INL/EXT-14-33339

AVTA Federal Fleet PEV Readiness Data Logging and Characterization Study for the National Park Service: Sleeping Bear Dunes National Lakeshore

Stephen Schey
Jim Francfort

November 2014

The INL is a U.S. Department of Energy National Laboratory
operated by Battelle Energy Alliance

DISCLAIMER

This information was prepared as an account of work sponsored by an agency of the U.S. Government. Neither the U.S. Government nor any agency thereof, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness, of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. References herein to any specific commercial product, process, or service by trade name, trade mark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the U.S. Government or any agency thereof.

INL/EXT-14-33339

AVTA Federal Fleet PEV Readiness Data Logging and Characterization Study for the National Park Service: Sleeping Bear Dunes National Lakeshore

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

November 2014

Idaho National Laboratory
Idaho Falls, Idaho 83415

http://avt.inl.gov

Prepared for the
U.S. Department of Energy
Office of Nuclear Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

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's Advanced Vehicle Testing. Battelle Energy Alliance, LLC contracted with Intertek Testing Services, North America (Intertek) to collect and evaluate data on federal fleet operations as part of the Advanced Vehicle Testing Activity's Federal Fleet Vehicle Data Logging and Characterization Study. The Advanced Vehicle Testing Activity study seeks to collect and evaluate data to validate the utilization of advanced plug-in electric vehicle (PEV) transportation.

This report focuses on the Sleeping Bear Dunes National Lakeshore (SLBE) fleet to identify daily operational characteristics of select vehicles and report findings on vehicle and mission characterizations to support the successful introduction of PEVs into the agencies' fleets.

Individual observations of these selected vehicles provide the basis for recommendations related to electric vehicle adoption and whether a battery electric vehicle or plug-in hybrid electric vehicle (collectively referred to as PEVs) can fulfill the mission requirements.

Intertek acknowledges the support of Idaho National Laboratory and SLBE for participation in the study.

Intertek is pleased to provide this report and is encouraged by enthusiasm and support from the National Park Service and SLBE personnel.

EXECUTIVE SUMMARY

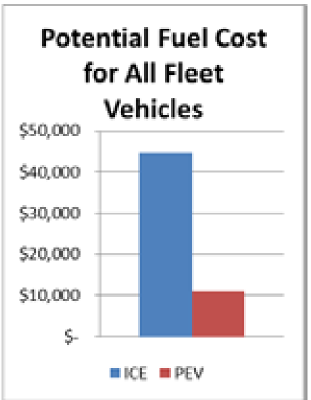
Federal agencies are mandated to purchase alternative fuel vehicles, increase consumption of alternative fuels, and reduce petroleum consumption. Available plug-in electric vehicles (PEVs) provide an attractive option in the selection of alternative fuel vehicles. PEVs, which consist of both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), have significant advantages over internal combustion engine (ICE) 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 intended to evaluate the extent to which Sleeping Bear Dunes National Lakeshore (SLBE) could convert part, or all, of their fleet of vehicles from petroleum-fueled vehicles to PEVs.

It is likely that more fuel efficient ICE vehicles, including hybrid electric vehicles, exist that may provide improvements for the current fleet; however, this study's focus is on replacing ICE vehicles with suitable 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; however, they also have the ability to extend their operating range with an onboard ICE. 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; it should be noted, however, that not all PHEVs have a mode in which the battery provides all of the motive power at all speeds. This study focuses on the mission requirements of fleet of vehicles, with the objective of identifying vehicles that may be replaced with PEVs, with emphasis on BEVs that provide maximum benefit.

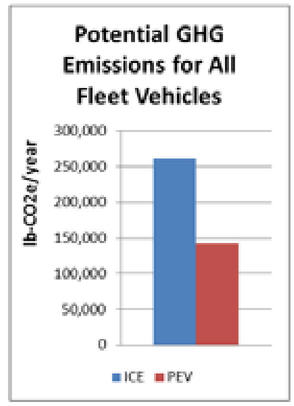
SLBE contains over 71,000 acres of land on the eastern Lake Michigan shore. SLBE has 59 vehicles in its fleet, with fourteen identified as representative of the fleet and instrumented for data collection and analysis. Fleet vehicle mission categories are defined in Section 4, and while the SLBE vehicles conduct many different missions, three (i.e., pool, support, and enforcement missions) were selected by agency management to be part of this fleet evaluation. These three mission categories accounted for 57 of the59 total fleet vehicles. The remaining two vehicles were specialty vehicles.

This report observes that a mix of BEVs and PHEVs are capable of performing most of the required missions and of providing an alternative vehicle for the pool, support, and enforcement vehicles, because while some vehicles travel long distances, the group could support some BEVs for the short trips and PHEVs for the longer trips. The recommended mix of vehicles will provide sufficient range for individual trips and time would be available each day for charging to accommodate multiple trips per day. These charging events could occur at the vehicle home base. Replacement of vehicles in the current fleet would result in significant reductions in the emission of GHGs and in petroleum use, as well as reduced fleet operating costs.



PEVs currently commercially available cannot replace certain vehicles and missions, such as those requiring heavy-duty, load-hauling trucks and passenger vans. However, based on data collected for the monitored vehicles, the 14-vehicle fleet subset could possibly consist of seven BEVs and seven PHEVs. The replacement of these 14 internal combustion vehicles with PEVs could result in an annual GHG savings over 32,500 lbs-CO_2e (i.e., a 46% reduction) and an annual fuel cost savings of over $9,000 (i.e., a 76% reduction).

Based on data collected from the monitored vehicles and extrapolating to the 59 vehicles, a fleet consisting of two specialty vehicles, three conventional heavy-duty trucks, two conventional passenger vans, 28 BEVs, and 24 PHEVs may meet the park's needs. The replacement of the 52 ICE vehicles with PEVs could result in an annual GHG savings over 118,600 lbs-CO_2e (i.e., a 45% reduction) and an annual fuel cost savings of over $33,600 (i.e., a 75% reduction).



PEV charging stations could be located in various locations of the SLBE and could benefit not only SLBE's own fleet vehicles, but those in the visiting public that own PEVs.

Intertek suggests that SLBE may wish to move forward in the near future with the replacement of pool, support, and enforcement 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.

CONTENTS

FIGURES

TABLES

ACRONYMS

AC	Alternating Current
BEA	Battelle Energy Alliance, LLC
BEV	battery electric vehicle
CD	Charge Depleting
CS	Charge Sustaining
DC	Direct Current
DOE	Department of Energy
EPA	U.S. Environmental Protection Agency
EVSE	electric vehicle supply equipment
GHG	greenhouse gas emissions
GPS	global positioning system
GSA	General Services Administration
ICE	internal combustion engine
INL	Idaho National Laboratory
Intertek	Intertek Testing Services, North America
LSV	Low-Speed Vehicle
OEM	original equipment manufacturers
PEV	plug-in electric vehicle (includes BEVs and PHEVs, but not hybrid electric vehicles)
PHEV	plug-in hybrid electric vehicle
SAE	Society of Automotive Engineers
SLBE	Sleeping Bear Dunes National Lakeshore
VIN	vehicle identification number

AVTA Federal Fleet PEV Readiness Data Logging and Characterization Study for the National Park Service: Sleeping Bear Dunes National Lakeshore

1. INTRODUCTION

Federal agencies are mandated by the Energy Policy Act of 1992[1], Energy Policy Act of 2005[2], Executive Order 13423 (President Bush 2007)[3], and the Energy Independence and Security Act of 2007[4] to purchase alternative fuel vehicles, increase consumption of alternative fuels, and reduce petroleum consumption.

Battelle Energy Alliance, LLC, managing and operating contractor for Idaho National Laboratory, is the lead laboratory for the U.S. Department of Energy's advanced vehicle testing and manages the Advanced Vehicle Testing Activity Federal Fleet Vehicle Data Logging and Characterization Study, which promotes utilization of advanced electric-drive vehicle transportation technologies. The Advanced Vehicle Testing Activity focuses its testing activities on emerging and newly commercialized plug-in electric vehicle (PEV) technologies because of the high-energy efficiencies and reduced consumption of petroleum through use of electric-drive vehicles. BEA selected Intertek Testing Services, North America (Intertek) to collect data on federal fleet operations and report the findings on vehicle and mission characterizations to support the successful introduction of PEVs into federal fleets.

It is likely that more fuel-efficient internal combustion engine (ICE) vehicles, including hybrid electric vehicles, exist that may provide improvements for the current fleet; however, this study's focus is on replacing ICE vehicles with suitable PEVs.

Because of the large number of vehicles in federal fleets in the United States, these fleets provide a substantial opportunity for the introduction of battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) (collectively referred to as PEVs). However, to assess the scale of this opportunity, additional data are required to characterize the various missions performed by each fleet and to determine which existing vehicles are most suitable for replacement by a PEV.

The Sleeping Bear Dunes National Lakeshore (SLBE), located on the eastern shore of Lake Michigan, contains over 71,000 acres of land (Figures 1 and 2). There are 46 permanent employees and 84 seasonal employees. Known for its outstanding natural features, including forests, beaches, dune formations, ancient glacial phenomena, and varied recreational uses, the park receives approximately 1.1 million site visitors a year.[5]

The climate is typical of the western side of the lower peninsula of Michigan. The park is open year around, although the Pierce Stocking Scenic Drive is closed November through April. SLBE is an excellent site for fleet evaluation, not only due to its size, diversity of weather, and vehicle types, but because of its accessibility by the public. SLBE has an opportunity to be a leader in the adoption of BEVs and PHEVs for its fleet.

---

[1] http://thomas.loc.gov/cgi-bin/query/z?c102:h.r.776.enr [accessed January 10, 2014].

[2] http://www.gpo.gov/fdsys/pkg/BILLS-109hr6enr/pdf/BILLS-109hr6enr.pdf [accessed January 10, 2014].

[3] http://www.gsa.gov/portal/content/102452 [accessed January 10, 2014].

[4] http://www.gpo.gov/fdsys/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf [accessed January 10, 2014].

[5] http://www.nps.gov/slbe/parkmgmt/statistics.htm [Accessed August 15, 2014].

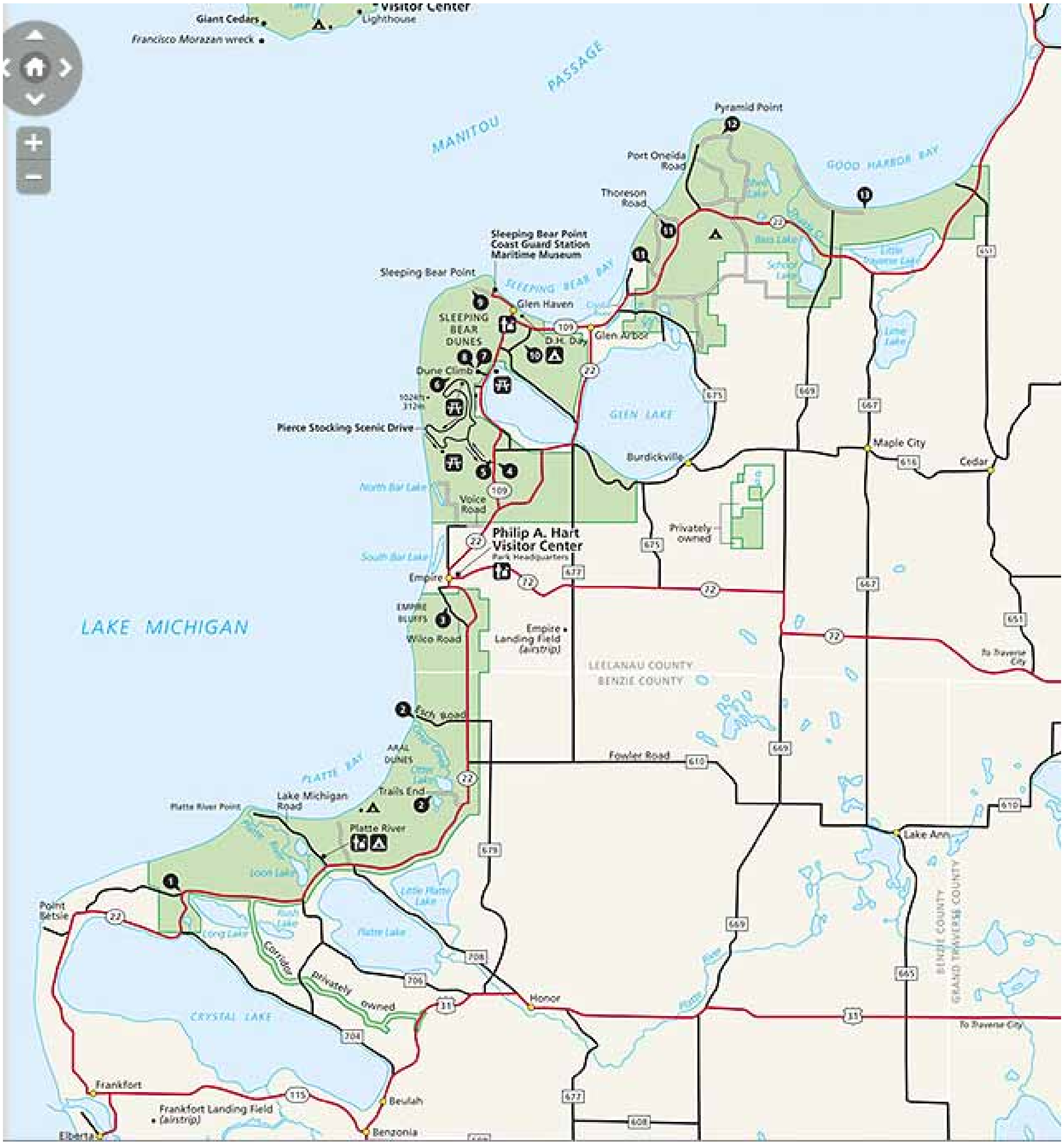


Figure 1. SLBE graphical representation.[6]

[6] http://www.nps.gov/slbe/photosmultimedia/photogallery.htm?maxrows=21&startrow=1 [accessed August 15, 2014].

Figure 2. Sleeping Bear Point Trail.[7]

2. PROJECT OBJECTIVE

This study explores federal fleet vehicles and their usage characteristics, with a primary goal of supporting the goals of Presidential Executive Order 13514, which includes the following:

- Pursuing opportunities with vendors and contractors to address and incentivize greenhouse gas (GHG) emission reductions and petroleum use reductions
- Implementing strategies and accommodations for transit, travel, training, and conferences that actively reduce carbon emissions associated with commuting and travel by agency staff
- Meeting GHG emissions reductions associated with other federal government sustainability goals
- Implementing innovative policies and practices that address agency-specific Scope 3 GHG emissions.[8]

Because of the large number of vehicles in the federal fleets, there is a substantial opportunity for PHEV and BEV adoption. Federal fleets offer an opportunity as a first market replacement for alternative fuels due to their scale, refueling patterns, and regular vehicle turnover.[9]

This project has the following four defined tasks:

1. **Data collection:** Coordinate with the fleet manager to collect data on agency fleet vehicles. This includes collecting information on the fleet vehicle and installing data loggers on a representative sample of the fleet vehicles to characterize their missions.

---

[7] http://www.nps.gov/media/photo/gallery.htm?id=FFBDB724-155D-4519-3EB1B4231827921A [accessed August 15, 2014].

[8] http://energy.gov/sites/prod/files/2013/10/f3/eo13514.pdf [accessed February 5, 2014].

[9] *Fleet Purchase Behavior: Decision Processes and Implications for New Vehicle Technologies and Fuel*, Nesbitt, Sperling, University of California, Davis 2001.

2. **Data analysis and review:** Examine the data collected by the loggers and fleet vehicle characteristics to describe typical fleet activity. Incorporate fleet manager's input on introducing PEVs to the agency's fleet.
3. **PEV implementation feedback:** Provide feedback to fleet personnel and Battelle Energy Alliance, LLC on the selection criteria for replacement PEVs in their specific fleet vehicle missions.
4. **Observations and recommendations:** Provide actionable information to introduce PEVs into agency fleet operations and assess any related impacts for the facility.

Data collected from vehicles include trip distance, idle time, time between uses, and stop locations. Data collection continues for 30 to 60 days using a non-intrusive data logger, which gathers and transmits information using global positioning satellites and cellular service. The loggers collect data at 1-minute intervals and transmit when an active signal is present.

Extrapolating the results of this analysis to the larger fleet provides estimates of potential savings in gasoline consumption and GHG emissions. This report also provides recommendations relating to fleet management of BEVs and PHEVs for additional consideration.

Fleet managers may use the information supplied in this report to help them to identify which vehicles are candidates for replacement by BEVs or PHEVs, based on their use. BEVs are preferred because of the greater potential reduction of GHG emissions, fuel cost, and petroleum usage; however, they are not likely to be suitable for all vehicle missions.

The information in this report supports a final report to Battelle Energy Alliance, LLC/Idaho National Laboratory and the U.S. Department of Energy. The aggregated results for all agencies' fleets will provide an overview of federal fleets, vehicle missions, vehicle uses, and agencies needs to plan and establish a more systematic method for the adoption of BEVs and PHEVs.

3. METHODS

3.1 Fleet Vehicle Survey

Agency fleet managers selected fleet vehicles for this study and provided basic information for each vehicle, including its managing agency, home base for the vehicle, contact information, primary vehicle mission, vehicle ownership, fuel type, and odometer reading.

SLBE identified 59 fleet vehicles in their fleet. Vehicle missions were assumed based on park input (see Table 0). (Note that Section 4 provides descriptions of the vehicle mission types.) Intertek coordinated with the SLBE fleet manager to identify the specific vehicles for data collection for inclusion in the study. The fleet manager assessed their wide range of vehicles and made selections of high-interest, representative vehicles based on vehicle missions and vehicle type/class. Selection also favored vehicles used at least twice a week. Because data loggers rely on the vehicle's battery power, non-use of the vehicle can result in the vehicle having a depleted battery. Intertek received no reports of depleted batteries during the study at SLBE. Fourteen vehicles were selected, with eight pool vehicles, four support vehicles, and two enforcement vehicles.

Table 1. Fleet evaluation.

Vehicle Mission	Study Vehicles	Total Fleet Reported	Percentage Studied
Pool Vehicles	8	31	25.8%
Support Vehicles	4	24	16.7%
Enforcement Vehicles	2	2	100%
Specialty Vehicles		2	0%
Total Fleet Vehicles	14	59	23.7%

3.2 Data Collection

Individual privacy concerns exist when monitoring vehicle movement with data loggers. Data collection occurs by vehicle identification as identified by Intertek, data logger number, and vehicle identification number (VIN) or agency-assigned vehicle number. Intertek receives no information related to the vehicle operator and provides no raw data to the fleet managers. In this manner, Intertek does not collect, analyze, or report on individual driving habits.

3.2.1 Data Logger

Non-intrusive data loggers, produced by InTouchMVC[10] and depicted in Figure 3, were inserted into the vehicle's onboard diagnostic port to collect and transmit the relevant data. Installation of the data logger and manual recording of information about the vehicle that ties the logger and vehicle together in the data, typically takes less than 5 minutes. Once installed and activated (during vehicle use), the data loggers collect vehicle information once every minute during vehicle operation and transmit by cellular communication to the data center.

Figure 3. InTouchMVC data logger.

Intertek maintains the data logger's connectivity and verifies data transmission weekly. Missing data (i.e., reported as "null" values) are frequently the result of lost global positioning system reception, logger device removal, or extended periods in regions with insufficient cellular reception. Intertek filters the vehicle and data logger information if these null values present a significant impact on the data collected and no resolution is possible. This report also identifies the statistics on this validation process.

SLBE requested and installed eleven data loggers into the selected fleet vehicles. The agency removed and shipped the data loggers to Intertek at the conclusion of the data collection period.

3.2.2 Data Captured

Data consist of key-on events, key-off events, and position updates logged every minute while the vehicle is keyed-on. InTouchMVC converted these data points into records of trip events, stop events, and idle events.

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

[10] www.intouchmvc.com [accessed January 10, 2014]

- Stop start time, location, and duration

3.3 Data Analysis

3.3.1 Definitions

Figure 4 illustrates a vehicle outing, which is comprised of trips, stops, and idle events, that may occur during one day or over several days. The following list provides a definition of these terms:

1. **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.
2. **Trip**: A trip begins with a key-on event and ends with the next key-off event.
3. **Vehicle stop**: A vehicle stop includes a key-off/key-on event pair.
4. **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.
5. **Trip travel time**: Trip travel time is the amount of time required to complete a trip, excluding stops, but including idle time.

Definitions of additional analysis and survey terms are as follows:

1. **Operating shift**: Fleet manager-defined period worked.
2. **Study days**: Days during which the data loggers are connected.
3. **Vehicle days**: Study days during which a vehicle is used.
4. **Null values**: Data record unusable for analysis for various reasons.

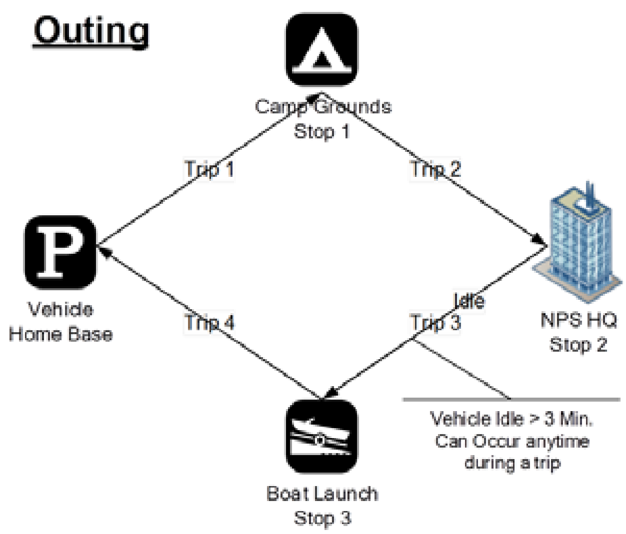


Figure 4. Vehicle outing.

3.3.2 Data Evaluation

Processing the data involves removal of null values and aggregation by different spatial and temporal scales. Aggregation was by day, by trip, and by outing to produce figures showing the patterns of use. Aggregation by vehicle mission followed to characterize use for the agency fleet. Section 5 presents these results. Data were extrapolated to provide the overall fleet usage and benefit analysis when fleet information was provided. Section 6 presents these benefits. Intertek observations are included in Section 7.

Statistical data analysis uses Python 2.7 with the MATLAB Plotting Library graphics environment (Matplotlib) and spatial display with ESRI ArcGIS.[11] Frequency distributions summarize travel behavior of each vehicle and vehicle mission during the study period. Rounding of the tables and figures are to three significant digits.

4. VEHICLES

4.1 Vehicle Missions

The vehicle mission is an important characteristic in the fleet study. Information used to define the vehicle mission includes the vehicle's configuration, vehicle use, classification per 40 CFR Part 600.315-82 and Environmental Protection Agency (EPA), the participating agency use, and generally assumed vehicle use. Based on fleet information gathered, Intertek has established the following seven mission/vehicle categories for analysis. They are as follows and examples are depicted in Figure 5:

1. **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.
2. **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 C provides further definition.
3. **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.
4. **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.
5. **Specialty vehicles**: Vehicles designed to accommodate a specific purpose or mission (such as ambulances, mobile cranes, and handicap controls).
6. **Shuttles/buses**: Vehicles designed to carry more than 12 passengers and further outlined in 49 CFR 532.2.
7. **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.

