in the parking lot directly to the east of Building 4291. See Figure 35 for potential EVSE placement.

5.2.2 Directorate of Community Activities Support Group Home Base Power and Electric Vehicle Supply Equipment Locations

Table 11 identifies the home base locations for the DCA Support Group-monitored vehicles near the Northwest Adventure Center Buildings 8050 and 2057. Electrical distribution for Building 8050 is shown on Sheet:6-6. Transformer T03345 serves this area. It is suggested that the EVSE be installed in the parking lot directly to the west of Building 8050. See Figure 36 for potential locations.

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[w] http://www.google.com/earth/ [accessed August 14, 2014].

Figure 35. EVSE potential location near Building 4291.

Figure 36. EVSE potential location near Building 8050.

Electrical distribution for Building 2057 is shown on Sheet 11-1. Transformer T03263 serves the area. The area appears to be mostly warehousing and has no specific parking lot for vehicles. If possible, an area may be cleared to the east of this building for EVSE placement. See Figure 37 for the potential EVSE location.

Figure 37. EVSE potential location near Building 2057.

5.2.3 Public Works Group Home Base Power and Electric Vehicle Supply Equipment Locations

Table 16 identifies the home base locations for the Public Works Group-monitored vehicles. Seven vehicles are home based near Building 2044. In addition, the two vehicles home based near Buildings 2063 and 2012 are near this area. Electrical distribution for Building 2044 is shown on Sheet: 11-1. Transformer T01759 serves the area through transformer SV-9 H-17. It is suggested that the EVSE be installed in the parking lot directly on the northwest parking area of Building 2044. See Figure 38 for potential locations.

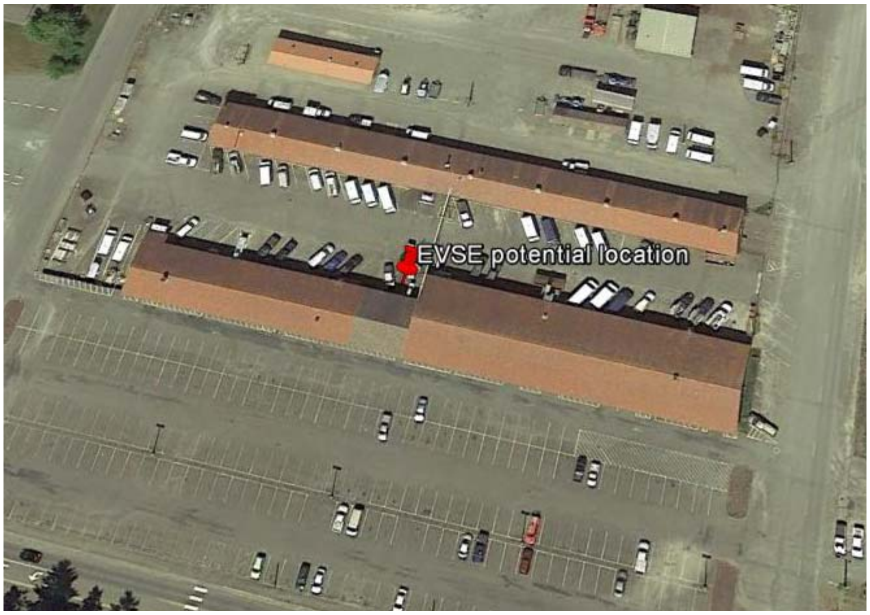

Figure 38. EVSE potential location near Building 2044.

Two vehicles are home based near Building 555 and one near Building 540. Building 555 is shown on Sheet 8-4, but no electrical details are provided. Building 540 could not be located on the available maps, but it is expected to be in the same vicinity as Building 555. It is suggested that the EVSE be installed in the parking lot closest to Building 555. See Figure 39 for potential locations.

Figure 39. EVSE potential location near Building 555.

Two vehicles are home based near Building 300 at McChord field. No electrical details are provided. It is suggested that the EVSE be installed in the parking lot near these buildings. See Figure 40 for potential locations.

Figure 40. EVSE potential locations near Building 300.