4.2 Alternative Fuel Vehicles

As the operating agency, SLBE has a unique opportunity to plan for the adoption of BEVs and PHEVs, along with planning for the supporting infrastructure. The adoption of PHEVs and BEVs is a primary goal of the General Services Administration (GSA) and supports the directives previously referenced.

As GSA increases its certification of PHEVs and BEVs, agencies can plan for vehicle replacement through GSA for passenger vehicles and trucks. Table 2 presents the replacement requirements for fleet vehicles. Note that both the age and mileage requirements need to be met in order for the vehicle to qualify for replacement, except where noted as "or."

[11] www.esri.com [accessed January 10, 2014].

Figure 5. Vehicle missions.

Table 2. GSA vehicle replacement requirements.

GSA Vehicle Replacement Requirements[12]			
	Fuel Type	Years	Miles
Passenger vehicles	Gasoline or Alternative Fuel Vehicle	3 4 5 Any age	36,000 24,000 75,000 Any mileage
	Hybrid	5	Any miles
	Low Speed BEV	6	Any miles
Light trucks 4 x 2	Non-diesel	7	65,000
	Diesel	8 or	150,000
	Hybrid	7	Any mileage
Light trucks 4 x 4	Non-diesel	7 or	60,000
	Diesel	8 or	150,000
	Hybrid	7	Any mileage

4.3 Battery Electric Vehicle and Plug-In Hybrid Electric Vehicle Benefits/Challenges

BEVs are fully powered by the battery energy storage system available onboard the vehicle. The Nissan Leaf is an example of a BEV. Because the BEV has no other energy source for propulsion, the range, power requirements, and mission of the needed vehicle factor greatly in purchasing decisions. Maximizing BEV capabilities typically requires batteries more than an order of magnitude larger in capacity than the batteries in hybrid electric vehicles.

[12] http://www.gsa.gov/graphics/fas/VehicleReplacementStandardsJune2011Redux.pdf [accessed January 10, 2014].

PHEVs obtain their power from at least two energy sources. The typical PHEV configuration uses a battery and an ICE that is powered by either gasoline or diesel. PHEV designs differ between manufacturers. All have a charge-depleting (CD) mode, in which the battery is depleted of its stored energy to propel the vehicle, and a charge-sustaining (CS) mode (or extended range mode) that is entered after CD mode is complete, in which the battery and the ICE work together to provide propulsion, while the state of charge of the battery is maintained between set limits. Some PHEVs' operation in CD modes is purely electric, while others employ the engine to supplement the battery power during the initial battery depletion to a set state of charge (usually below 50%).

4.3.1 Battery Electric Vehicle Benefits/Challenges

EPA identifies the following benefits of BEVs[13]:

- **Energy efficient:** Electric vehicles convert about 59 to 62% of the electrical energy from the grid to power at the wheels, whereas conventional gasoline vehicles only convert about 17 to 21% of the energy stored in gasoline to power at the wheels.
- **Environmentally friendly:** PEVs emit no tailpipe pollutants, although the power plant producing the electricity may emit them. Electricity from nuclear, hydro, solar, or wind-powered plants causes no air pollutants.
- **Performance benefits:** Electric motors provide quiet, smooth operation and exhibit maximum torque at zero and low speeds, while also requiring less maintenance than ICEs.
- **Reduce energy dependence:** Electricity is a domestic energy source.

The EPA also identifies challenges associated with BEVs, including the following:

- **Driving range:** Most BEVs can only travel about 100 to 200 miles (or less) before recharging, whereas gasoline vehicles can often travel over 300 miles before refueling and some much further.
- **Recharge time:** Fully recharging the battery pack can take 4 to 8 hours. With a high-power direct current (DC) fast charger (DCFC), restoration from a depleted state to 80% capacity can take approximately 30 minutes.
- **Battery cost:** The large battery packs are expensive and may need to be replaced one or more times.
- **Bulk and weight**: Battery packs are heavy and take up considerable vehicle space.

4.3.2 Plug-in Hybrid Electric Vehicle Benefits/Challenges

EPA identifies the following benefits of PHEVs[14]:

- **Less petroleum use:** PHEVs are expected to use about 40 to 60% less petroleum than conventional vehicles. Because electricity is produced primarily from domestic resources, PHEVs reduce dependence on oil.
- **Fewer emissions:** PHEVs are expected to emit fewer GHG emissions than conventional vehicles, but as with BEVs, the difference depends largely on the type of power plant supplying the electricity.
- **Higher vehicle costs, lower fuel costs:** PHEVs will likely cost $1,000 to $7,000 more than comparable non-PHEVs. Fuel will cost less because electricity is much cheaper than gasoline, but the fuel savings depends on how much of the driving is done on the off-board electrical energy.

---

[13] http://www.fueleconomy.gov/feg/evtech.shtml [accessed December 27, 2013].

[14] http://www.fueleconomy.gov/feg/phevtech.shtml [accessed July 19, 2013].

- **Recharging takes time:** Recharging the battery typically takes several hours. However, PHEVs do not have to be plugged in to be driven. They can be fueled solely with gasoline, but will not achieve maximum range, fuel economy, or fuel savings without charging.
- **Measuring fuel economy:** Because a PHEV can operate on electricity alone, gasoline alone, or a mixture of the two, EPA provides a fuel economy estimate for gasoline-only operation (i.e., CS mode), electric-only operation (i.e., all-electric CD mode), or combined gasoline and electric operation (i.e., blended CD mode).

In most cases, the PEV retail cost is higher than a non-PEV model. This incremental purchase cost may be a fleet budget challenge; however, many original equipment manufacturers (OEMs) have offered incentives to encourage the use and adoption of BEVs and PHEVs. Some OEMs have recently reduced vehicle cost, while also increasing vehicle range. Additionally, federal and state incentives have increased the attractiveness of purchasing a PEV. A common assumption is that increasing PEV sales will result in a reduction in this incremental purchase cost and a positive feedback loop will ensue.

4.4 Plug-In Electric Vehicle Availability

GSA provides a summary of light and medium-duty passenger vehicles available for lease or purchase through the GSA portal[15], although not all BEVs and PHEVs currently on the market are ‘certified’ to be GSA replacements. Vehicles not on the GSA list of ‘certified’ vehicles require an agency to self-certify a functional need or provide alternative measures for exemptions. Table 3 summarizes the vehicles that may be suitable replacements and are certified replacements through GSA. Note that the “CD/CS” column provides the EPA fuel economy values for CD and CS modes. The fuel economy of CD mode is provided in units of miles-per-gallon-of-gasoline-equivalent (MPGe). This metric allows for the electricity consumption during CD mode to be compared with fuel consumption during CS mode (or against conventional vehicles). The Nissan Leaf and Mitsubishi i-MiEV are not included in the alternative fuel guide for 2014, but they have appeared in previous guides.

Replacement is dependent on vehicle configuration characteristics and the vehicle mission. Further evaluation related to vehicle purpose and mission follows in Section 5.

Tables 4 through 7 provide summaries of PHEVs and BEVs either currently available or near commercialization in both passenger cars and pickup trucks, but do not appear on the GSA ‘certified’ vehicle list. These vehicles may qualify for use by the agency through demonstrating a functional need.

Table 3. GSA certified PEVs.

Make/Model	GSA Class	Type	CD/CS	GSA Incremental Price
Chevrolet Volt	Sedan, Subcompact	PHEV	98 MPGe/37 mpg	$17,087.18
Ford C-MAX Energi	Sedan, Subcompact	PHEV	100 MPGe/38 mpg	$14,899.52
Ford Focus Electric	Sedan, Subcompact	BEV	110 MPGe/99 mpg	$16,573.09
Ford Fusion Energi	Sedan, Compact	PHEV	100 MPGe/38 mpg	$19,289.99

Note that EPA differs in vehicle class. EPA identifies the Volt as a compact, the C_MAX Energi as a midsize, the Fusion Energi as a midsize, and the Focus as a compact.[16]

[15] http://www.gsa.gov/portal/content/104224 [accessed March 6, 2014].

[16] http://www.fueleconomy.gov/feg/Find.do?action=sbs&id=34130 [accessed August 1, 2014].

Table 4. OEM PHEV cars and availability.

Make	Model	Model Year
Audi	A3 eTron PHEV	2015 (estimate)
Chevrolet	Volt	2011
Honda	Accord PHEV	2014
Toyota	Prius PHEV	2012
Volvo	V60 Plug-in	2016 (estimate)
BMW	i3 with range extender	2014

Table 5. OEM BEV cars and availability.

Make	Model	Model Year
BMW	i3	2014
Chevrolet	Spark EV	2014
Fiat	500e	2013(California only)
Ford	Focus Electric	2012
Honda	Fit EV	2013
Kia	Soul EV	2014 (estimate)
Mercedes-Benz	B-Class ED	2015 (estimate)
Nissan	Leaf	2011
smart	ED	2014
Tesla	Model S	2012
Tesla	Model X	2015 (estimate)
Volkswagen	Golf	2015 (estimate)
Volvo	C30 Electric	2016 (estimate)

Table 6. OEM PHEV trucks, vans, and availability.

Make	Model	Model Year
Land Rover	Range Rover Sport	2016 (estimate)
Mitsubishi	Outlander PHEV	2015 (estimate)
Via	VTRUX VR300	2013

Table 7. OEM BEV trucks, vans, and availability.

Make	Model	Model Year
Nissan	eNV200	2015 (estimate)
Toyota	RAV4 EV	2013 (California only – elsewhere 2015 estimate)

As further indication of the expanding market for PEVs, companies are offering after-market vehicle upgrades involving the addition of plug-in capabilities to OEM vehicles. For example, Echo Automotive, headquartered in Scottsdale, Arizona, is a newly formed company that, in 2012, began to offer a "…low-cost, bolt-on, plug-in hybrid system that can quickly be installed on new or existing fleet vehicles to increase fuel efficiency and decrease operating costs – all without affecting the OEM power train or requiring costly infrastructure." Options such as this company's conversions might be of benefit to the passenger vans identified in the SLBE fleet, but for which no replacement PEV is currently available.

4.5 Plug-In Electric Vehicle Charging

Refueling 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.

4.5.1 Electric Vehicle Supply Equipment Design

4.5.1.1 Charging Components. Electric vehicle supply equipment (EVSE) stations deliver electric power from the utility to the applicable charge port on the vehicle. Figure 6 illustrates the primary components of a typical EVSE alternating current (AC) Level 2 unit.

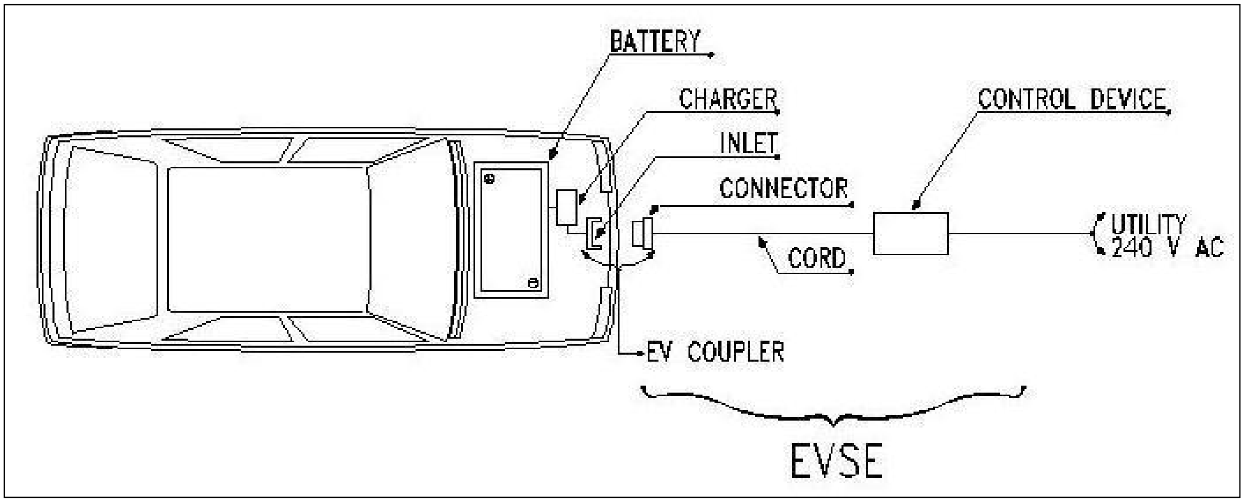
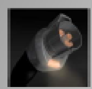
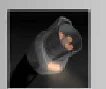


Figure 6. AC Level 2 charging diagram.[17]

The electric utility delivers AC current to the charging location. The conversion from AC to the DC electricity necessary for battery charging can occur either on or off board the vehicle. Section 4.5.1.2 provides further explanation of the different EVSE configurations. For onboard conversion, AC current flows through the PEV inlet to the onboard charger. The charger converts AC to the 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. Off board 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 no PHEVs currently) accommodate DC charging.

4.5.1.2 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 7 summarizes these attributes and the estimated recharge times. Actual recharge times depend on the onboard equipment, including the charger, battery, and battery management system.

[17] 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].

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 7. Society of Automotive Engineers charging configurations and ratings terminology.[18]

Most PEV manufacturers supply an AC Level 1 cord-set with the vehicle, which provides sufficient capabilities for some drivers, but often provides an emergency backup capability because of the long recharge times. AC recharging capabilities found in the public arena more typically are AC Level 2. Figure 8 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 9 shows this connector, which is colloquially known as the J1772 "combo connector."

Some BEVs introduced in the United States prior to the approval of the J1772 standard for DC charging employ the CHAdeMO (designed in Japan) standard for connector and inlet design. Figure 10 shows this connector. EVSE units that are either J1772-compliant or CHAdeMO-compliant are both known as DCFCs.

The presence of the two separate standards for DC charging 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 have provided DC inlets where PHEV suppliers have not, 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 be offering DC charging capability as an option).

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

It is noted that DC Level 1 and DC Level 2 charging are commonly combined and labeled "DC fast charging."

Figure 8. J1772 connector and inlet.[19]

Figure 9. J1772-compliant combo connector.[20]

Figure 10. CHAdeMO-compliant connector.[21]

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

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

Because the battery of a BEV is typically much larger than that of a PHEV, recharge times are longer (see Figure 7). 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. PHEVs, on the other hand, 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.

4.5.2 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 recharge times that are faster than AC Level 1 charging. 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 10 provides an example of a public AC Level 2 EVSE unit.[22]

Figure 11. Public AC Level 2 EVSE.

DCFCs also are available from several manufacturers. Figure 12 illustrates one such charger.[23] This particular charger uses the CHAdeMO connector standard.

In general, installation costs are higher for DCFC because of the higher voltage requirements and the inclusion of the AC to DC converter and other safety and design features. 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.

---

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

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

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

Figure 12. Public DCFC unit.

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

5. SLEEPING BEAR DUNES NATIONAL LAKESHORE ANALYSIS

5.1 Sleeping Bear Dunes National Lakeshore Fleet

SLBE reports 59 Interior and GSA vehicle in their complete fleet. Table 8 shows the breakdown of EPA vehicle class by Park division.

Table 8. SLBE fleet vehicles.

Division	Sedan Midsize	Sedan Large	SUV	Mini-van	Cargo Van	Pass Van	Pickup or LD Truck	Heavy Duty Truck	Specialty	Total
Super. Office	1									1
Admin			2				1			3
Maintenance	1		1	1	2	1	24	3	1	34
Protection Res/Vis							2		1	3
Interpretation	5		2				2			9
Natural Res Mgmt	1		1	1		1	5			9
Total	8	0	6	2	2	2	34	3	2	59

Based on SLBE input on fleet vehicles, an assessment of mission by vehicle type was completed. Table 9 shows the results of that assessment.

Table 9. SLBE fleet mission assessment.

Mission	Sedan Compact	Sedan Midsize	Sedan Large	SUV	Mini -van	Cargo Van	Pass Van	Pickup or LD Truck	Heavy Duty Truck	Specialty	Total
Pool		6		5	2		2	16			31
Support		2		1		2		16	3		24
Law Enforce.								2			2
Specialty										2	2
Total		8		6	2	2	2	34	3	2	59

5.2 Survey Results

Fourteen vehicles were included in the study at SLBE. Eight vehicles have pool missions, four have support missions, and two are law enforcement. Table 10 presents a summary of these vehicles and Table 11 provides details about the monitored vehicles.

Table 10. Vehicle study summary.

Mission	Sedan - Compact	Sedan - Large	Minivan	SUV	Van-Cargo	Pickup Truck	Truck HD	Total
Pool		1				7		8
Support					1	3		4
Law Enforcement				2				2
Total		1		2	1	10		14

Table 11. Detailed SLBE vehicle index.

Vehicle Index						
Log	Fleet Vehicle Id	Make	Model	Year	EPA Class	Mission
21	G63-2883K	Ford	F150	2011	Pickup	Pool
22	I514830	Chevrolet	K2500	2012	Pickup	Support
23	I513632	Chevrolet	Colorado	2010	Pickup	Pool
24	I410692	Ford	F150	2007	Pickup	Pool
25	G620442M	Chevrolet	Tahoe	2012	SUV	Law Enforcement
26	I513822	Chevrolet	Silverado	2011	Pickup	Pool
27	I410688	Chevrolet	K2500	2007	Pickup	Pool
28	I515072	Chevrolet	Express Van	2013	Van - Cargo	Support
29	I410680	Dodge	Dakota	2007	Pickup	Support
30	G62-4494K	Chevrolet	Tahoe	2010	SUV	Law Enforcement
31	I510187	Chevrolet	Colorado	2006	Pickup	Support
32	I512719	Chevrolet	Impala	2010	Sedan - Large	Pool
33	I410690	Ford	F150	2007	Pickup	Pool
34	I410691	Ford	F150	2007	Pickup	Pool

Specific vehicle references may be made to the vehicle ID or logger ID in this report. Appendix B provides the analysis of each individual vehicle included in this study. Grouping the vehicles by mission created an aggregated view of mission requirements to provide observations related to PEV replacement.

The missions of these three categories vary considerably; therefore, these missions were evaluated separately.

5.3 Data Validity

SLBE data collection took place from May 31 through August 31, 2013. Vehicle data sheets (presented in Appendix B) detail the collected data for each vehicle, including specific dates the logger provided data.

Of the data collected, validation occurred for 99.8%, while null values exist for the balance. Table 12 shows this information by mission type.

Table 12. Vehicle data logger reporting summary.

Vehicle Data Logger Reporting Summary			
Mission	% Collected	% Null Values	Total
Pool	99.9	0.1	100%
Support Vehicles	99.2	0.8	100%
Law Enforcement	99.7	0.3	100%
All Vehicles	99.8	0.2	100%

5.4 Pool Vehicles Evaluation

5.4.1 Survey and Site Information

Pool vehicles are typically light-duty motor vehicles for use in passenger transportation, with not more than 10 passengers. Pool missions can vary by agency, location, and jurisdiction; however, they typically utilize sedans, minivans, SUVs, vans, or small pickup trucks and typically do not carry specific cargo or equipment. Table 9 identifies the eight vehicles (i.e., seven pickup trucks and a large sedan).

Incorporation of BEVs and/or PHEVs into the pool mission is a definite possibility. Pool vehicles used for shorter trips or outings qualify for BEV or PHEV replacement, while other pool vehicle activities that are associated with longer trips may require PHEV capabilities.

5.4.2 Summary for Pool Vehicles

Appendix B provides the vehicle data sheets for each of the pool vehicles monitored. This section aggregates data for all pool vehicles. Table 13summarizes pool travel during the study period for those days in which the vehicle was driven. Vehicle use occurred primarily between 0700 and 1600 hours daily. The vehicles were driven 18,347 miles, logged 779 hours, and idled for 92 hours during the 92-day study period.

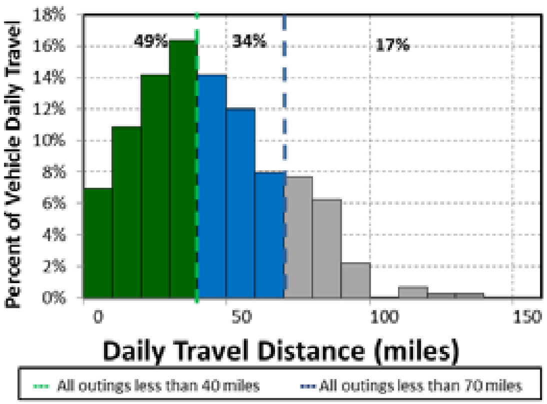
Table 13. Pool vehicles travel summary.

Pool Vehicles Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	44.2/138.1	14.1/109.9	3.2/32.9	18,347
Travel Time (Minutes)	112.6/333.0	35.9/313.0	8.0/111.0	46,738
Idle Time (Minutes)	13.3/NA	4.2/NA	0.9/NA	5,521

5.4.3 Pool Vehicles Daily Summary

Figure 13 identifies daily travel distance and time for all the pool vehicles. The green line and bars indicate typical electric range on a single charge for a PHEV, while the blue line and bars (including the green bars) indicate the same for a BEV. Figures 14 and 15 show the composite history in distance and time traveled for the pool vehicles. In the stacked bar charts of Figures 14 and 15, the contribution of each vehicle is indicated by a different color. Note that pool Vehicle I410691 (Logger 34) failed to provide data for unknown reasons.

When driven, the average travel distance per day for pool vehicles is 44.2 miles. On 83% of these vehicle days, the daily travel was less than the 70 miles considered to be within the BEV safe range. That is, while BEV range can vary based on several factors, most BEVs provide at least 70 miles of vehicle range on a single battery charge. Seventeen percent of pool daily travel was greater than 70 miles and 49% of vehicle travel days were less than the 40 miles considered to be within the CD range of a PHEV.



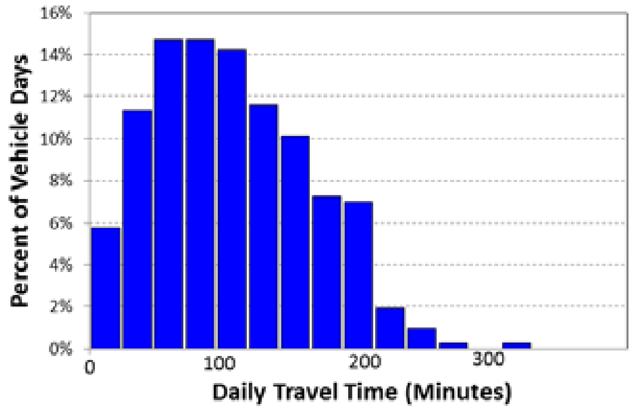


Figure 13. Pool vehicle daily travel miles and time (all vehicles).

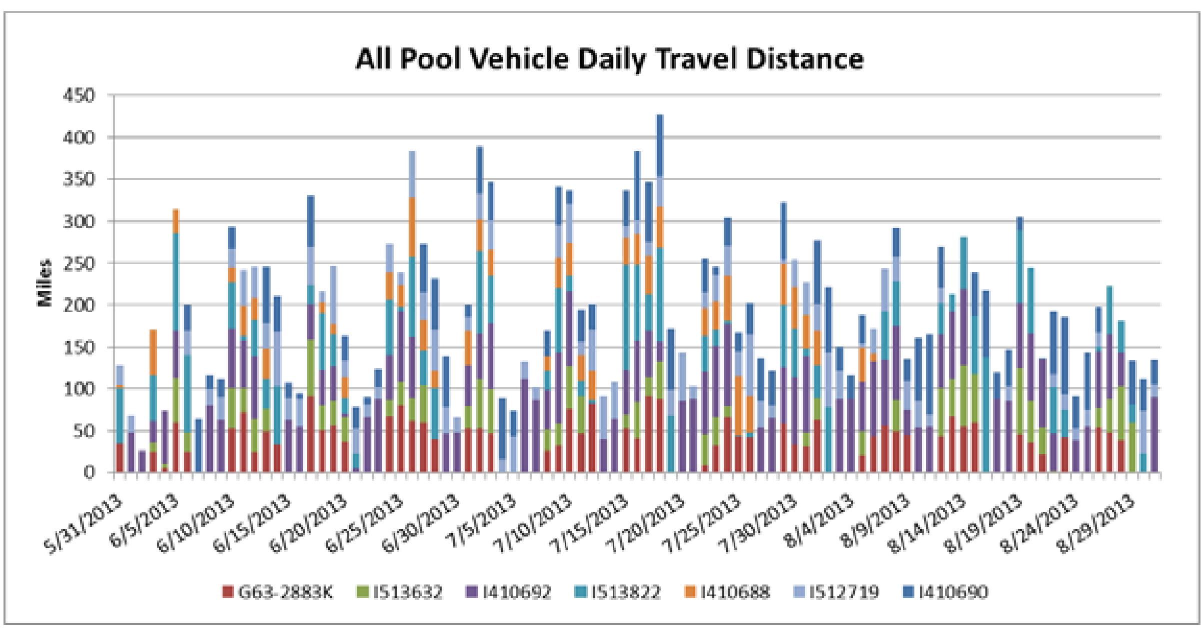


Figure 14. Pool vehicle daily travel history (all vehicles).

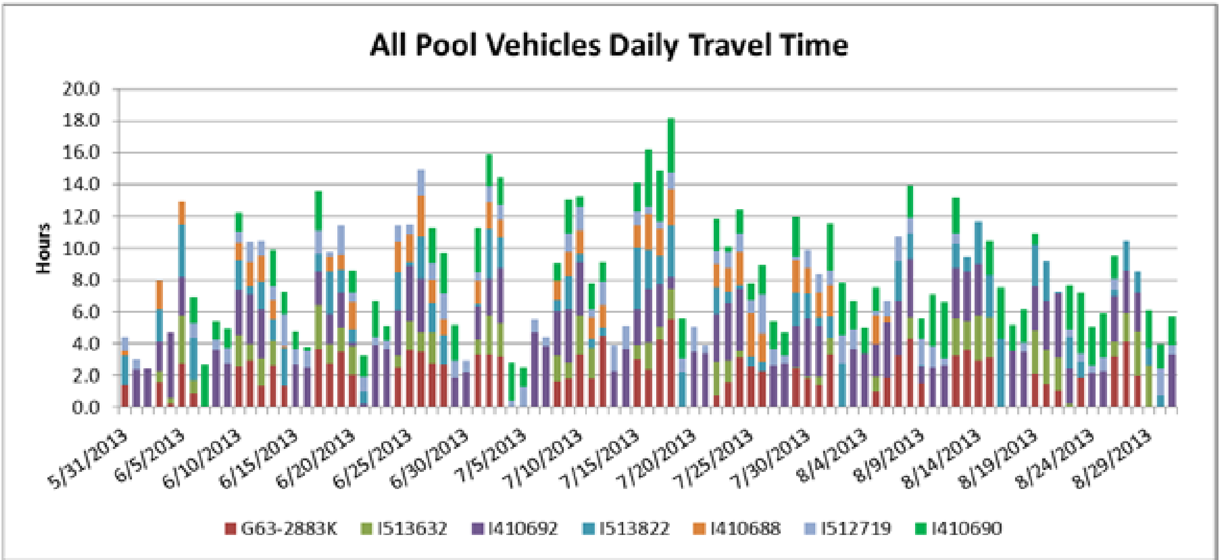


Figure 15. Pool vehicles travel time (all vehicles).

Figures 14 and 15 show that the vehicles were not used every day, although there were many days when most of the vehicles were in use. Vehicles I512719 and I410692 had the highest number of travel days, while Vehicles I410688 and I513632 had the least.

Figure 16 displays the summary of use by time of day for all pool vehicles. Figure 17 shows the outing distances traveled, including data for all pool vehicles.

Appendix B provides the details of each of the pool vehicle’s outing travel. Every vehicle exceeded 70 miles of travel on at least one outing.

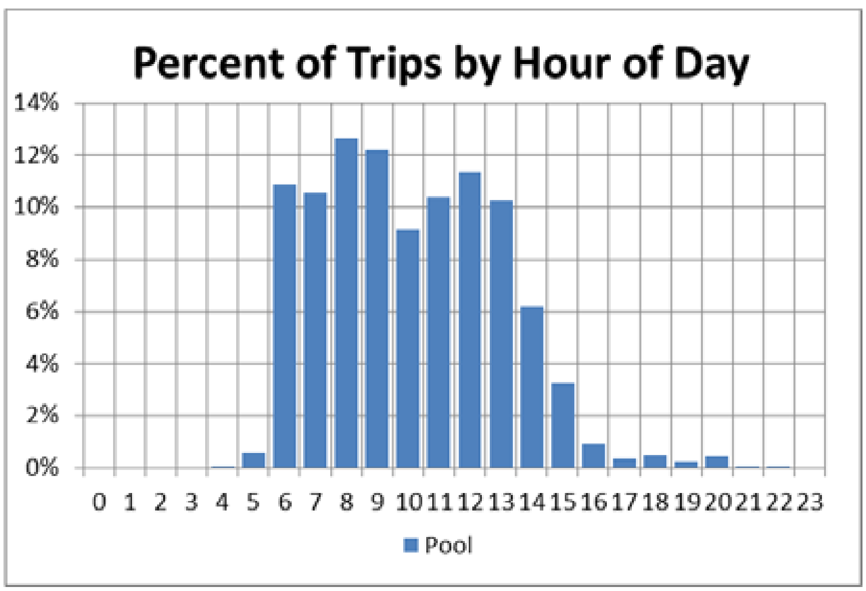


Figure 16. Pool vehicles hourly usage.

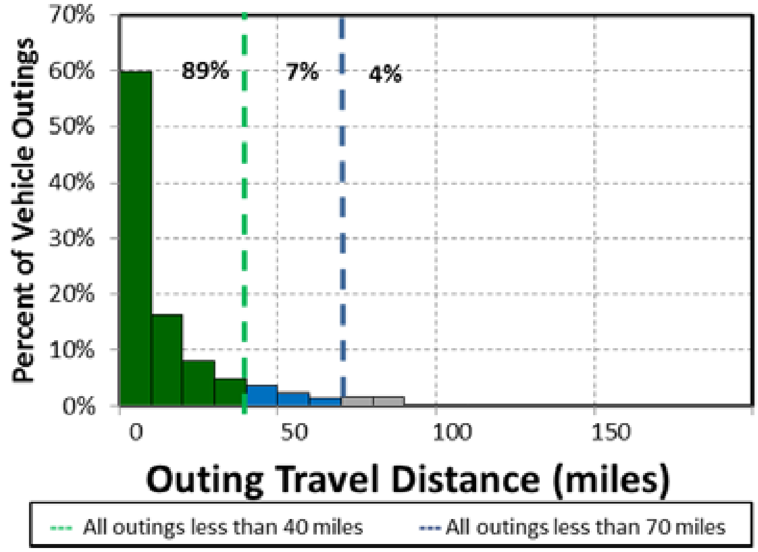


Figure 17. Pool vehicle outings.

The average travel outing for pool vehicles was 14.1 miles. On 96% of these vehicle outings, the distance traveled was less than the 70 miles considered to be within the BEV safe range. Only 4% percent of pool outing travel was greater than 70 miles, and 89% of vehicle travel outings were less than the 40 miles considered to be within the CD range of a PHEV. In summary, these vehicles can be characterized by fairly low daily travel and outing distances (i.e., the average numbers are quite low), with a few days of travel that just exceed the typical BEV range.

5.4.4 Pool Vehicle Observations/Summary

There appears to be three choices for SLBE in implementing PEVs into the pool fleet. It should be noted that the objective would be to incorporate as many BEVs as possible to realize the advantages of reduced petroleum usage and reduced emissions of GHGs. One pool vehicle, I410691, did not report data but it was assumed to have followed the usage trends of the other pool vehicles.

1. **All BEV fleet:** While some BEV manufacturers report vehicle range exceeding 70 miles, Intertek recommends careful evaluation of experienced range to ensure vehicle missions are accomplished. Nevertheless, assuming the 70-mile safe range for a BEV, an all-BEV fleet does not appear to be possible due to the length of some of the daily travel.

2. **Mixed BEV/PHEV fleet:** Certainly, PHEVs can accomplish the same mission as the current fleet when only considering travel times and distances, because the PHEV's gasoline engine can provide motive power when the battery has been depleted. Figure 13 shows that on 49% of all vehicle travel days, the total daily travel is less than 40 miles, which typically is the maximum distance a PHEV will travel in CD mode. This represents a significant operating cost savings opportunity, while retaining the ability to go longer distances when needed. In addition, 89% of the outings are less than 40 miles and could be completed in CD mode for certain PHEVs if the battery is fully charged prior to the outing.

   Meanwhile, 96% of the outings are within the typical capability of a BEV; therefore, EVSE at the home base could provide recharge energy for another outing. A mixed fleet requires fleet manager attention to assign vehicles appropriately for the anticipated use on that day.

   This would suggest that 4% of the fleet could be PHEVs to handle the travel greater than 70 miles per day without requiring additional opportunity charging during daytime stops and 96% of the fleet could be BEVs. However, this does not allow for the use of several vehicles at the same time and would require a greater level of fleet management, with the daily assignment of vehicles based on anticipated driving distance. Allowing more conservatism in assigning vehicles, three PHEVs and five BEVs could conservatively meet the demand for these eight pool vehicles. The monitored pool vehicles are pickup trucks and one sedan and replacement PEVs are currently available for these vehicle types.

3. **All PHEV fleet:** As noted above, PHEVs can accomplish the same mission as the current fleet when only considering travel times and distances. Replacing all current vehicles with PHEVs only requires an evaluation of the individual vehicle capabilities of currently available PHEVs to meet current pool requirements. These eight pool vehicles have replacement PEVs available. Data show that for a significant number of days, the PHEV will operate in CD mode. The first 40 miles of longer travel days would also be powered by (at least mostly) electricity so that 49% of all pool vehicle travel would be (again, at least mostly) battery powered with only one charge per day. As above, this represents an opportunity for significant operating cost savings, while retaining the ability to go longer distances when needed. Intermediate charging opportunities provide additional benefit, enhancing CD mode. Data show significant charging opportunities are available throughout the day during stop times.

The vehicle summary shows sufficient time for charging at the base location during the course of the day and additional opportunities at intermediate charging stations are not required. These stations also provide charging opportunities for the visiting public, whose fees may assist in offsetting operating costs. Given the availability of daytime changing, with experience, SLBE may find that a greater fraction of BEVs within the pool vehicle fleet may meet their needs.

Considering a full complement of 31 pool vehicles in the total fleet, Intertek notes that two are passenger vans for which no PEV is currently available as a potential replacement. However, for the balance of the vehicles, Intertek suggests that a mixed fleet may be possible. While the remaining vehicles were not monitored, using the same ratio as above suggests a fleet of 18 BEVs and 11 PHEVs would conservatively meet vehicle travel requirements. Typically, additional EVSE at frequently visited locations would provide recharging for both the BEV and PHEV that may be of benefit.

5.4.5 Pool Vehicle Charging Needs

Upon review of these data, Intertek suggests replacement of the studied pool fleet with five BEVs and three PHEVs. No available PHEVs at this writing provide for DCFC nor do the data suggest that this would be a significant benefit for PHEVs in the pool fleet. A DCFC at the home base will provide a more rapid recharge for BEVs, but appears to be unnecessary, given that our conservative estimate shows that 96% of outings are less than a typical BEV’s driving range.

As noted above, AC Level 2 overnight charging of BEVs is typical, whereas overnight charging of PHEVs can usually be accomplished with AC Level 1 charging.

Intertek’s experience suggests that each vehicle should have an assigned charging parking space at its home base. Assigned stations require less management attention to ensure completion of overnight charging. BEVs and PHEVs not assigned to these stations also benefit during visits to the location as part of their normal operation. For the entire fleet of pool vehicles, the 18 BEVs require 18 AC Level 2 EVSE units for overnight charging and the 11 PHEVs require 11 AC Level 1 outlets at each vehicle’s overnight parking location. Intertek recommends a minimum of two EVSE at each location to maximize charge capability without a significant increase in installation costs. The PHEVs can utilize the AC Level 2 EVSE at the home base during the day to increase the amount of vehicle miles traveled in CD mode. For these monitored vehicles, Intertek suggests BEVs could replace Vehicles G63-2883K, I513632, I513822, I410688, and I512719. PHEVs could replace Vehicles I410692, I410690, and I410691.

At times, fleet vehicles obtain benefit from using public charging infrastructure. Figure 18 displays the availability of public charging for the SLBE area at the time of this writing. Unfortunately, all public EVSE are located in Traverse City at some distance and would not likely provide support.

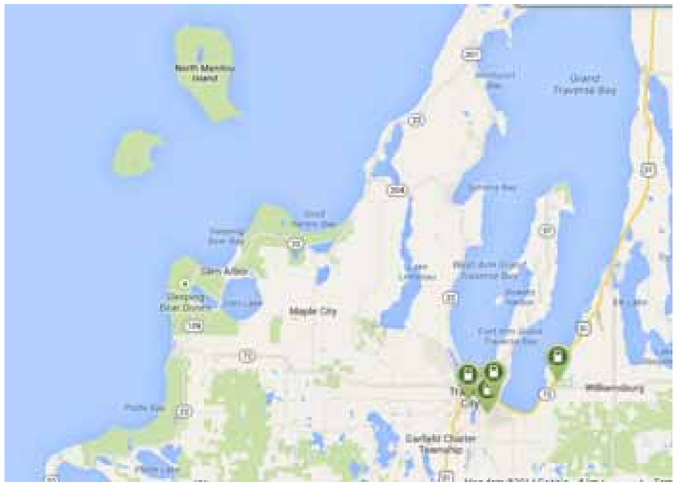


Figure 18. Public EVSE in SLBE region.[24]

5.5 Support Vehicles Evaluation

Support vehicles provide a specific work function, facilitating the mission of a particular group. The vehicles are generally passenger or light-duty pickup trucks and may contain after-market modifications to support the mission. While assigned to maintenance and service areas, missions may vary depending on agency needs.

5.5.1 Summary for Support Vehicles

Appendix B provides the vehicle data sheets for each of the four support vehicles monitored. This section aggregates the data for all support vehicles.

Table 14 summarizes support vehicle travel during the study period. Vehicle use occurred primarily between 0600 and 1400 hours daily. Support vehicles traveled 7,400 miles, logged 287 hours, and idled for 39 hours during the study period.

Table 14. Support vehicle travel summary.

Support Vehicle Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	40.4/156.7	12.8/94.5	4.5/37.8	7,400
Travel Time (Minutes)	94.3/287.0	29.9/232.0	10.5/118.0	17,252
Idle Time (Minutes)	12.8/NA	4.0/NA	1.4/NA	2,334

5.5.2 Support Vehicle Daily Summary

Figure 19 identifies daily travel distance and time for all support vehicles. The green line and bars indicate typical electric range on a single charge for a PHEV, while the blue line and bars indicate the

[24] http://www.plugshare.com/ [accessed August 21, 2014].

same for a BEV. Figures 20 and 21 show the composite history in distance and time traveled for the support vehicles. In the stacked bar charts of Figures 20 and 21, the contribution of each vehicle is indicated by a different color.

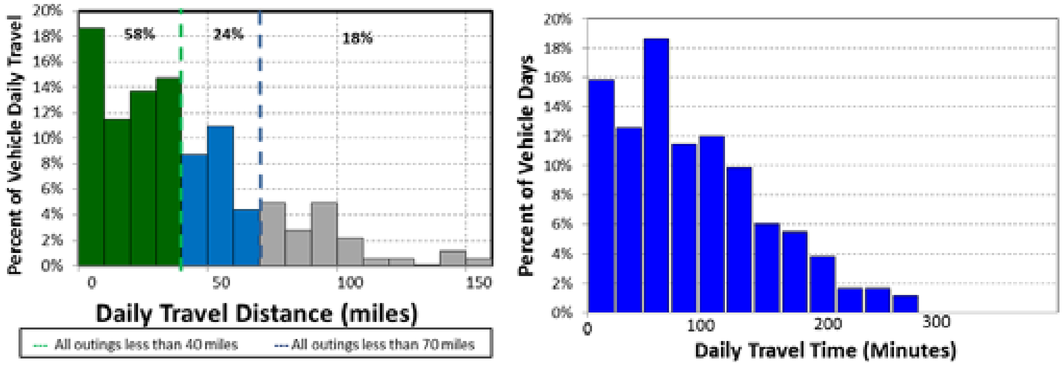


Figure 19. Support vehicles percentage of daily use versus daily travel miles and time (all vehicles).

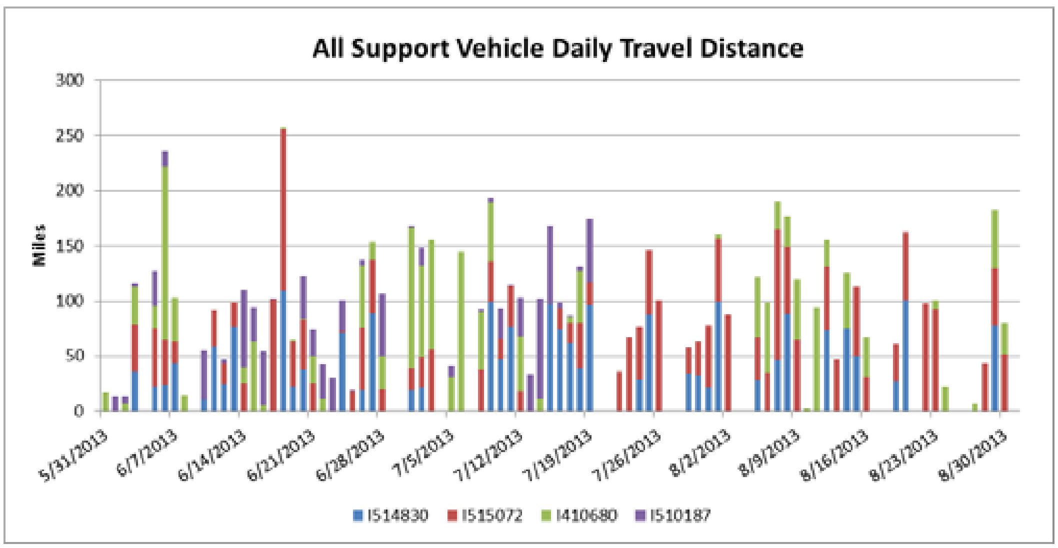


Figure 20. Support vehicle daily travel miles (all vehicles).

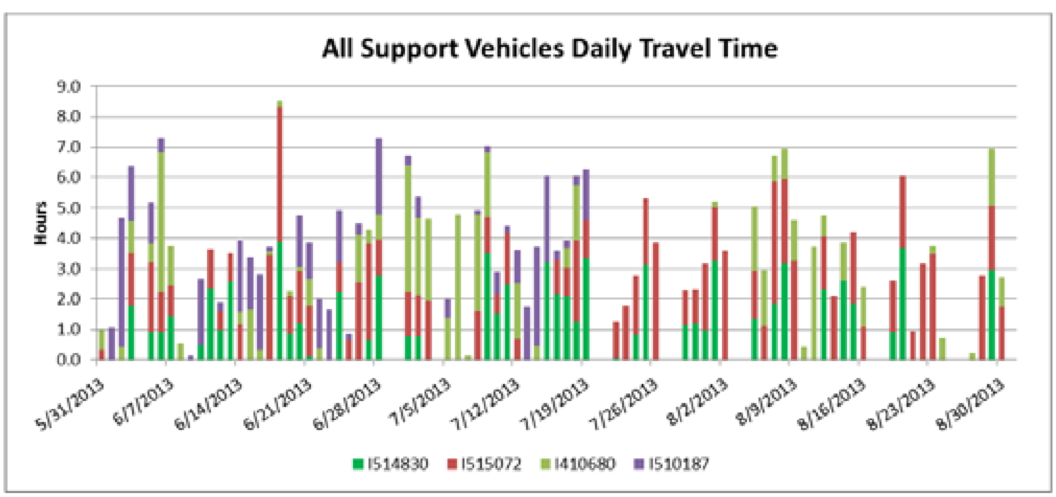


Figure 21. Support vehicle daily travel time (all vehicles).

The history graphs identify when several support vehicles may be in use at the same time and the total miles driven.

During the study period, the average travel distance per day, when driven, by support vehicles was 40.4 miles. On 82% of these vehicle days, the daily travel was less than the 70 miles considered to be within the BEV safe range. Eighteen percent of support vehicle daily travel was greater than 70 miles, and 58% of vehicle travel days are less than the 40 miles considered to be within the battery only range of a PHEV.

Figures 19, 20, and 21 show that the vehicles were not used every day, although there were many days when several of the vehicles were in use. Vehicles I515072 and I410680 had the highest number of travel days, while Vehicles I514830 and I510187 had the least. Figure 22 displays the summary of use by time of day for all support vehicles combined. Figure 23 shows the outing distances for all support vehicles.

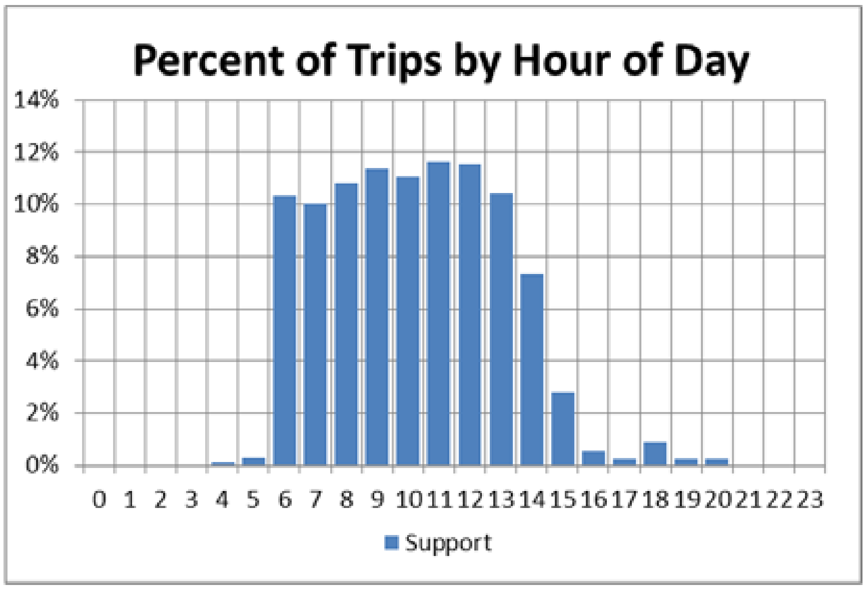


Figure 22. Support vehicles hourly usage.