5.2.4 Motor Transport Branch Home Base Power and Electric Vehicle Supply Equipment Locations

Table 22 identifies the home base locations for the Motor Transport Branch-monitored vehicles. Eight vehicles are home based near Buildings 9641/9654 and 9640. Electrical distribution for Building 9641 is shown on Sheet: 7-6. Several transformers serve the area: T01187, T01201, T03490, and T01167. It is suggested that the EVSE be installed in the parking lot to the west of Building 9641 to serve the area. See Figure 41 for potential locations. The site to the west is more centrally located between buildings; however, the location west of Building 9641 is closer to the electrical supply.

Figure 41. EVSE potential location near Building 9641.

Five vehicles are home based near Building 9040 Madigan Health Care System. Electrical distribution for Building 9040 is shown on Sheet: 7-5. The parking area near Fitzsimmons would appear to be a good location. Transformer T03127 serves the area. It is suggested that the EVSE be installed in the parking lot west of Building 9060 to serve the area. See Figure 42 for potential locations. This location is likely quite distant from the electrical supply. Other locations to the south of the medical building may be appropriate as well.

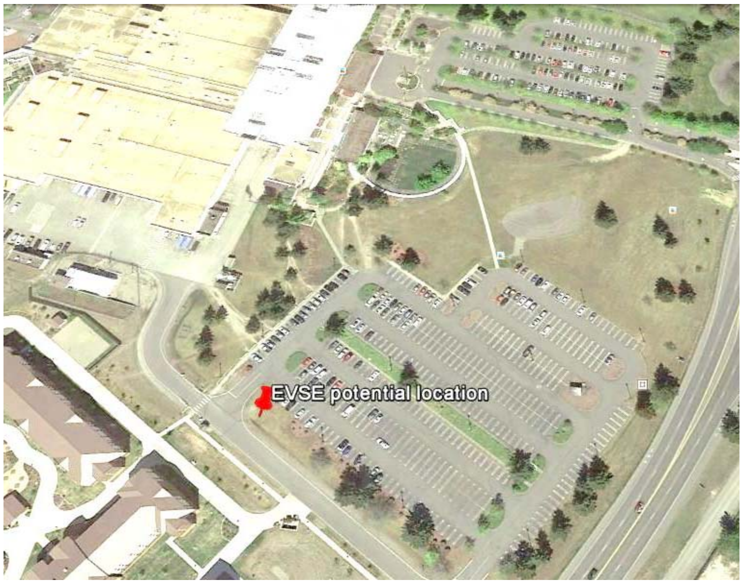

Figure 42. EVSE potential location near Building 9040.

Four vehicles are home based near Building 100 62nd AW Headquarters. Electrical distribution for this area was not provided. The parking area to the north would appear to be a good location near what appears to be building ventilation equipment that likely will provide electrical supply. See Figure 43 for potential locations.

Figure 43. EVSE potential location near Building 100.

Three vehicles are home based near Ramps C, D, and J. Electrical distribution for this area was not provided. The parking area off Levitow Boulevard (shown in Figure 44) may be a good location that serves all three ramps.

Figure 44. EVSE potential location near McChord ramps.

The balance of the Motor Transport Branch vehicles are single units that are home-based in various areas. Location selection similar to that above could be utilized to identify potential EVSE locations.

6. OBSERVATIONS

Intertek appreciates the opportunity to present the results of this evaluation. Observations reported herein provide input to the next phases of this study, specifically the following:

- The Task 3 vehicle utilization report (INL/EXT-14-33337) and this report suggest PEV replacements and the identification of charging infrastructure needs and locations. This information will provide input to the Task 4 effort.
- Suggested PEV replacements can be considered along with vehicle age to prepare a replacement schedule as part of Task 4.
- The vehicle replacement schedule will dictate the charging infrastructure deployment schedule.
- Vehicle and EVSE schedules can factor into budget considerations for implementing vehicle replacements.
- Vehicle and EVSE schedules can factor into base objectives in fuel cost reductions and greenhouse gas emissions reductions.

The analysis shows that the average vehicle travels less than 3,600 miles per year. This is an average of 300 miles per month or 75 miles per week. This was considered here to reduce the number of AC Level 2 EVSE and thus reduce EVSE costs. It may also reflect the opportunity for JBLM to reduce the overall number of vehicles in its fleets.

Intertek suggests that JBLM may wish to move forward in the near future with the replacement of pool, support, and transport vehicles with PEVs as current budget and vehicle replacement schedules allow. Certainly, the vehicle types studied in this report may be candidates for immediate replacement.