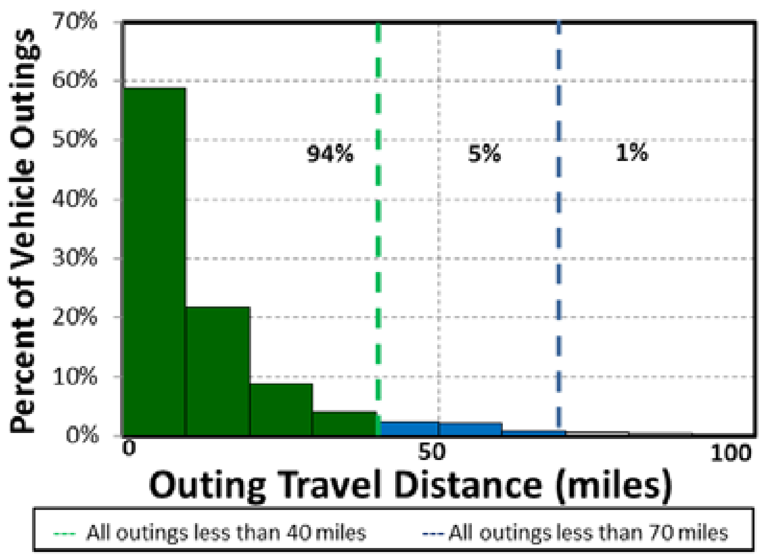


Figure 23. Support vehicle outings.

Appendix B provides the details of each of the support vehicle's daily travel.

The average travel outing for support vehicles was 12.8 miles and 94% of vehicle travel outings are less than the 40 miles and considered to be within the CD mode range of a PHEV.

In summary, these vehicles can be characterized by fairly low daily travel and outing distances (i.e., the average numbers are quite low), but each has experienced longer excursions, resulting in peak daily data higher than the BEV range.

5.5.3 Support Vehicle Observations/Summary

As a group, the support vehicles had infrequent daily travel distances exceeding 70 miles.

The support vehicles consist of one cargo van and three pickup trucks. Pickup trucks are a popular choice for support vehicles because they are versatile to support the various types support activities (i.e., special cargo or equipment transport). In some cases, SUVs or mini-vans can perform the same mission. Section 4.4 provides information on PEV trucks and vans currently or soon to be available.

As before, there appear to be three possible options for SLBE in implementing PEVs into the support vehicle fleet. It should be noted that the objective would be to incorporate as many BEVs as possible to realize the advantages of reduced petroleum usage and reduced emissions of GHGs.

1. **All BEV fleet:** While some BEV manufacturers report vehicle ranges exceeding 70 miles, Intertek recommends careful evaluation of experienced range to ensure vehicle missions are accomplished. Nevertheless, assuming the 70-mile safe range for a BEV, an all-BEV fleet is not advisable for support vehicles because of the need for some vehicles to exceed the typical BEV range.
2. **Mixed BEV/PHEV fleet:** Certainly, PHEVs can accomplish the same mission as the current fleet when only considering travel times and distances, because the PEV's gasoline engine can provide motive power when the battery has been depleted. Figure 19 shows that on 58% of all vehicle travel days, the total daily travel was less than 40 miles, which typically is the maximum distance a PHEV will travel in CD mode. This represents a significant operating cost savings opportunity, while retaining the ability to go longer distances when needed. In addition, 94% of the outings were less than 40 miles and could be completed in CD mode for certain PHEVs if the battery was fully charged prior to the outing.

   Fully 99% of the outings were within the typical capability of a BEV; therefore, EVSE at the home base could provide recharge energy for another outing. A mixed fleet requires fleet manager attention to assign vehicles appropriately for the anticipated use on that day.

   The data suggest that 18% of the fleet could be PHEVs to handle the travel greater than 70 miles per day without requiring additional opportunity charging during daytime stops and 82% of the fleet could be BEVs. However, this does not allow for the use of several vehicles at the same time and would require a greater level of fleet management, with the daily assignment of vehicles based on anticipated driving distance. It is suggested that replacing these vehicles with two PHEVs and two BEVs could conservatively meet the demand.
3. **All PHEV fleet:** As noted above, PHEVs can accomplish the same mission as the current fleet when only considering travel times and distances. Replacing all current vehicles with PHEVs only requires an evaluation of the individual vehicle's capabilities of currently available PHEVs to meet current support vehicle requirements.

The vehicle summary shows sufficient time for charging at the base location during the course of the day. These stations also provide charging opportunities for the visiting public, whose fees may assist in offsetting operating costs.

The current fleet contains 24 total support vehicles, whose assessment of mission by vehicle type is shown in Table 9. Three of these vehicles are heavy-duty trucks for which there currently are no PEV replacement options. Thus, it is assumed that the composition would include three conventional heavy-duty pickup trucks, 10 BEVs, and 11 PHEVs to replace the SLBE fleet and continue to carry out the same mission.

5.5.4 Support Vehicle Charging Needs

Upon review of these data, Intertek suggests replacement of most of the support vehicle fleet with 10 BEV and 11 PHEVs. No available PHEVs at the time of this writing provide for DCFC nor do the data suggest that this would be a significant benefit for PHEVs in the support vehicle fleet. A DCFC at the home base would provide a more rapid recharge for BEVs, but it appears to be unnecessary. The majority of the support vehicle activity occurs during daytime hours, which leaves significant time during the nighttime hours for recharging.

As noted above, AC Level 2 overnight charging of BEVs is typical, whereas overnight charging of PHEVs can usually be accomplished with AC Level 1 charging. Opportunity charging at intermediate stops obtains the greater benefits from AC Level 2 EVSE. However, remote intermediate stop locations were not identified in the data.

For the entire fleet of support vehicles, 10 BEVs require 10 AC Level 2 EVSE for overnight charging and 11 PHEVs require 11 AC Level 1 outlets for home base charging. Intertek recommends a minimum of two EVSE at each location to maximize charge capability without a significant increase in installation costs. As noted above, there are no publicly accessible EVSE in the vicinity to provide significant backup charging resources.

Greater management attention provides the possibility of reducing the overall number of AC Level 2 EVSE. A ratio of two AC Level 2 charging stations to three vehicles typically sustains a normal fleet operation. Fleet managers rotate vehicles on the charger to complete charging of all vehicles in the allotted time. This analysis does assume a fully recharged battery at the start of each day. SLBE will gain experience in this management as the PEV fleet grows.

5.6 Law Enforcement Vehicles Evaluation

Enforcement vehicles are typically light-duty motor vehicles specifically approved in an agency's appropriation act for use in apprehension, surveillance, police, or other law enforcement work. Enforcement missions can vary by agency, location, and jurisdiction; however, they typically utilize sedans, minivans, vans, or small pickup trucks and typically do not carry specific cargo or equipment.

Incorporation of BEVs and/or PHEVs into the enforcement mission is a definite possibility. Enforcement vehicles used to patrol small areas and for parking enforcement activities qualify for BEV or PHEV replacement, while other law enforcement vehicle activities that are associated with longer trips may require PHEV capabilities.

5.6.1 Summary for Enforcement Vehicles

Appendix B provides the vehicle data sheets for the enforcement vehicle monitored. Note that no data was transmitted for Vehicle G62-4494K for unknown reasons. The data presented here is for Vehicle G62-0442M that was monitored. Comparisons to other enforcement vehicles from other sites were made where appropriate.

Table 15 summarizes enforcement vehicle travel during the study period. Vehicle use occurred primarily between 0600 and 1400 hours daily. Support vehicles traveled 7,400 miles, logged 287 hours, and idled for 39 hours during the study period.

Table 15. Support vehicle travel summary.

Support Vehicle Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	80.3/144.2	37.4/171.5	7.3/54.4	4,903
Travel Time (Minutes)	247.6/525.0	115.2/468.0	22.4/251.0	15,103
Idle Time (Minutes)	70.4/NA	32.8/NA	6.4/NA	4,296

5.6.2 Enforcement Vehicle Daily Summary

Figure 24 identifies daily travel distance and time for the enforcement vehicle. The green line and bars indicate typical electric range on a single charge for a PHEV, while the blue line and bars indicate the same for a BEV. Figures 25 and 26 show the composite history in distance and time traveled for the enforcement vehicle.

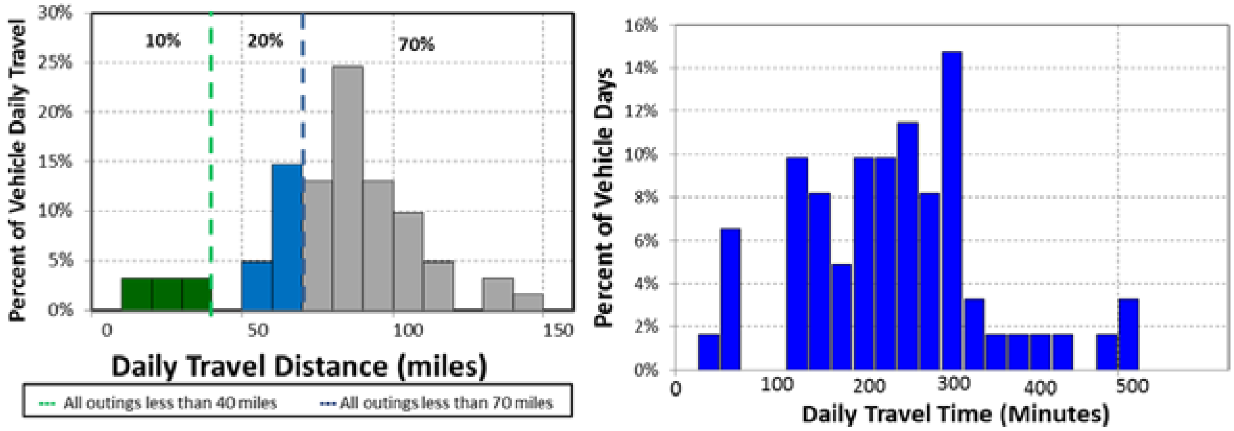


Figure 24. Enforcement vehicle percentage of daily use versus daily travel miles and time (all vehicles).

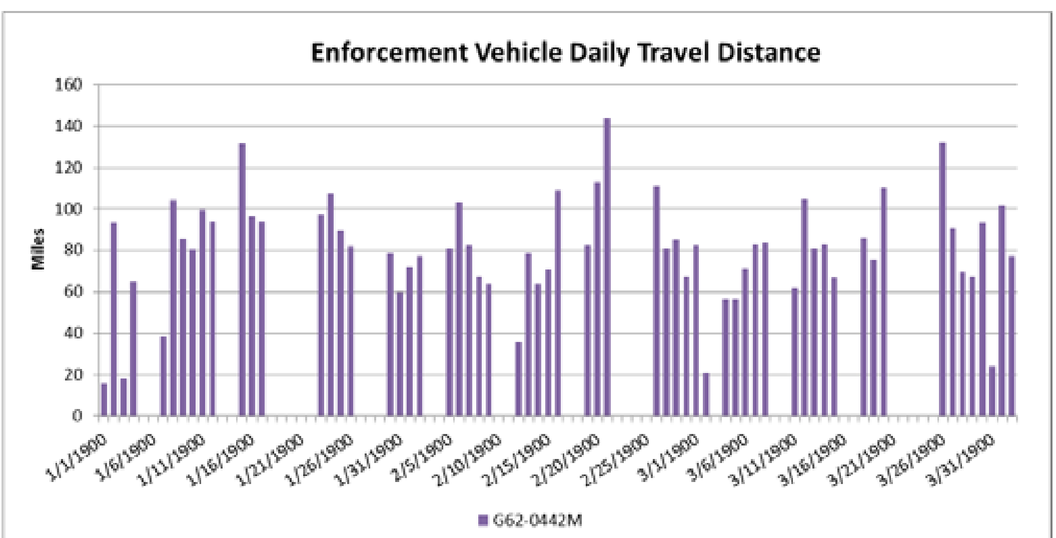


Figure 25. Enforcement vehicle daily travel miles (all vehicles).

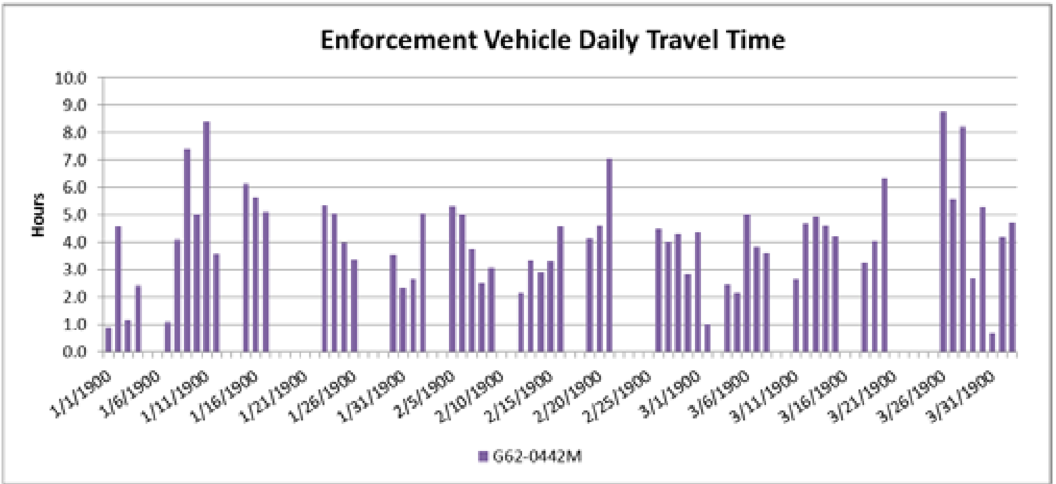


Figure 26. Enforcement vehicle daily travel time (all vehicles).

The history graphs identify when several support vehicles may be in use at the same time and the total miles driven.

During the study period, the average travel distance per day, when driven, by the enforcement vehicles was 80.3miles. On 30% of these vehicle days, the daily travel was less than the 70 miles considered to be within the BEV safe range. Seventy percent of support vehicle daily travel was greater than 70 miles, and 10% of vehicle travel days were less than the 40 miles considered to be within the battery only range of a PHEV.

Figures 25 and 26 show that the vehicle was not used every day, although frequent usage was indicated. Figure 27 displays the summary of use by time of day for the enforcement vehicle combined.

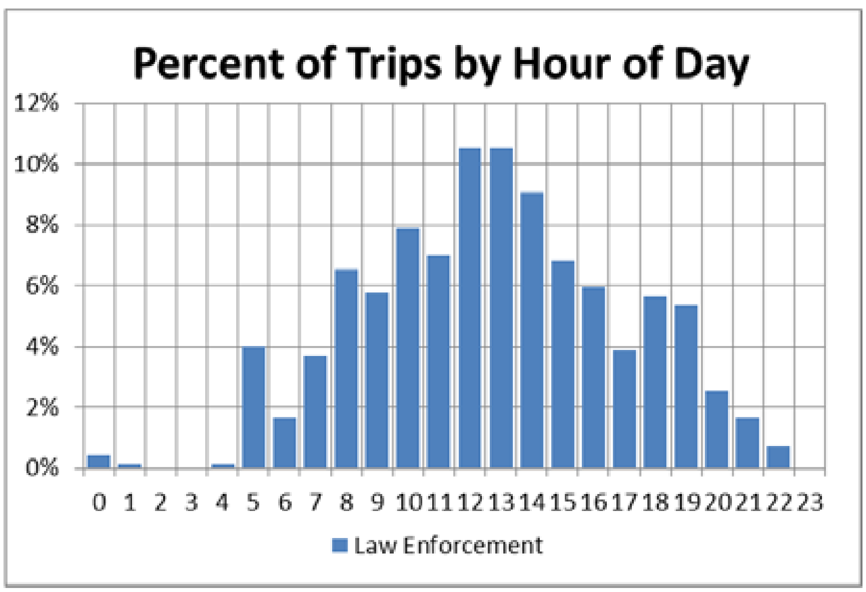


Figure 27. Enforcement vehicle hourly usage.

Figure 28 shows the outing distances for the enforcement vehicle.

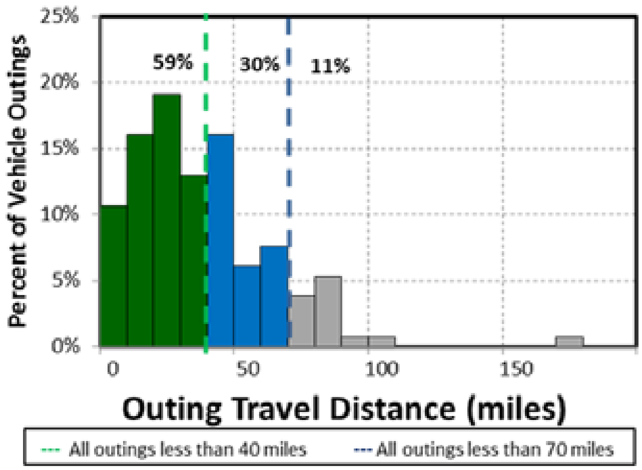


Figure 28. Support vehicle outings.

Appendix B provides the details of the enforcement vehicle's daily travel.

The average travel outing for the enforcement vehicles was 37.4 miles and 59% of vehicle travel outings were less than the 40 miles considered to be within the CD mode range of a PHEV.

In summary, these vehicles can be characterized by fairly consistent daily travel above the BEV range, with long idle times. This daily travel and the outings are higher than that observed for enforcement vehicles at other national parks. The idle times are consistent with other parks and the nature of the enforcement mission.

5.6.3 Enforcement Vehicle Observations/Summary

Both enforcement vehicles are SUVs. These are a popular choice for enforcement vehicles because they are versatile for supporting various types of enforcement activities.

As before, there appear to be three possible options for SLBE in implementing PEVs into the enforcement vehicle fleet. It should be noted that the objective would be to incorporate as many BEVs as possible to realize the advantages of reduced petroleum usage and reduced emissions of GHGs.

1. **All BEV fleet:** While some BEV manufacturers report vehicle ranges exceeding 70 miles, Intertek recommends careful evaluation of experienced range to ensure vehicle missions are accomplished. Nevertheless, assuming the 70-mile safe range for a BEV, an all-BEV fleet is not possible for enforcement vehicles due to the long distances experienced by the vehicles. In addition, the mission of enforcement vehicles does not typically lend itself to range limitations.

2. **Mixed BEV/PHEV fleet:** Certainly, PHEVs can accomplish the same mission as the current fleet when only considering travel times and distances, because the PEV's gasoline engine can provide motive power when the battery has been depleted. Figure 24 shows that on 10% of all vehicle travel days, the total daily travel was less than 40 miles, which typically is the maximum distance a PHEV will travel in CD mode. This represents a significant operating cost savings opportunity, while retaining the ability to go longer distances when needed. In addition, 59% of the outings were less than 40 miles and could be completed in CD mode for certain PHEVs if the battery was fully charged prior to the outing.

   Fully 89% of the outings were within the typical capability of a BEV; therefore, EVSE at the home base could provide recharge energy for another outing. A mixed fleet requires fleet manager attention to assign vehicles appropriate for the anticipated use on that day.

The data suggest that 70% of the fleet could be PHEVs to handle travel greater than 70 miles per day without requiring additional opportunity charging during daytime stops and 30% of the fleet could be BEVs. Because this vehicle's travel was higher than that typically observed for enforcement vehicles, it was suggested that replacing these two vehicles with two PHEVs would best meet this demand.

3. **All PHEV fleet:** As noted above, PHEVs can accomplish the same mission as the current fleet when only considering travel times and distances. Replacing all current vehicles with PHEVs only requires an evaluation of the individual vehicle capabilities of currently available PHEVs to meet current support vehicle requirements.

The vehicle summary shows sufficient time for charging at the base location during the course of the day. These stations also provide charging opportunities for the visiting public, whose fees may assist in offsetting operating costs.

The current fleet contains these two enforcement vehicles. Thus, Intertek suggests that two PHEVs could replace these vehicles and continue to carry out the same mission.

5.6.4 Enforcement Vehicle Charging Needs

As noted above, overnight charging of PHEVs can usually be accomplished with AC Level 1 charging. Opportunity charging at intermediate stops obtains the greater benefits from AC Level 2 EVSE. However, remote intermediate stop locations were not identified in the data.

For the entire fleet of enforcement vehicles, two PHEVs require two AC Level 1 outlets for home base charging. Intertek recommends a minimum of two EVSE at each location to maximize charge capability without a significant increase in installation costs. As noted above, there are no publicly accessible EVSE in the vicinity to provide significant backup charging resources.

This analysis does assume a fully recharged battery at the start of each day. SLBE will gain experience in management as the PEV fleet grows.

5.7 Balance of Fleet Vehicles

The balance of the SLBE fleet consists of specialty, heavy-duty trucks, and passenger vans. Certain select PEVs are being demonstrated for various specialty applications, but none are listed in the GSA schedule.

6. GREENHOUSE GAS EMISSIONS AVOIDED AND FUEL COST REDUCTION ANALYSIS

PEV substitution for an existing conventional vehicle avoids GHG emissions and reduces fuel costs. The GHG emissions avoided occur due to the difference in emissions associated with power plant electricity generation versus fuel combustion that occurs in the engine of a conventional vehicle. This analysis does not account for life-cycle emissions that occur outside of the electricity generation and fuel combustion phases (i.e., materials and resource extraction, production supply-chains, and decommissioning are not accounted for). These phases are beyond the scope of this report due to the significant effort required to conduct an accurate environmental life-cycle assessment for a transportation system in a very specific setting. The analysis used is known as a "tank-to-wheel" analysis rather than a "well-to-wheel" analysis that would include the aforementioned phases. Cost reduction also occurs because the cost of electricity is comparable to the cost of gasoline on a unit of energy basis; however, PEVs are more efficient than conventional ICE vehicles. Because fuel logs were not kept, the mileage accumulated by each vehicle and the extrapolation to annual miles provide one source of annual miles estimates. SLBE also provided information related to anticipated annual miles. These are compared to that calculated during the study to identify the source of fuel consumption estimates for the study vehicles.

In order to perform the analysis, EPA fuel economy ratings are used.[25] Tables 16 and 17 provide these ratings. Ratings for the PHEVs in Table 17 include CD operation. Because these data are estimates, assumptions include the following:

1. PHEVs operate in CD mode only for the percentage of travel less than 40 miles per day. This is reasonable for most daily operations, as described in Section 5. This is conservative because there exists additional charge time between most outings. It is also conservative in that the replacement PEV typically will have greater fuel economy when operating in CS mode. BEVs operate in electric mode for 100% of travel.
2. The energy consumption for the Mitsubishi Outlander is assigned the same value as the RAV4 EV and the Via Motors VTRUX PU is estimated because the EPA has not yet created ratings for these vehicles.
3. Table 17 suggests the PEVs to replace existing monitored vehicles. See Section 4.4 for vehicle availability.
4. Annual miles are calculated from the actual miles identified in the study and extrapolated to a full 365-day year. This is compared to the annual miles reported by SLBE for information. The SLBE annual miles are used for reduction calculations, if available. Miles in CD mode are the SLBE annual miles times percent of daily travel less than 40 miles for the PHEV replacement and full annual miles for the BEV replacement.

Table 16. U.S. EPA fuel economy ratings of current fleet vehicles.

Vehicle	Logger	Mission	Make and Model	Model Year	Fuel Economy-Combined (miles/gallon)
G63-2883K	21	Pool	Ford F150	2011	18
I514830	22	Support	Chevrolet K2500	2012	18
I513632	23	Pool	Chevrolet Colorado	2010	21
I410692	24	Pool	Ford F150	2007	15
G62-0442M	25	Law Enforcement	Chevrolet Tahoe	2012	17
I513822	26	Pool	Chevrolet Silverado	2011	17
I410688	27	Pool	Chevrolet K2500	2007	17
I515072	28	Support	Chevrolet Express Van	2013	17
I410680	29	Support	Dodge Dakota	2007	17
G62-4494K	30	Law Enforcement	Chevrolet Tahoe	2010	17
I510187	31	Support	Chevrolet Colorado	2006	21
I512719	32	Pool	Chevrolet Impala	2010	22
I410690	33	Pool	Ford F150	2007	15
I410691	34	Pool	Ford F150	2007	15

Table 17. U.S. EPA PEV energy consumption assumptions.

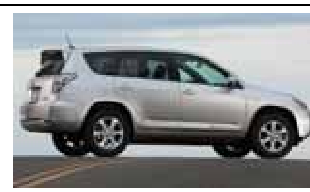
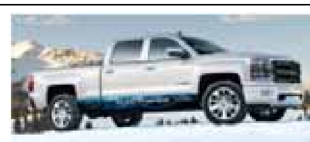
Mission	**Replacement PEV**	**Wh/mile**
Pool	Toyota RAV4 EV	440
Support	Via Motors VTRUX PU	475
Pool	Nissan eNV200	400
Pool	Via Motors VTRUX PU	475

[25] http://www.fueleconomy.gov/feg/Find.do?action=sbs&id=33558 [accessed February 2, 2014]

Mission	Replacement PEV	Wh/mile
Law Enforcement	Mitsubishi Outlander	440
Pool	Nissan eNV200	400
Pool	Toyota RAV4 EV	440
Support	Via Motors VTRUX Van	475
Support	Nissan eNV200	400
Law Enforcement	Mitsubishi Outlander	440
Support	Toyota RAV4 EV	440
Pool	Nissan Leaf	300
Pool	Via Motors VTRUX PU	475
Pool	Via Motors VTRUX PU	475

Table 18 provides a pictorial view of potential replacement PEVs.

Table 18. PEV substitutions for current vehicles.

Vehicle Class	Current Vehicle Example	Replacement PHEV	Replacement BEV
Sedan – Midsize/Large	 Chevrolet Impala	 Ford Fusion 370 wh/mi	 Nissan Leaf 300 wh/mi
SUV and Minivan	 Chevrolet Tahoe	 Mitsubishi Outlander 440 wh/mi	 Toyota RAV4 440 wh/mi
Pickup Truck	 Chevrolet Colorado	 Via Motors VTRUX 475 wh/mi	 Nissan eNV200 400 wh/mi
Pickup Truck (alternate)	 Ford F150	 Mitsubishi Outlander 440 wh/mi	 Toyota RAV4 440 wh/mi

Vehicle Class	Current Vehicle Example	Replacement PHEV	Replacement BEV
Cargo Van	 Chevrolet Express Van	 Via VTRUX Van 475 Wh/mi	 Nissan eNV200 400 Wh/mi

Calculations provided for GHG emissions and fuel savings include both a total United States perspective and for the local area. The electricity generation mix of power plants for the total United States is different from the local mix of generation in the SLBE area. Likewise, the national average cost for petroleum fuel is different from the local cost for fuel. This analysis includes both approaches in order to allow for local evaluation and to provide the potential benefit for fleet vehicles in other locations of the United States that may be of interest. The final report from Intertek to Idaho National Laboratory summarizing results from all sites studied across the United States primarily will consider the national figures. For clarity, only the local figures are shown here. The national figures are included in Appendix C.

For the GHG emissions avoided portion of the analysis, the GHG emissions (in pounds of carbon dioxide equivalent (*lb-CO_2e*; which also accounts for other GHGs such as methane and nitrous oxide), from combustion of gasoline is 20.1 lb-CO_2e/gallon.[26] The United States averages for GHG emissions for the production of electricity is 1.53 lb-CO_2e/kWh.[27]

Consumers Energy provides electric power to SLBE and reports a mix of generation from several power plants, including nuclear, coal, gas, oil, hydro, renewables, and wind generation and reported sales of approximately 35 million MWh in 2013.[28] EPA reports GHG emissions from the production of electricity. The annual report is available in the Emissions and Generation Resource Integrated Database. The most recent publication is for 2010.[29] Using the generation mix reported by Consumers Energy and the Emissions and Generation Resource Integrated Database plant reports, emissions for 2010 for the production of 35 million MWh electricity were 1.426lb-CO_2e/kWh. This emission rate closely matches the national average.

GHG emissions avoided are the GHG emitted by the current vehicle (total annual gallons gasoline × GHG emissions/gallon) minus the annual GHG emitted by the replacement PEV (total annual kWh × GHG emissions/kWh). For the PHEVs, the percentages of outings less than 40 miles are counted for the annual miles saved in CD mode, with the balance of the miles accounted as fueled with gasoline.

Table 18 shows the calculation of annual miles based on the recorded and extrapolated miles in this study. The SLBE reported annual miles are also shown for comparison. The replacement vehicle is identified for each vehicle. It is important to note that the analysis conducted above suggests replacement vehicles for the fleet of vehicles rather than necessarily replacing the exact vehicle monitored. The percent of miles in CD mode is 100% for BEVs because all travel is battery powered. The percent of miles in CD mode for PHEVs is obtained from the daily travel shown in Appendix B. Miles in CD mode is the percentage of SLBE reported annual miles.

[26] http://www.theevproject.com/cms-assets/documents/106077-891082.ghg.pdf [accessed 19 July 2013].

[27] http://www.theevproject.com/cms-assets/documents/106077-891082.ghg.pdf [accessed July 19, 2013].

[28] http://www.consumersenergy.com/content.aspx?ID=1373aspx [accessed August 15, 2014].

[29] http://www.epa.gov/cleanenergy/energy-resources/egrid/ [accessed 8 June 2014].

Table 19. CD mode miles calculations.

Vehicle	Replacement Vehicle	Study Calculated Annual Miles	SLBE Reported Annual Miles	Percent of Miles CD Mode	CD Mode Miles
G63-2883K	RAV4	10,753	11831	100%	11,831
I514830	VTRUX PU	8,824	8,000*	49%	3,920
I513632	eNV200	6,979	6579	100%	6,579
I410692	VTRUX PU	18,689	7656	12%	919
G62-0442M	Outlander	19,454	10000	10%	1,000
I513822	eNV200	11,421	7173	100%	7,173
I410688	RAV4	5,279	4441	100%	4,441
I515072	VTRUX Van	10,412	9000*	48%	4,320
I410680	eNV200	7,049	5285	100%	5,285
G62-4494K	Outlander	No data	13949	10%	1,395
I510187	RAV4	3,401	2484	100%	2,484
I512719	Leaf	8,983	6193	100%	6,193
I410690	VTRUX PU	11,896	7000	51%	3,570
I410691	VTRUX PU	No data	7000	45%	3,150

*Estimated annual miles not provided by SLBE.

For the cost-avoided piece of the analysis, fuel cost assumptions are $3.447/gallon of gasoline for the United States and $3.433/gallons in the Midwest.[30] Electrical cost are 0.0984 $/kWh for the United States and 0.1098$/kWh in Michigan.[31] Therefore, fuel costs savings are the current vehicle's calculated annual gasoline cost (total annual gallons gasoline × cost/gallon) minus the electricity cost (total annual kWh × cost/kWh) of the replacement PEV traveling the same distance.

The miles calculated above for CD mode yields estimates for yearly GHG emissions avoided and fuel cost reductions. The results of this analysis (shown Table 20) demonstrate that the substitution of a conventional ICE vehicle with a PEV can reduce the GHG emissions and fuel costs dramatically. The table also shows the percentage reduction in GHG emissions and fuel costs for ease of comparison. For example, if the Mitsubishi Outlander replaces law enforcement Vehicle G62-0442M, a 47% reduction in GHG emissions in Michigan occurs. The Chevrolet Tahoe produces 1,182 lb-CO_2e/year for the distance traveled, whereas the Outlander produces 627 lb-CO_2e/year for that same distance, for a reduction of 555 lb-CO_2e/year.

Table 20. Greenhouse gas emissions avoidance and fuel cost reduction analysis summary.

	Mission	Replacement Model	Extrapolated Local Yearly CO_2e Avoided (lb-CO_2e/year)	% reduction	Extrapolated Local Yearly Fuel Cost Reduction	% reduction
	Pool	RAV4	5,788	44%	$1,685	75%
	Support	VTRUX PU	1,722	39%	$543	73%
	Pool	eNV200	2,544	40%	$787	73%
	Pool	VTRUX PU	609	49%	$162	77%
	Law Enforcement	Outlander	555	47%	$154	76%
	Pool	eNV200	4,390	52%	$1,133	78%

[30] http://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_sco_w.htm [accessed July 25 2014].

[31] http://www.eia.gov/electricity/state/ [Accessed July 25, 2014].

	Mission	Replacement Model	Extrapolated Local Yearly CO_2e Avoided (lb-CO_2e/year)	% reduction	Extrapolated Local Yearly Fuel Cost Reduction	% reduction
	Pool	RAV4	2,464	47%	$682	76%
	Support	VTRUX Van	2,182	43%	$647	74%
	Support	eNV200	3,234	52%	$835	78%
	Law Enforcement	Outlander	774	47%	$214	76%
	Support	RAV4	819	34%	$286	70%
	Pool	Leaf	3,009	53%	$762	79%
	Pool	VTRUX PU	2,366	49%	$631	77%
	Pool	VTRUX PU	2,087	49%	$557	77%
Total			**32,542.8**	**46%**	**$9,079**	**76%**
Total Pool			23,257	47%	$6,399	76%
Total Support			7,957	44%	$2,311	75%
Total Enforcement			1,329	47%	$368	76%

Table 20 shows the high potential benefit in the reduction of GHG emissions in the local SLBE area. In addition, the fuel cost reduction potential benefit is also significant due to the low cost of power.

As presented in Section 5, 18 BEVs and 11 PHEVs could replace the pool fleet of 31 vehicles, while retaining the two passenger vans. The support fleet of 24vehicles would retain three heavy-duty pickups and replace the balance with 10 BEVs and 11 PHEVs. Two PHEVs are assumed to replace the enforcement fleet of two vehicles. Using an average savings per vehicle, Table 20 provides the avoided GHG and fuel cost savings should these replacements occur. The table also shows the percentage reduction in GHG emissions and fuel costs for ease of comparison. Only local Michigan savings are projected in this table, while national figures are presented in Appendix C.

Table 21. Extrapolated greenhouse gas emissions avoided and fuel cost savings for the entire fleet.

Mission	Extrapolated Local Yearly CO_2e Avoided (lb-CO_2e/year)	% reduction	Extrapolated Local Yearly Fuel Cost Reduction ($/year	% reduction
Pool	88,698	47%	$24,708	76%
Support	28,577	42%	$8,544	74%
Enforcement	1,329	47%	$368	76%
Total	118,604	45%	$33,620	75%

7. OBSERVATIONS

Intertek appreciates the opportunity to present the results of this evaluation. Observations for possible follow-up action include the following:

Observation #1:

Implementation: SLBE can move forward in the near future with the replacement of pool, support, and enforcement vehicles with PEVs as current budget and vehicle replacement schedules allow. Certainly, most of the vehicle types studied in this report are candidates for immediate replacement.

Observation #2:

Fleet Inventory: A more thorough examination of the quantities and types of fleet vehicles within each usage category may be beneficial to quantify the potential for replacement by PEVs. While Intertek suggests a mix of BEVs and PHEVs, a more refined look may be possible. In addition, this study did not look at the other fleet vehicle categories (such as specialty vehicles).

Observation #3:

Vehicle Replacement Plan: The development of a detailed vehicle replacement plan could be beneficial. This plan would include cost and schedule for vehicle replacement. A more detailed survey and calculation of the use of the fleet vehicles (such as vehicle parking locations, age of vehicle, expected replacement time, expected replacement costs, GSA vehicle costs, EVSE cost, total life costs, and EVSE installation costs) provide support to this replacement plan. A more refined estimate for reduced GHG emissions, petroleum usage reduction, and fuel cost savings flow from this detailed plan.

Observation #4:

Infrastructure Planning: In conjunction with the replacement plan, evaluation of the SLBE sites for the placement of PEV charging infrastructure could be beneficial. Intertek has significant experience in this area and plans will consider fleet vehicle charging needs and the convenience that charging infrastructure provides employees and visitors. This planning also considers the existing facility's electrical distribution system. Vehicle home base considerations factor into the ratio of PEVs to EVSE units to maintain all vehicles at operational readiness.

Charging stations located at various destination points may provide additional infrastructure for PEV charging of the SLBE fleet. Charging stations at SLBE may also provide an opportunity for charging by the public. SLBE can benefit through collection of charging fees during times when these stations are not required for the overnight charging of fleet vehicles. The fees avoid the questions associated with a federal agency providing fuel for privately owned vehicles and support the costs for installation and operation of the EVSE.

Appendix A

Definitions

Alternative fuel	An alternative fuel means any fuel other than gasoline and diesel fuels, such as methanol, ethanol, and gaseous fuels (40 CFR 86.1803-01). A fuel type other than petroleum-based gasoline or diesel as defined by the Energy Policy Act (examples include ethanol, methanol, compressed natural gas, propane, and electrical energy).
City fuel economy (MPG)	City fuel economy means the city fuel economy determined by operating a vehicle (or vehicles) over the driving schedule in the federal emission test procedure or determined according to the vehicle-specific 5-cycle or derived 5-cycle procedures (40 CFR 600.001).
Conventional fuel	A petroleum-based fuel (examples include gasoline and diesel fuel).
Daily travel	The sum of daily trips and stops in one day.
Diesel fuel	Diesel means a type of engine with operating characteristics significantly similar to the theoretical diesel combustion cycle. The non-use of a throttle during normal operation is indicative of a diesel engine (49 CFR 86-1803).
E85	Ethanol fuel blend of up to 85% denatured ethanol fuel and gasoline or other hydrocarbons by volume.
Electric vehicle	Electric vehicle means a motor vehicle that is powered solely by an electric motor drawing current from a rechargeable energy storage system, such as from storage batteries or other portable electrical energy storage devices, including hydrogen fuel cells, provided that (1) The vehicle is capable of drawing recharge energy from a source off the vehicle, such as residential electric service (2) The vehicle must be certified to the emission standards of Bin #1 of Table S04-1 in § 86.1811-09(c)(6) (3) The vehicle does not have an onboard combustion engine/generator system as a means of providing electrical energy (40 CFR 86-1803).
Ethanol-fueled vehicle	Ethanol-fueled vehicle-means any motor vehicle or motor vehicle engine that is engineered and designed to be operated using ethanol fuel (i.e., a fuel that contains at least 50% ethanol ($C_2 H_5 OH$) by volume) as fuel (40 CFR 86.1803-01).
Federal vehicle standards	The document that establishes classifications for various types and sizes of vehicles, general requirements, and equipment options. It is issued annually by the GSA Vehicle Acquisition and Leasing Service's Automotive Division.
Government motor vehicle	Any motor vehicle that the government owns or leases. This includes motor vehicles obtained through purchase, excess, forfeiture, commercial lease, or GSA fleet lease.
Gross vehicle weight rating	Gross vehicle weight rating (GVWR) means the value specified by the vehicle manufacturer as the maximum design loaded weight of a single vehicle (e.g., vocational vehicle) (US Government Printing Office 2009)
GSA fleet	GSA fleet lease means obtaining a motor vehicle from the General Services Administration fleet (GSA fleet) (41 CFR 102-34).

Heavy light-duty truck	Heavy light-duty truck means any light-duty truck rated greater than 6,000 lb GVWR. The light-duty truck 3 (LDT3) and LDT4 classifications comprise the heavy light-duty truck category (40 CFR 86.1803-01).
Highway fuel economy (Hwy MPG)	Highway fuel economy means the highway fuel economy determined either by operating a vehicle (or vehicles) over the driving schedule in the federal highway fuel economy test procedure or determined according to either the vehicle-specific, 5-cycle equation, or the derived 5-cycle equation for highway fuel economy (40 CFR 600.001).
Hybrid electric vehicle	Hybrid electric vehicle means a motor vehicle that draws propulsion energy from onboard sources of stored energy that are both an internal combustion engine or heat engine using consumable fuel and a rechargeable energy storage system (such as a battery, capacitor, hydraulic accumulator, or flywheel), where recharge energy for the energy storage system comes solely from sources on board the vehicle.
Idle time	Idle time is logged whenever a vehicle idles with the engine running for 3 minutes or longer.
Law enforcement	Law enforcement motor vehicle means a light-duty motor vehicle that is specifically approved in an agency-s appropriation act for use in apprehension, surveillance, police, or other law enforcement work or specifically designed for use in law enforcement. If not identified in an agency’s appropriation language, a motor vehicle qualifies as a law enforcement motor vehicle only in the following cases: (1) A passenger automobile having heavy-duty components for electrical, cooling, and suspension systems and at least the next higher cubic inch displacement or more powerful engine than is standard for the automobile concerned (2) A light truck having emergency warning lights and identified with markings such as “police” (3) An unmarked motor vehicle certified by the agency head as essential for the safe and efficient performance of intelligence, counterintelligence, protective, or other law enforcement duties (4) A forfeited motor vehicle seized by a federal agency that subsequently is used for performing law enforcement activities (41 CFR Part 102-34.35).
Light-duty motor vehicle	Any motor vehicle with a GVWR of 8,500 pounds or less (41 CFR 102-34).
Light-duty truck	Light-duty truck means any motor vehicle rated at 8,500 pounds GVWR or less, which has a curb weight of 6,000 pounds or less and, which has a basic vehicle frontal area of 45 square feet or less, which is as follows: (1) Designed primarily for purposes of transportation of property or is a derivation of such a vehicle (2) Designed primarily for transportation of persons and has a capacity of more than 12 persons (3) Available with special features, enabling off-street or off-highway operation and use. LDT1 means any light light-duty truck up through 3,750-lb loaded vehicle weight. LDT2 means any light light-duty truck greater than 3,750-lb loaded vehicle weight.

	LDT3 means any heavy light-duty truck up through 5,750-lb adjusted loaded vehicle weight. LDT4 means any heavy light-duty truck greater than 5,750-lb adjusted loaded vehicle weight (US Government Printing Office 2009)
Light-duty vehicle	Light-duty vehicle means a passenger car or passenger car derivative capable of seating 12 passengers or less.
Low-speed vehicle	Low-speed vehicle means a motor vehicle (1) That is 4-wheeled (2) Whose speed attainable in 1.6 km (1 mile) is more than 32 kilometers per hour (20 miles per hour) and not more than 40 kilometers per hour (25 miles per hour) on a paved level surface (3) Whose GVWR is less than 1,361 kilograms (3,000 pounds) (49 CFR 571.3 – Definitions).
Medium-duty passenger vehicle	Medium-duty passenger vehicle means any heavy-duty vehicle (as defined in this subpart) with a GVWR of less than 10,000 pounds that is designed primarily for transportation of persons. The medium-duty passenger vehicle definition does not include any vehicle which (1) Is an "incomplete truck" as defined in this subpart (2) Has a seating capacity of more than 12 persons (3) Is designed for more than 9 persons in seating rearward of the driver's seat (4) Is equipped with an open cargo area (for example, a pick-up truck box or bed) of 72.0 inches in interior length or more. A covered box not readily accessible from the passenger compartment will be considered an open cargo area for purposes of this definition (US Government Printing Office 2009)
Model year	Model year means the manufacturer's annual production period (as determined by the administrator), which includes January 1 of such calendar year; provided that if the manufacturer has no annual production period, the term "model year" shall mean the calendar year (40 CFR 86-1803.01).
MPG	"MPG" or "mpg" means miles per gallon. This generally may be used to describe fuel economy as a quantity or it may be used as the units associated with a particular value.
MPGe	MPGe means miles per gallon equivalent. This generally is used to quantify a fuel economy value for vehicles that use a fuel other than gasoline. The value represents miles the vehicle can drive with the energy equivalent of one gallon of gasoline: (c) SCF means standard cubic feet (d) SUV means sport utility vehicle (e) CREE means carbon-related exhaust emissions [76 FR 39527, July 6, 2011].
Non-passenger automobile	A non-passenger automobile means an automobile that is not a passenger automobile or a work truck and includes vehicles described in paragraphs (a) and (b) of 49 CFR 523.5.

Owning agency	Owning agency means the executive agency that holds the vehicle title, manufacturer's Certificate of Origin or is the lessee of a commercial lease. This term does not apply to agencies that lease motor vehicles from the GSA fleet (41 CFR Part 102-34.35).
Passenger automobile	A passenger automobile is any automobile (other than an automobile capable of off-highway operation) manufactured primarily for use in the transportation of not more than 10 individuals (49 CFR 523.4 – Passenger automobile). A sedan or station wagon designed primarily to transport people (41 CFR 102-34).
Pickup truck	Pickup truck means a non-passenger automobile, which has a passenger compartment and an open cargo bed (49 CFR 523.2).
Plug-in hybrid electric vehicle	PHEV means a hybrid electric vehicle that has the capability to charge the battery from an off-vehicle electric source, such that the off-vehicle source cannot be connected to the vehicle while the vehicle is in motion (40 CFR 86.1803).
Vehicle class	The designation of motor vehicle types that include sedans, station wagons, ambulances, buses, and trucks, or different categories of vehicles according to Federal vehicle standards and further defined in 49 CFR 600.315-82.
Vehicle configuration	Vehicle configuration means a unique combination of basic engine, engine code, inertia weight class, transmission configuration, and axle ratio.
Vehicle days	The number of days a vehicle was driven or utilized during the (vehicle) study period.
Vehicle home base	The primary assigned outing beginning and ending parking location for the vehicle.
Vehicle study period	The time period the vehicle, within the study, has been equipped with a data logger.

Appendix B

SLBE Vehicle Data Sheets

Table B-1. SLBE vehicle index.

Vehicle Index						
Log	Fleet Vehicle Id	Make	Model	Year	EPA Class	Mission
21	G63-2883K	Ford	F150	2011	Pickup	Pool
22	I514830	Chevrolet	K2500	2012	Pickup	Support
23	I513632	Chevrolet	Colorado	2010	Pickup	Pool
24	I410692	Ford	F150	2007	Pickup	Pool
25	G620442M	Chevrolet	Tahoe	2012	SUV	Law Enforcement
26	I513822	Chevrolet	Silverado	2011	Pickup	Pool
27	I410688	Chevrolet	K2500	2007	Pickup	Pool
28	I515072	Chevrolet	Express Van	2013	Van - Cargo	Support
29	I410680	Dodge	Dakota	2007	Pickup	Support
30	G62-4494K	Chevrolet	Tahoe	2010	SUV	Law Enforcement
31	I510187	Chevrolet	Colorado	2006	Pickup	Support
32	I512719	Chevrolet	Impala	2010	Sedan - Large	Pool
33	I410690	Ford	F150	2007	Pickup	Pool
34	I410691	Ford	F150	2007	Pickup	Pool

Vehicle G63-2883K

	Make Model/Year	Ford F150/2011
	EPA Class Size	Pickup
	Mission	Pool
	VIN	1FTBF2B65BEC58718
	Parking Location	MT Yard
	Fleet Vehicle ID	G63-2883K
	Fuel Type	Gas
	EPA Label/MPG (City/Hwy/Combined)	16/22/18
	EPA GHG Emissions (Grams CO_2/Mi)	494
	Study Logger ID	21
	Total Vehicle Days/Total Study Days	56/92

Vehicle G63-2883K Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	48.4/91.6	10.5/74.4	3.6/27.1	2,710
Travel Time (Minutes)	153/333.0	33.3/311.0	11.5/111.0	8,582
Idle Time (Minutes)	28.5/NA	6.2/NA	2.1/NA	1,594

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	574	87.8%	Less than 2	564
10 to 20	79	12.1%	2 to 4	24
20 to 40	1	0.2%	4 to 8	10
40 to 60	0	0%	Greater than 8	56

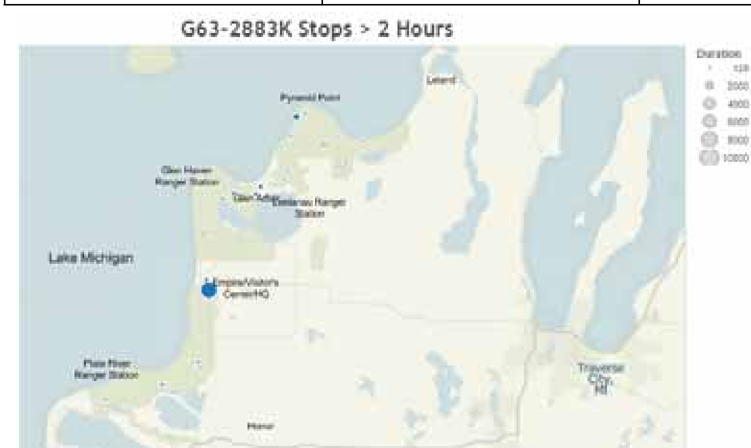


Figure B-1. Vehicle G63-2883K stops.

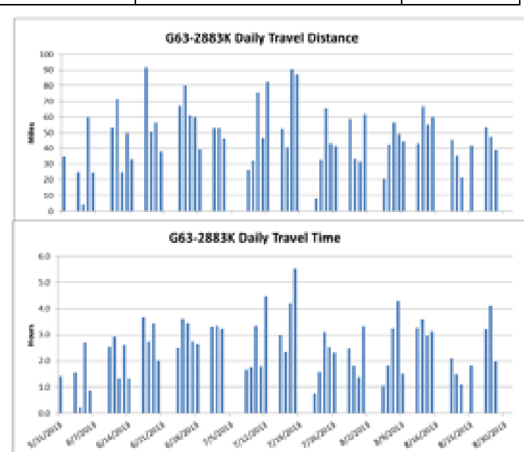


Figure B-2. Vehicle G63-2883K history.

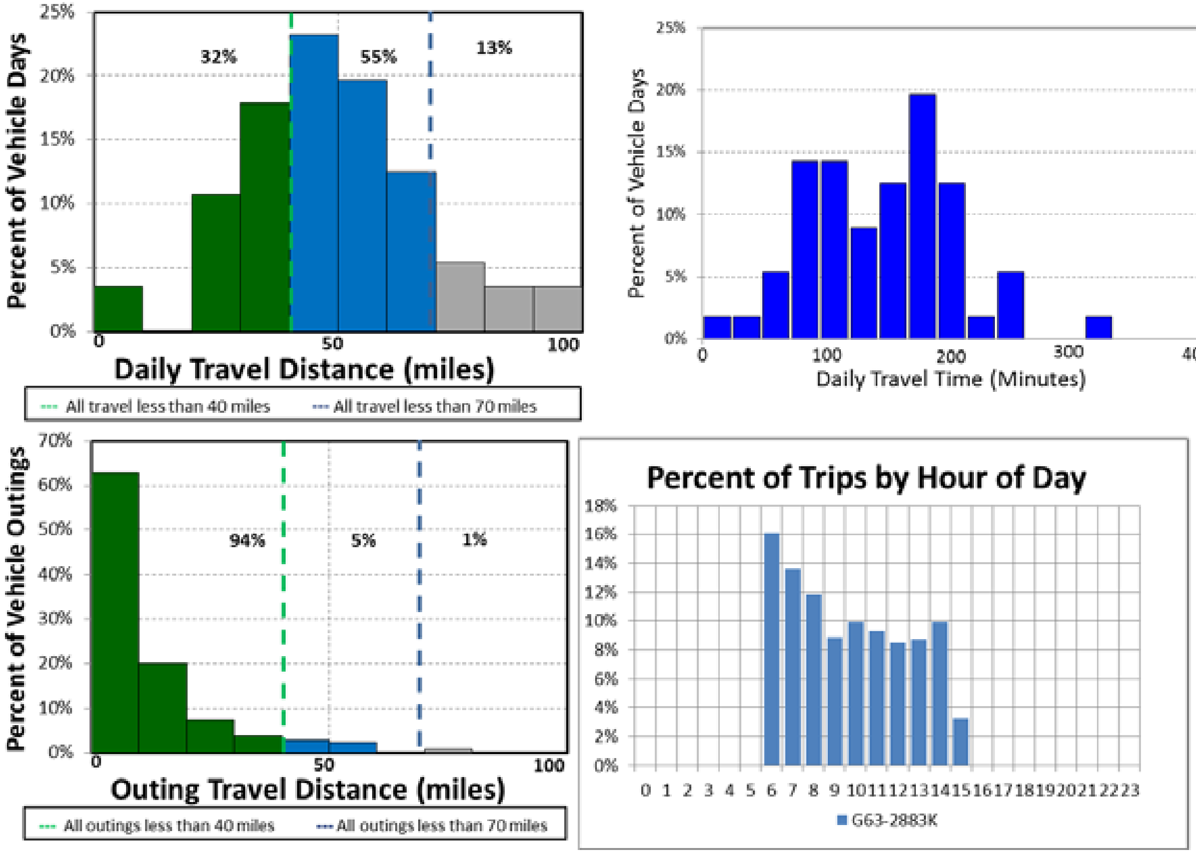


Figure B-3. Vehicle G63-2883K travel graphs.

Vehicle G63-2883K Observations

Logger 21 collected data on this vehicle for a period of 56 days of the 92-day study period. Validation occurred on 99.8% of the input data. Information provided on the vehicle survey for this vehicle indicated that this is a pool vehicle used by maintenance and typically parks in the MT Yard.

The reported odometer reading was 19,711 during the study period with an estimated usage of 11,831 miles/year. The vehicle was used on 61% of the available days, with an average daily usage of 2.6 hours and a peak daily usage of 5.6 hours on the days it was used. The vehicle was used during typical day shift hours.

Figure B-1 shows all stops exceeding 2-hour duration and shows that most occurred at the home base. Eighty-seven percent of daily travel and 99% of all outings were within the typically advertised range of a BEV of approximately 70 miles, with 13% of daily travel exceeding this range.

Figure B-3 shows 32% of daily travel and 94% of outings were within the typically advertised CD mode of 40 miles for PHEVs.

A BEV could meet 87% of the daily travel without additional charging opportunities. However, sufficient time exists daily for additional charging that could then meet 99% of outing usage. A fleet of BEVs and PHEVs is more likely to allow daily travel without requiring additional charge times, providing the PEV meets the other mission requirements. The survey information suggests no other special requirements exist other than maintenance activities.

Vehicle I514830

Make/Model/Year	Chevrolet K2500/2012
EPA Class Size	Pickup
Mission	Support
VIN	1GB2KVCG3DZ159626
Parking Location	MT Yard
Fleet Vehicle ID	I514830
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy/Combined)*	15/22/18 11/16/13
EPA GHG Emissions (Grams CO_2/Mi)*	494/484
Study Logger ID	22
Total Vehicle Days/Total Study Days	43/89

Vehicle I514830 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	50.0/109.7	14.1/94.5	4.3/23.8	2,152
Travel Time (Minutes)	106/233.0	29.7/182.0	9.2/41.0	4,544
Idle Time (Minutes)	6.6/NA	1.9/NA	0.6/NA	284

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	446	92.3%	Less than 2	419
10 to 20	37	7.7%	2 to 4	15
20 to 40	0	0%	4 to 8	10
40 to 60	0	0%	Greater than 8	39

Figure B-4. Vehicle I514830 stops.

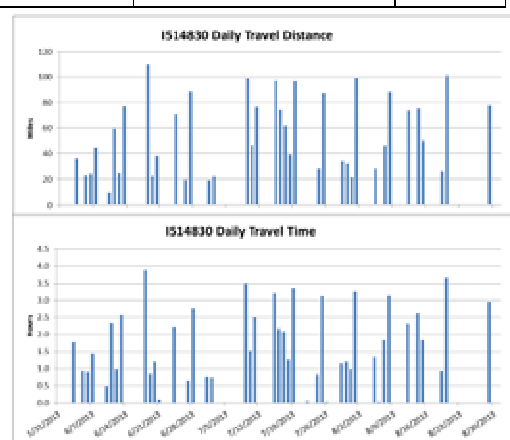


Figure B-5. Vehicle I514830 history.

*Chevrolet K2500 pickup not listed. Information is for Silverado C15 flex fuel.

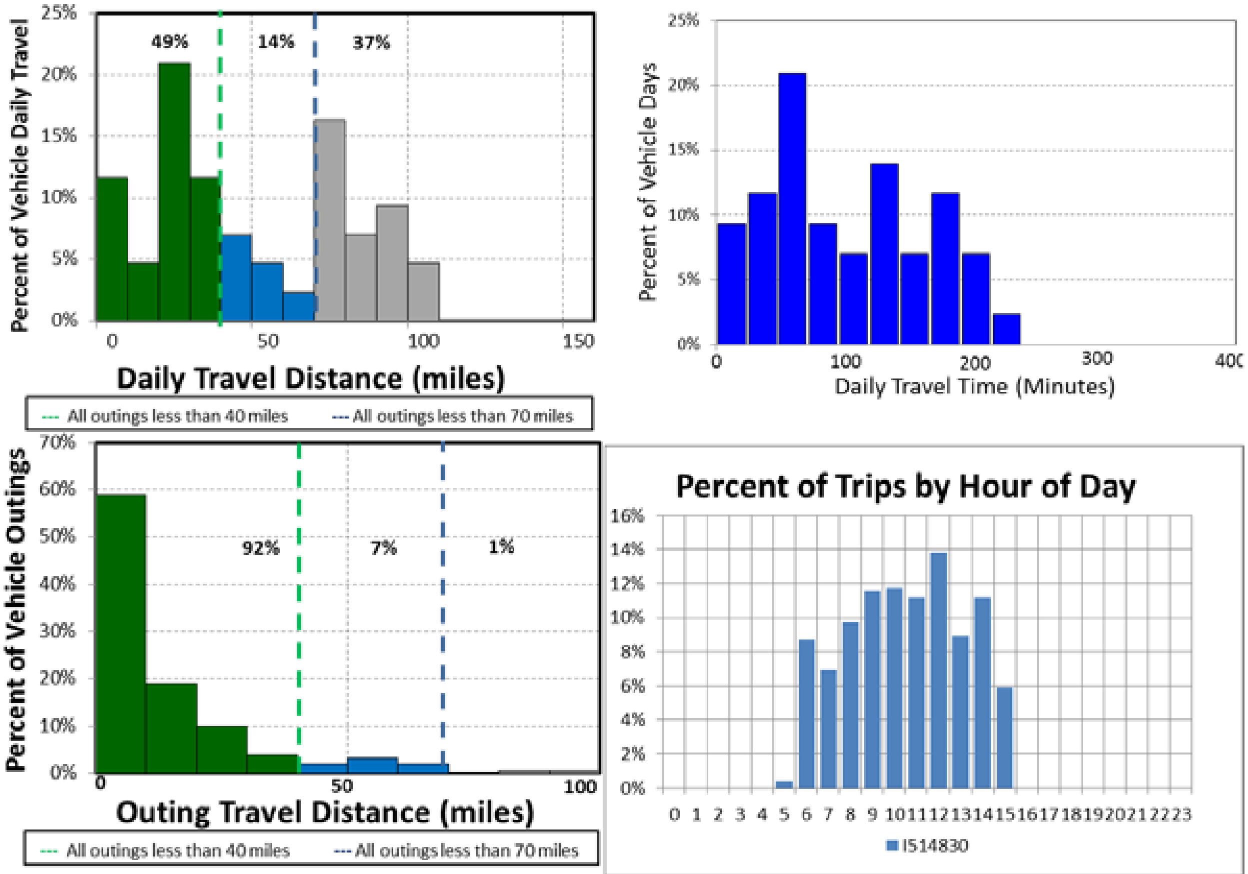


Figure B-4. Vehicle I514830 travel graphs.

Vehicle I514830 Observations

Logger 22 collected data on this vehicle for a period of 43 days of the 89-day study period. Validation occurred on 99.6% of the input data. Information provided on the vehicle survey for this vehicle indicated that this is a support vehicle used by maintenance and typically parks in the MT Yard.

The reported odometer reading was 4,462 during the study period. An estimated annual usage was not available. The vehicle was used on 48% of the available days, with an average daily usage of 1.8 hours and a peak daily usage of 3.9 hours on the days it was used. The vehicle was used during typical day shift hours.

Figure B-4 shows all stops exceeding 2-hour duration and shows that most occurred at the home base. Sixty-three percent of daily travel and 99% of all outings are within the typically advertised range of a BEV of approximately 70 miles, with 37% of daily travel exceeding this range.

Figure B-6 shows 49% of daily travel and 92% of outings are within the typically advertised CD mode of 40 miles for PHEVs.

A BEV could meet 63% of the daily travel without additional charging opportunities. However, sufficient time exists daily for additional charging that could then meet 99% of outing usage. A fleet of BEVs and PHEVs is more likely to allow daily travel without requiring additional charge times, providing the PEV meets the other mission requirements. The survey information suggests no other special requirements exist other than maintenance activities.

Vehicle I513632

Make/Model/Year	Chevrolet Colorado/2010
EPA Class Size	Pickup
Mission	Pool
VIN	1GCJTCDE2A8112207
Parking Location	BOQ
Fleet Vehicle ID	I513632
Fuel Type	Gas
EPA Label/MPG (City/Hwy/Combined)	18/25/21
EPA GHG Emissions (Grams CO_2/Mi)	423
Study Logger ID	23
Total Vehicle Days/Total Study Days	49/89

Vehicle I513632 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	34.7/80.1	10.0/71.0	2.8/31.4	1,702
Travel Time (Minutes)	91/184.0	26.3/159.0	7.3/83.0	4,475
Idle Time (Minutes)	10.4/NA	3.0/NA	0.8/NA	511

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	462	87.8%	Less than 2	461
10 to 20	60	11.4%	2 to 4	12
20 to 40	4	0.8%	4 to 8	8
40 to 60	0	0%	Greater than 8	45

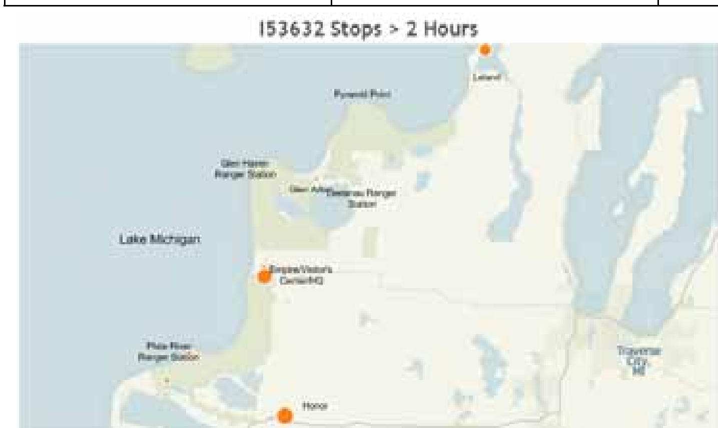


Figure B-7. Vehicle I513632 stops.

Figure B-8. Vehicle I513632 history.

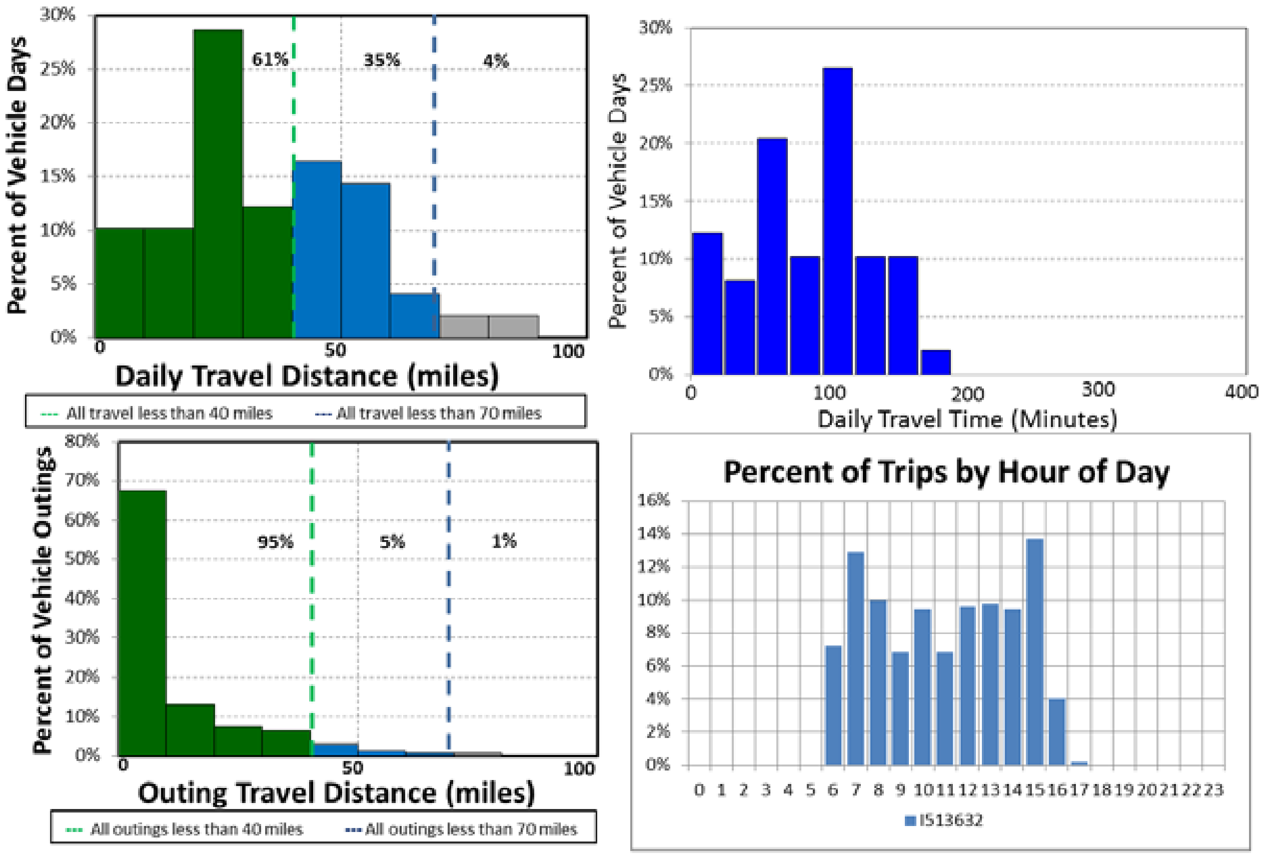


Figure B-5. Vehicle I513632 travel graphs.

Vehicle I513632 Observations

Logger 23 collected data on this vehicle for a period of 49 days of the 89-day study period. Validation occurred on 100% of the input data. Information provided on the vehicle survey for this vehicle indicated that this is a pool vehicle that typically parks at the BOQ.

The reported odometer reading was 17,739 during the study period, with an estimated annual usage of 6,579 miles. The vehicle was used on 55% of the available days, with an average daily usage of 1.5 hours and a peak daily usage of 3.1 hours on the days it was used. The vehicle was used during typical day shift hours.

Figure B-7 shows all stops exceeding the 2-hour duration and, while some of greater than 2 hours occurred away from the home base, the figure shows that most occurred at the home base. Seventy-percent of stops occurred in Empire and 18% in Lake.

Figure B-9 shows 96% of daily travel and 99% of all outings are within the typically advertised range of a BEV of approximately 70 miles, with 4% of daily travel exceeding this range.

Sixty-one percent of daily travel and 95% of outings are within the typically advertised CD mode of 40 miles for PHEVs.

A BEV could meet 96% of the daily travel without additional charging opportunities. However, sufficient time exists daily for additional charging that could then meet 99% of outing usage. A fleet of BEVs and PHEVs is more likely to allow daily travel without requiring additional charge times, providing the PEV meets the other mission requirements. The survey information suggests that no other special requirements exist.

Vehicle I410692

Make/Model/Year	Ford F150/2007
EPA Class Size	Pickup
Mission	Pool
VIN	1FTPF122V97KD4226
Parking Location	MT Yard
Fleet Vehicle ID	I410692
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy)	13/18/15 10/13/11
EPA GHG Emissions (Grams CO_2/Mi)	529/572
Study Logger ID	24
Total Vehicle Days/Total Study Days	72/91

Vehicle I410692 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	64.7/111.3	31.1/87.6	2.9/19.7	4,659
Travel Time (Minutes)	171/280.0	82.1/233.0	7.6/78.0	12,309
Idle Time (Minutes)	18.7/NA	9.0/NA	0.8/NA	1,347

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	1,297	87.5%	Less than 2	1,402
10 to 20	186	12.5%	2 to 4	7
20 to 40	0	0%	4 to 8	2
40 to 60	0	0%	Greater than 8	72

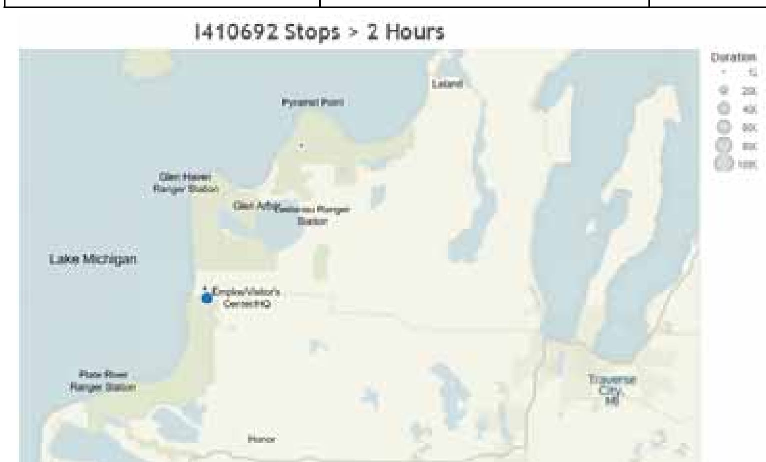


Figure B-10. Vehicle I410692 stops.

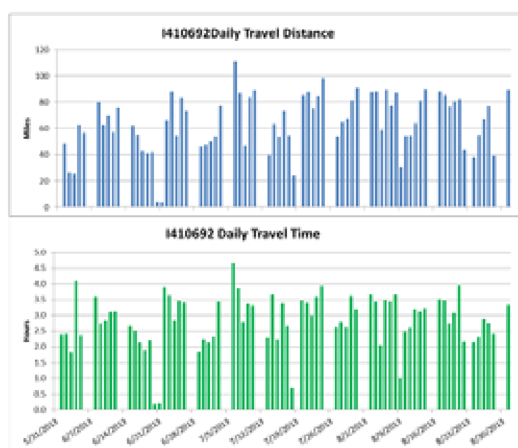


Figure B-11. Vehicle I410692 history.

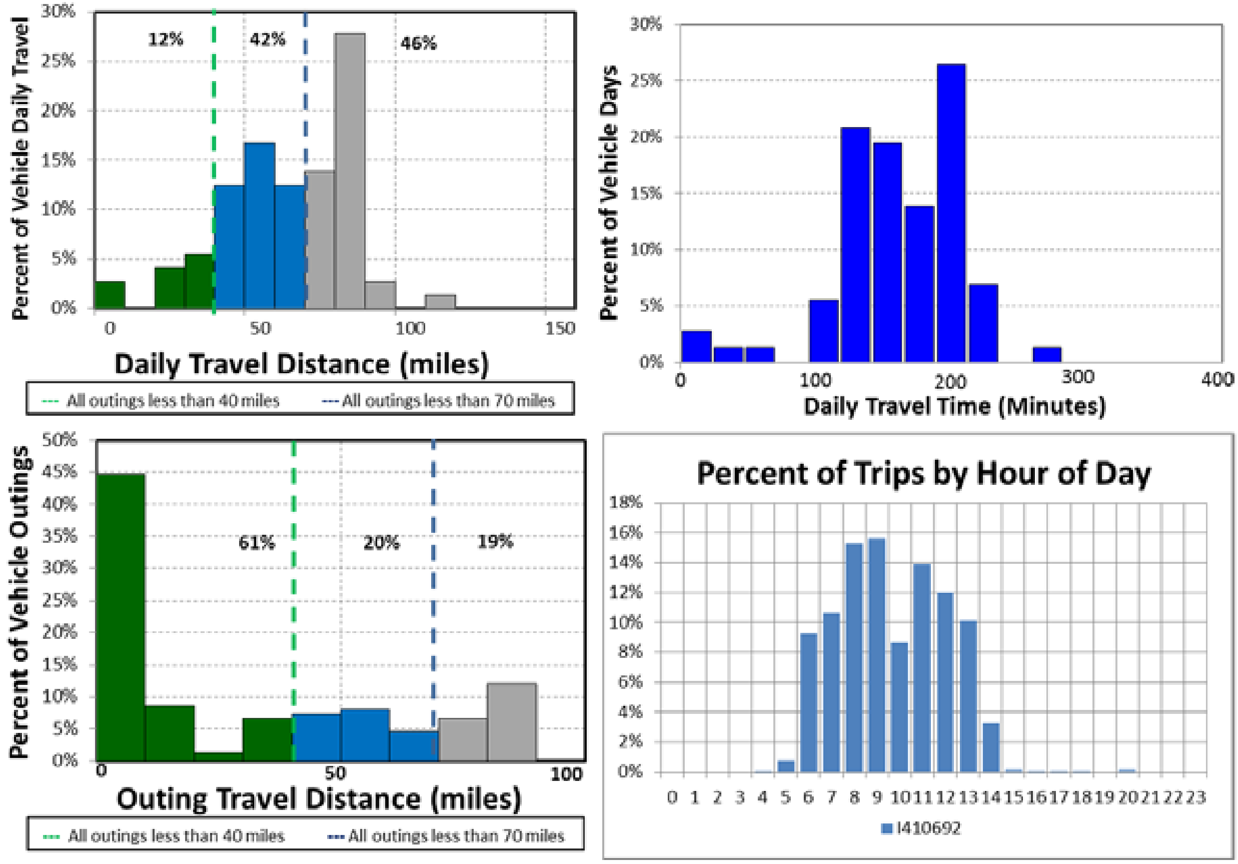


Figure B-6. Vehicle I410692 travel graphs.

Vehicle I410692 Observations

Logger 24 collected data on this vehicle for a period of 72 days of the 91-day study period. Validation occurred on 99.9% of the input data. Information provided on the vehicle survey for this vehicle indicated that this is a pool vehicle that typically parks at the MT Yard.

The reported odometer reading was 49,716 during the study period, with an estimated annual usage of 7,656 miles. The vehicle was used on 79% of the available days, with an average daily usage of 2.8 hours and a peak daily usage of 4.7 hours on the days it was used. The vehicle was used during typical day shift hours.

Figure B-10 shows most stops exceeding the 2-hour duration occurred at the home base.

Figure B-12 shows 54% of daily travel and 81% of all outings are within the typically advertised range of a BEV of approximately 70 miles, with 46% of daily travel exceeding this range.

Twelve percent of daily travel and 61% of outings are within the typically advertised CD mode of 40 miles for PHEVs.

A BEV would have a more difficult time of meeting the daily requirements of this vehicle. A fleet of BEVs and PHEVs in the pool fleet is more likely to allow daily travel without requiring additional charge times, providing the PEV meets the other mission requirements. The survey information suggests that no other special requirements exist other than maintenance activities.

Vehicle G62-0442M

Make/Model/Year	Chevrolet Tahoe/2012
EPA Class Size	SUV
Mission	Law Enforcement
VIN	1GNSK4E0XCR306391
Parking Location	Platte Ranger Station
Fleet Vehicle ID	G62-0442M
Fuel Type	Gas/E85
EPA Label / MPG (City/Hwy)	15/21/17 11/16/13
EPA GHG Emissions (Grams CO_2/Mi)	523/484
Study Logger ID	25
Total Vehicle Days/Total Study Days	61/92

Vehicle G62-0442M Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	80.4/144.2	37.4/171.5	7.3/54.4	4,903
Travel Time (Minutes)	248/525.0	115.3/468	22.4/251.0	15,103
Idle Time (Minutes)	70.4	32.8/NA	6.4/NA	4,296

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	903	96.5%	Less than 2	848
10 to 20	27	2.9%	2 to 4	23
20 to 40	5	0.5%	4 to 8	5
40 to 60	0	0%	Greater than 8	60

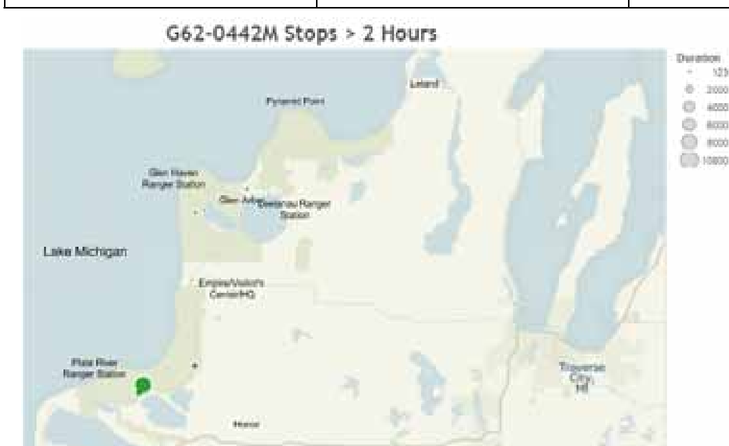


Figure B-13. Vehicle G62-0442M stops.

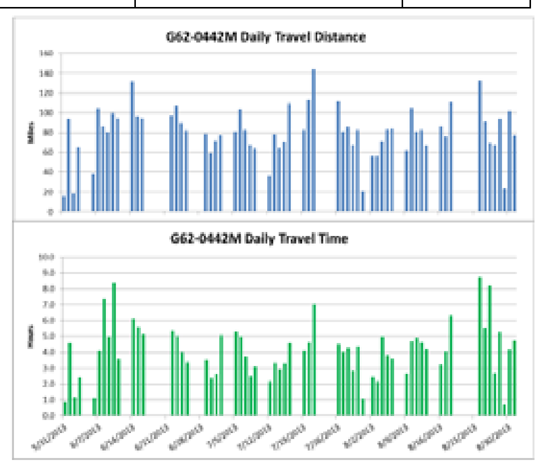


Figure B-14. Vehicle G62-0442M history.

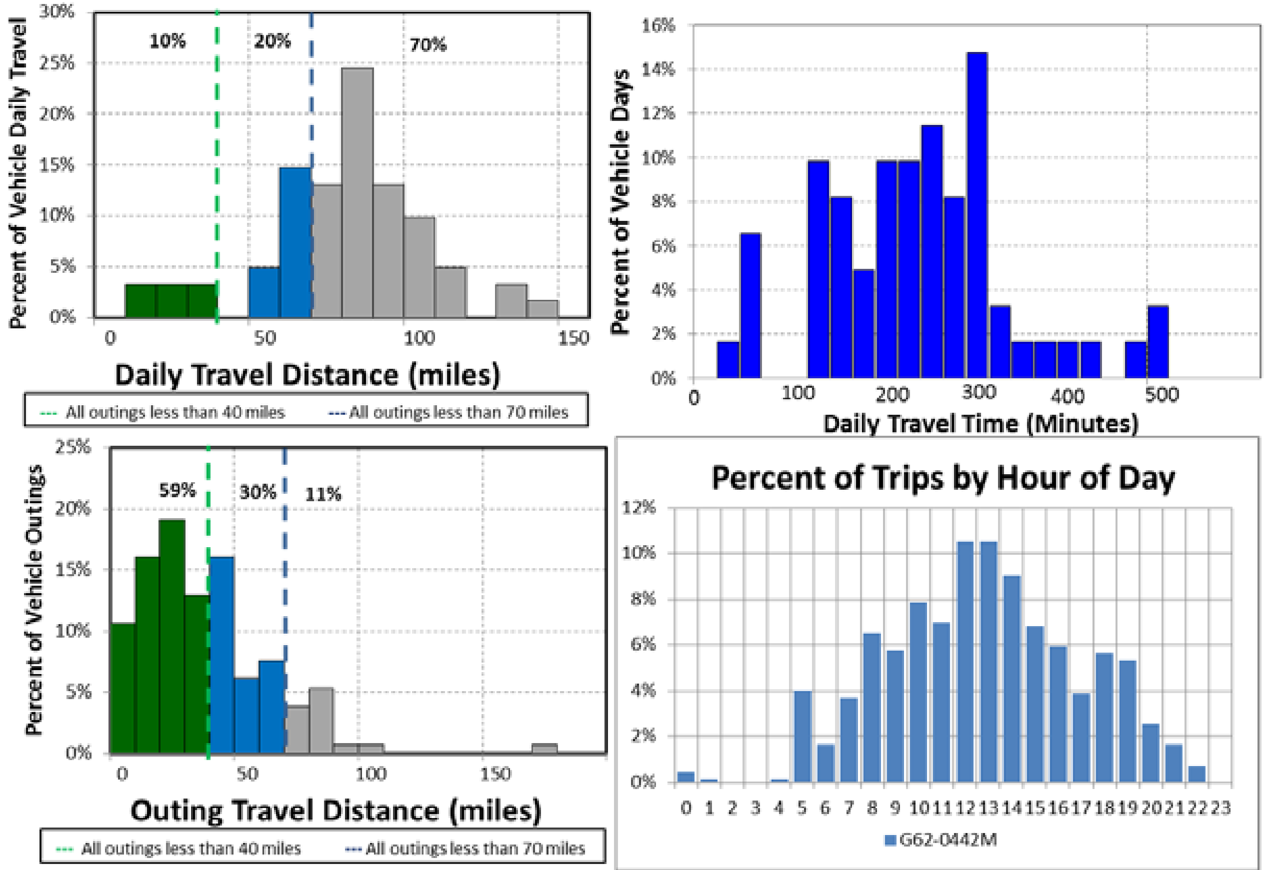


Figure B-7. Vehicle G62-0442M travel graphs.

Vehicle G62-0442M Observations

Logger 25 collected data on this vehicle for a period of 61 days of the 92-day study period. Validation occurred on 99.2% of the input data. Information provided on the vehicle survey for this vehicle indicated that this is a law enforcement vehicle that typically parks at the Platte Ranger Station.

The reported odometer reading was 16,748 during the study period, with an estimated annual usage of 10,000 miles. The vehicle was used on 66% of the available days, with an average daily usage of 4.1hours and a peak daily usage of 8.8 hours on the days it was used. The vehicle was used throughout the day with emphasis on typical day shift hours.

Figure B-13 shows most stops exceeding the 2-hour duration occurred at the home base.

Figure B-15 shows that 30% of daily travel and 89% of all outings are within the typically advertised range of a BEV of approximately 70 miles, with 70% of daily travel exceeding this range.

Ten percent of daily travel and 59% of outings are within the typically advertised CD mode of 40 miles for PHEVs.

A PHEV would best be able to meet the daily requirements of this vehicle, providing the PHEV meets the other mission requirements. The survey information suggests that no other special requirements exist that is typical of law enforcement vehicles.

Vehicle I513822

Make/Model/Year	Chevrolet Silverado/2011
EPA Class Size	Pickup
Mission	Pool
VIN	1GC0KVCG4BF145770
Parking Location	MT Yard
Fleet Vehicle ID	I513822
Fuel Type	Gas
EPA Label/MPG (City/Hwy/Combined)	15/20/17
EPA GHG Emissions (Grams CO_2/Mi)	523
Study Logger ID	26
Total Vehicle Days/Total Study Days	60/92

Vehicle I513822 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	48.0/138.1	9.8/84.9	4.7/32.9	2,879
Travel Time (Minutes)	99.0/260.0	20.1/149.0	9.8/51.0	5,943
Idle Time (Minutes)	8.7/NA	1.8/NA	0.9/NA	519

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	377	73.6%	Less than 2	426
10 to 20	21	4.1%	2 to 4	13
20 to 40	114	22.3%	4 to 8	13
40 to 60	0	0%	Greater than 8	60

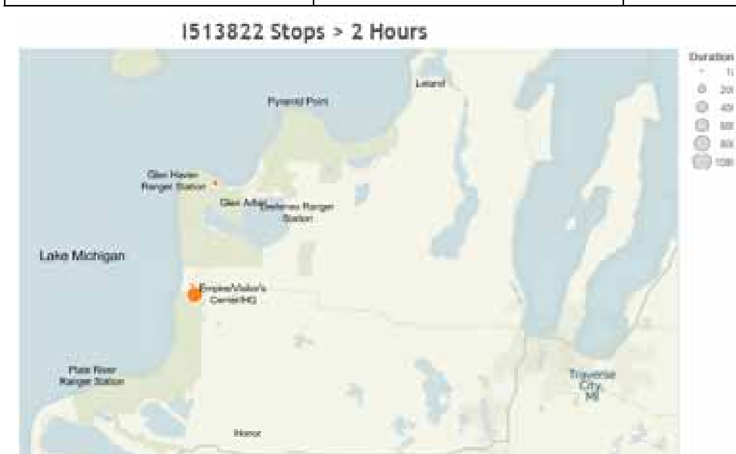


Figure B-16. Vehicle I513822 stops.

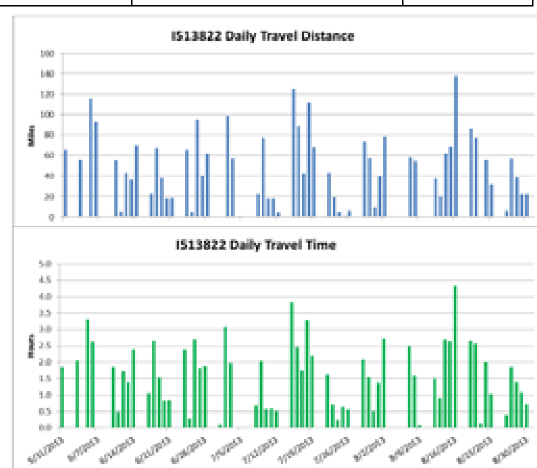


Figure B-17. Vehicle I513822 history.

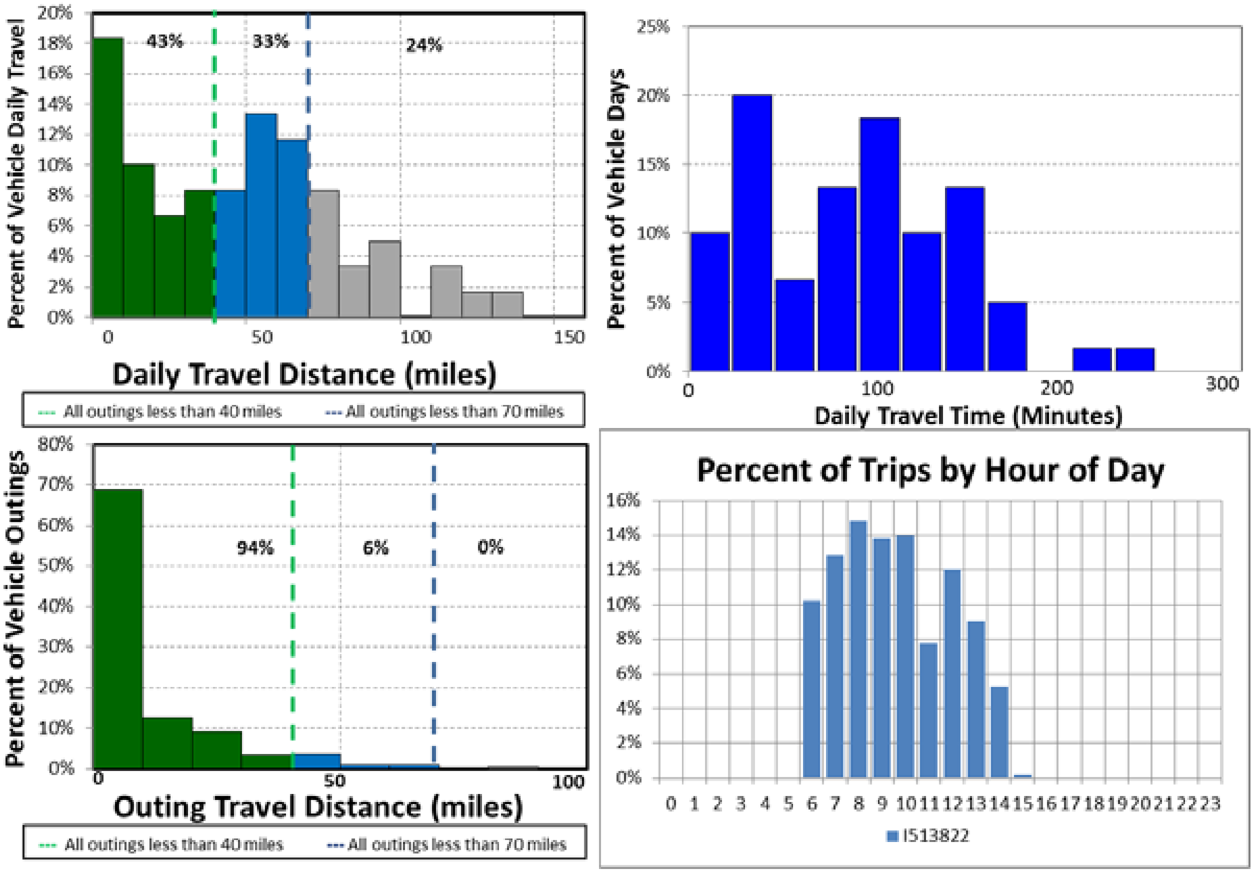


Figure B-8. Vehicle I513822 travel graphs.

Vehicle I513822 Observations

Logger 26 collected data on this vehicle for a period of 60 days of the 92-day study period. Validation occurred on 100% of the input data. Information provided on the vehicle survey for this vehicle indicated that this is a pool vehicle that typically parks at the MT Yard.

The reported odometer reading was 23,750 during the study period, with an estimated annual usage of 7,173 miles. The vehicle was used on 65% of the available days, with an average daily usage of 1.7 hours and a peak daily usage of 4.3 hours on the days it was used. The vehicle was used during typical day shift hours.

Figure B-16 shows most stops exceeding the 2-hour duration occurred at the home base.

Figure B-18 shows 76% of daily travel and 100% of all outings are within the typically advertised range of a BEV of approximately 70 miles, with 24% of daily travel exceeding this range.

Forty-three percent of daily travel and 94% of outings are within the typically advertised CD mode of 40 miles for PHEVs.

A BEV would have a difficult time of meeting the daily requirements of this vehicle. A fleet of BEVs and PHEVs in the pool fleet is more likely to allow daily travel without requiring additional charge times, providing the PEV meets the other mission requirements. The survey information suggests that no other special requirements exist other than maintenance activities.

Vehicle I410688

Make/Model/Year	Chevrolet K2500/2007
EPA Class Size	Pickup
Mission	Pool
VIN	1GCHK24U77E172190
Parking Location	MT Yard
Fleet Vehicle ID	I410688
Fuel Type	Gas
EPA Label/MPG (City/Hwy)*	15/21/17
EPA GHG Emissions (Grams CO_2/Mi)*	523
Study Logger ID	27
Total Vehicle Days/Total Study Days	40/92

Vehicle I410688 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	33.3/71.0	7.6/68.0	3.2/30.2	1,331
Travel Time (Minutes)	88/164.0	20.1/151.0	8.6/54.0	3,531
Idle Time (Minutes)	9.9/NA	2.3/NA	1.0/NA	396

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	295	92.5%	Less than 2	232
10 to 20	24	7.5%	2 to 4	41
20 to 40	0	0%	4 to 8	8
40 to 60	0	0%	Greater than 8	38

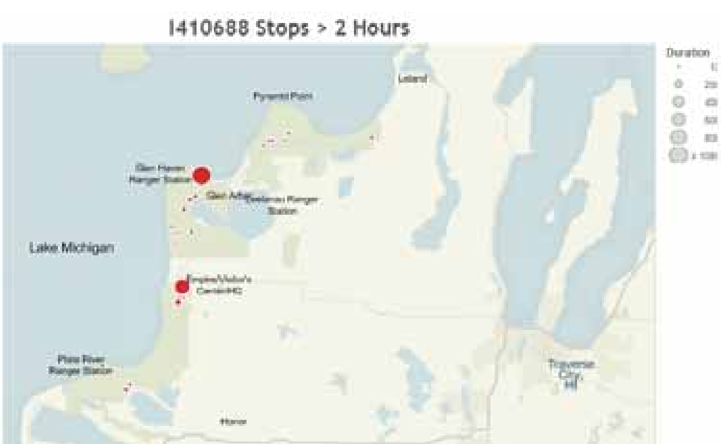


Figure B-19. Vehicle I410688 stops.

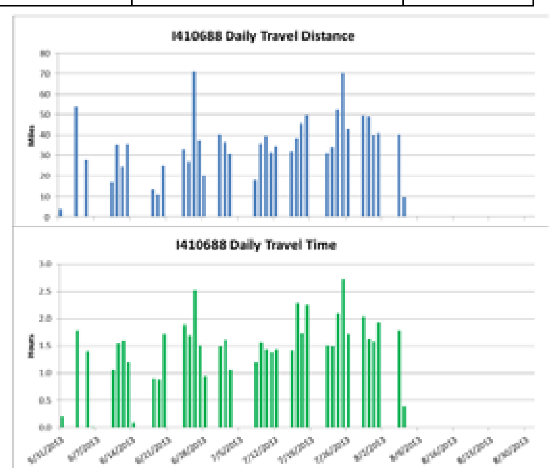


Figure B-20. Vehicle I410688 history.

*Information for K2500 not available. Silverado 1500 information provided.

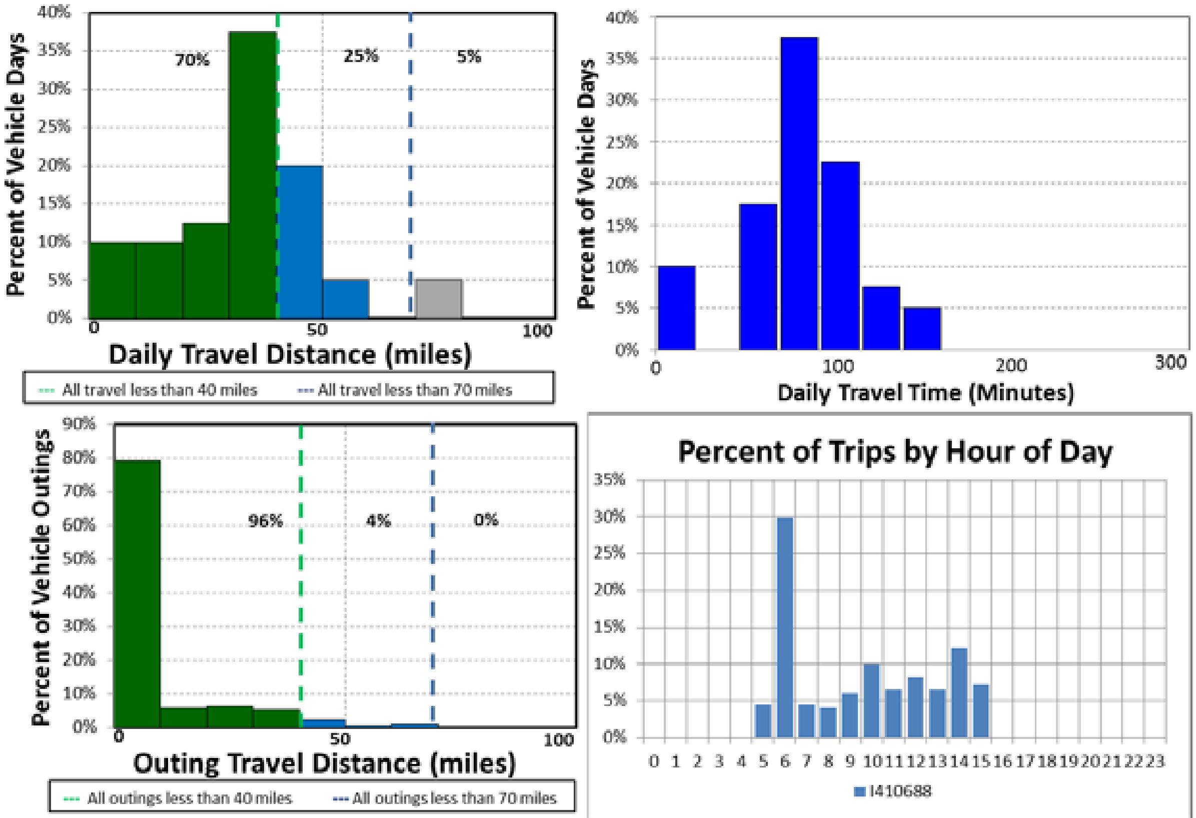


Figure B-9. Vehicle I410688 travel graphs.

Vehicle I410688 Observations

Logger 27 collected data on this vehicle for a period of 40 days of the 92-day study period. Validation occurred on 99.9% of the input data. Information provided on the vehicle survey for this vehicle indicated that this is a pool vehicle that typically parks at the MT Yard.

The reported odometer reading was 38,548 during the study period, with an estimated annual usage of 4,441 miles. The vehicle was used on 43% of the available days, with an average daily usage of 1.5 hours and a peak daily usage of 2.7 hours on the days it was used. The vehicle was used during typical day shift hours.

Figure B-19 shows stops exceeding the 2-hour duration occurred at the home base and the Dunes area.

Figure B-21 shows 95% of daily travel and 100% of all outings are within the typically advertised range of a BEV of approximately 70 miles, with 5% of daily travel exceeding this range.

Seventy percent of daily travel and 96% of outings are within the typically advertised CD mode of 40 miles for PHEVs.

A BEV could meet 95% of the daily travel without additional charging opportunities. However, sufficient time exists daily for additional charging that could then meet all usage. This would work well in a fleet of BEVs and PHEVs to allow daily travel without requiring additional charge times, providing the PEV meets the other mission requirements. The survey information suggests that no other special requirements exist other than maintenance activities.

Vehicle I515072

Make/Model/Year	Chevrolet Express Van/2013
EPA Class Size	Van - Cargo
Mission	Support
VIN	1GCWGFCA6D1131818
Parking Location	MT Yard
Fleet Vehicle ID	I515072
Fuel Type	Gas
EPA Label/MPG (City/Hwy)	15/20/17
EPA GHG Emissions (Grams CO_2/Mi)	529
Study Logger ID	28
Total Vehicle Days/Total Study Days	58/92

Vehicle I515072 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	45.2/145.9	10.2/84.8	4.9/37.8	2,624
Travel Time (Minutes)	111/264.0	25.0/162.0	12.1/118.0	6,443
Idle Time (Minutes)	22.6/NA	5.1/NA	2.4/NA	1,308

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	445	92.7%	Less than 2	393
10 to 20	24	5.0%	2 to 4	16
20 to 40	11	2.3%	4 to 8	14
40 to 60	0	0%	Greater than 8	57

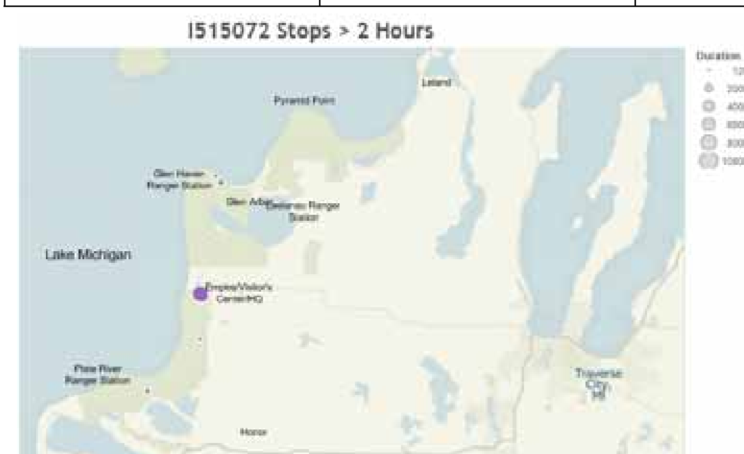


Figure B-22. Vehicle I515072 stops.

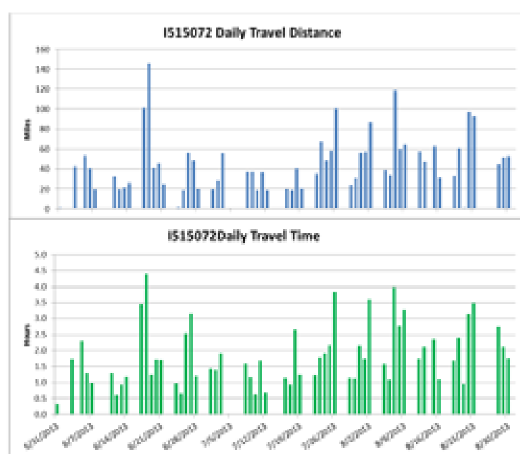


Figure B-23. Vehicle I515072 history.

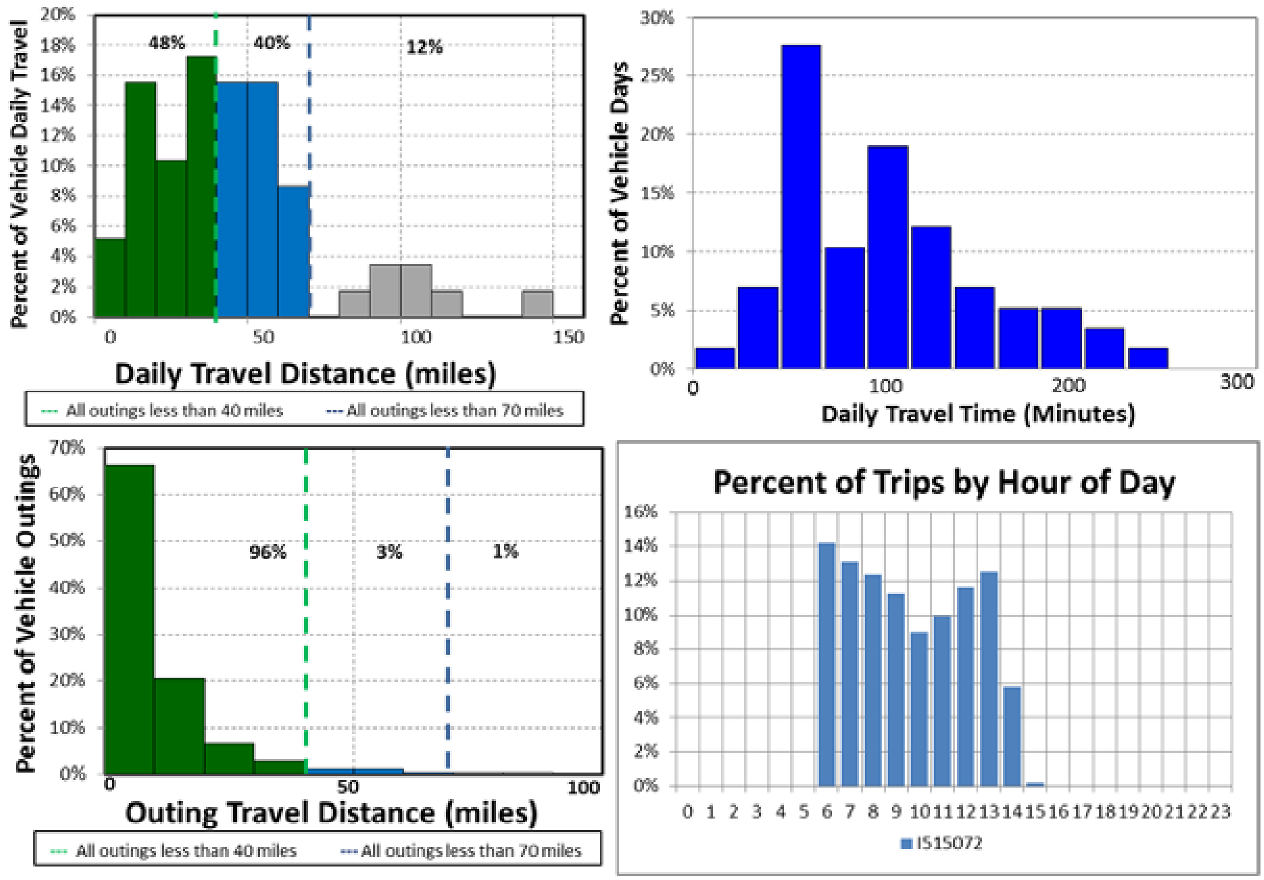


Figure B-10. Vehicle I515072 travel graphs.

Vehicle I515072 Observations

Logger 28 collected data on this vehicle for a period of 58 days of the 92-day study period. Validation occurred on 100% of the input data. Information provided on the vehicle survey for this vehicle indicated that this is a pool vehicle that typically parks at the MT Yard.

The reported odometer reading was 1,583 during the study period. The estimated annual usage was not available. The vehicle was used on 63% of the available days, with an average daily usage of 1.8 hours and a peak daily usage of 4.4 hours on the days it was used. The vehicle was used during typical day shift hours.

Figure B-22 shows stops exceeding the 2-hour duration typically occurred at the home base.

Figure B-24 shows 88% of daily travel and 99% of all outings are within the typically advertised range of a BEV of approximately 70 miles, with 12% of daily travel exceeding this range.

Forty-eight percent of daily travel and 96% of outings are within the typically advertised CD mode of 40 miles for PHEVs.

A BEV could meet 88% of the daily travel without additional charging opportunities. However, sufficient time exists daily for additional charging that could then meet 96% of all outings. This would work well in a fleet of BEVs and PHEVs to allow daily travel without requiring additional charge times, providing the PEV meets the other mission requirements. The survey information suggests that no other special requirements exist other than maintenance activities. Because this was the only cargo van monitored, a PHEV is suggested.

Vehicle I410680

Make/Model/Year	Dodge Dakota/2007
EPA Class Size	Pickup
Mission	Support
VIN	1D3HE28K27S242297
Parking Location	Crescent Dr., Empire
Fleet Vehicle ID	I410680
Fuel Type	Gas
EPA Label/MPG (City/Hwy)	15/20/17
EPA GHG Emissions (Grams CO_2/Mi)	523
Study Logger ID	29
Total Vehicle Days/Total Study Days	47/92

Vehicle I410680 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	37.8/156.7	23.1/77.8	5.0/30.5	1,777
Travel Time (Minutes)	78/287.0	47.4/193.0	10.3/55.0	3,648
Idle Time (Minutes)	5.1/NA	3.1/NA	0.7/NA	240

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	306	92.4$	Less than 2	271
10 to 20	14	4.2%	2 to 4	8
20 to 40	11	3.3%	4 to 8	4
40 to 60	0	0%	Greater than 8	48

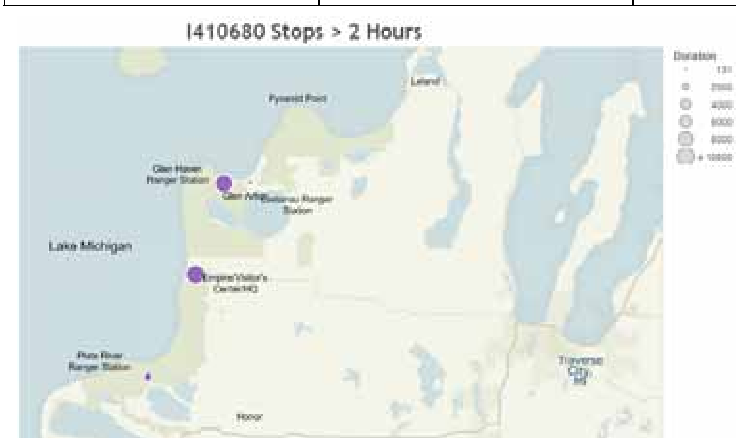


Figure B-25. Vehicle I410680 stops.

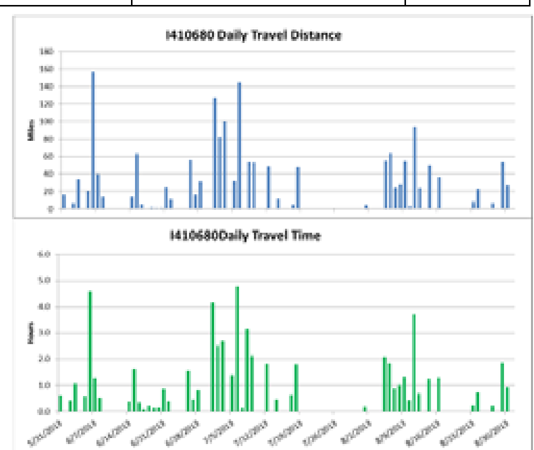


Figure B-26. Vehicle I410680 history.

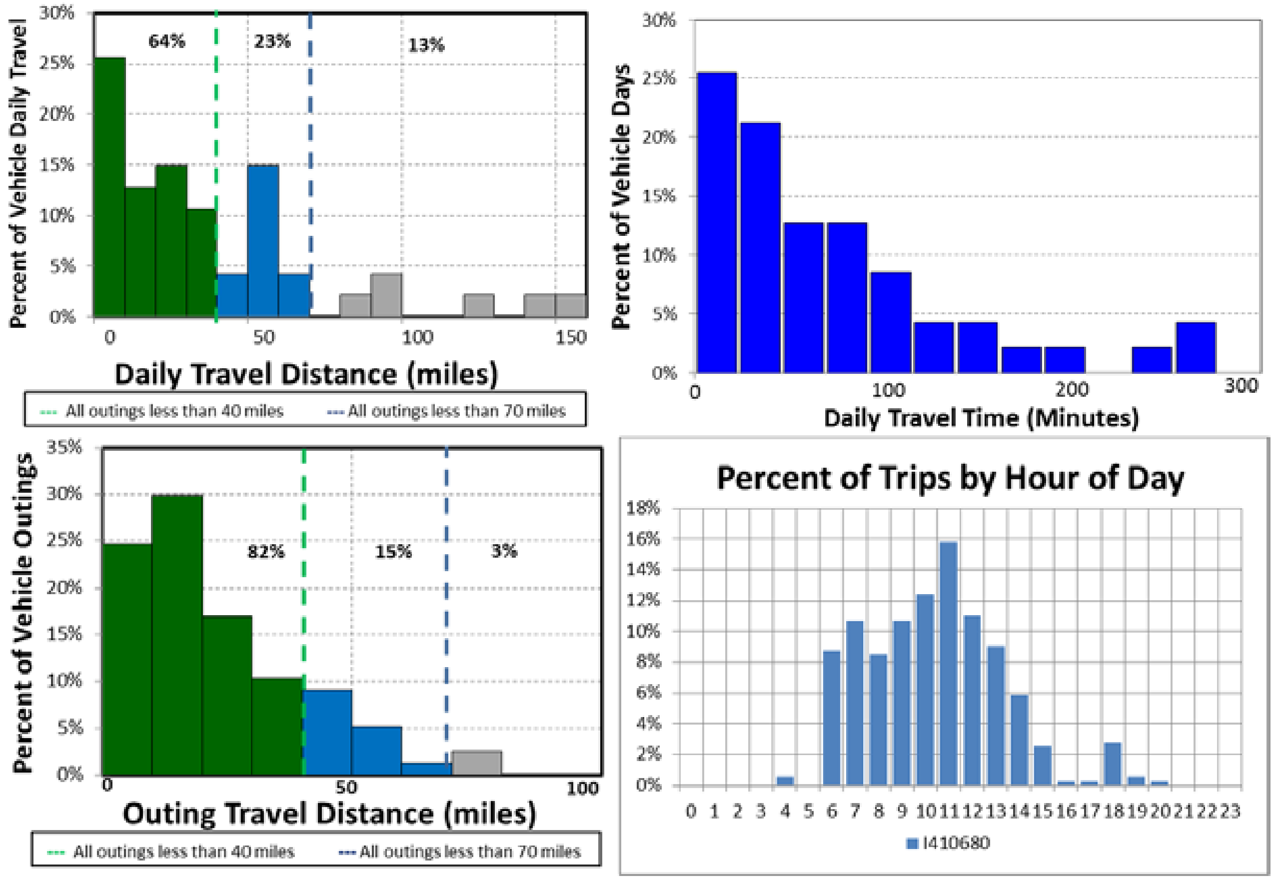


Figure B-11. Vehicle I410680 travel graphs.

Vehicle I410680 Observations

Logger 29 collected data on this vehicle for a period of 47 days of the 92-day study period. Validation occurred on 100% of the input data. Information provided on the vehicle survey for this vehicle indicated that this is a support vehicle that typically parks at the Platte station and is assigned to fees.

The reported odometer reading was 28,156 during the study period, with an estimated annual usage of 5,285 miles. The vehicle was used on 51% of the available days, with an average daily usage of 1.3 hours and a peak daily usage of 4.8 hours on the days it was used. The vehicle was used during typical day shift hours.

Figure B-25 shows the vehicle split its time between Glen Arbor and Empire. The data indicate the primary home base is on Crescent Dr. in Empire.

Figure B-27 shows 87% of daily travel and 97% of all outings are within the typically advertised range of a BEV of approximately 70 miles, with 13% of daily travel exceeding this range.

Sixty-four percent of daily travel and 82% of outings are within the typically advertised CD mode of 40 miles for PHEVs.

A BEV would have a difficult time of meeting the daily requirements of this vehicle. A fleet of BEVs and PHEVs in the support fleet is more likely to allow daily travel without requiring additional charge times, providing the PEV meets the other mission requirements. The survey information suggests that no other special requirements exist.

Vehicle G62-4494K

Make/Model/Year	Chevrolet Tahoe/2010
EPA Class Size	SUV
Mission	Law Enforcement
VIN	1GNUKAE07AR278716
Parking Location	Leelanau Ranger Station
Fleet Vehicle ID	G62-4494K
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy)	15/21/17 11/16/13
EPA GHG Emissions (Grams CO_2/Mi)	523/484
Study Logger ID	30
Total Vehicle Days/Total Study Days	No data

Vehicle G62-4494K Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/10.0/Peak	Total
Travel Distance (Miles)				
Travel Time (Minutes)				
Idle Time (Minutes)				

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10			Less than 2	
10 to 20			2 to 4	
20 to 40			4 to 8	
40 to 60			Greater than 8	

Vehicle G62-4494K Observations

No data were transmitted for unknown reasons.

Information provided on the vehicle survey for this vehicle indicated that this is a law enforcement vehicle that typically parks at the Leelanau Ranger Station.

The reported odometer reading was 43,176 during the study period, with an estimated annual usage of 13,949 miles.

Vehicle I510187

Make/Model/Year	Chevrolet Colorado/2006
EPA Class Size	Pickup
Mission	Support
VIN	1GCCS136768264212
Parking Location	Leelanau Fees
Fleet Vehicle ID	I510187
Fuel Type	Gas
EPA Label/MPG (City/Hwy)	18/25/21
EPA GHG Emissions (Grams CO_2/Mi)	423
Study Logger ID	31
Total Vehicle Days/Total Study Days	35/91

Vehicle I510187Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	24.2/91.1	9.5/73.7	3.3/27.8	848
Travel Time (Minutes)	75/255.0	29.4/232.0	10.3/63.0	2,617
Idle Time (Minutes)	14.3/NA	5.6/NA	2.0/NA	502

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	256	97.7%	Less than 2	212
10 to 20	5	1.9%	2 to 4	13
20 to 40	1	0.4%	4 to 8	3
40 to 60	0	0%	Greater than 8	34

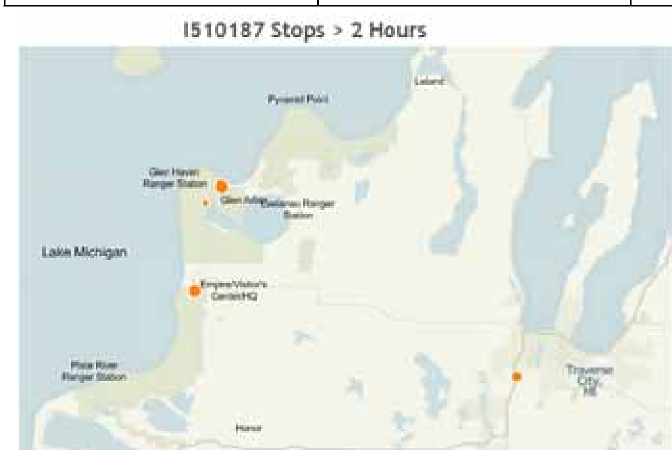


Figure B-28. Vehicle I510187 stops.

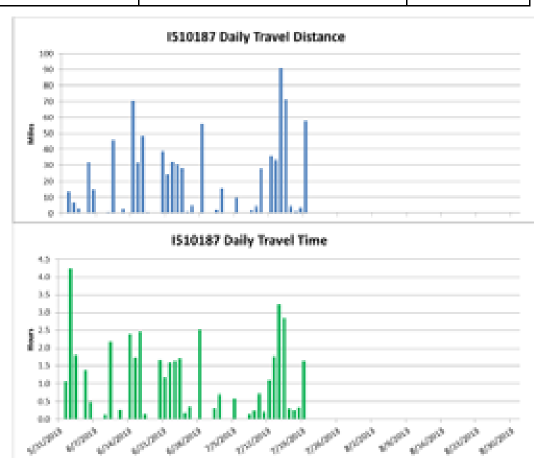


Figure B-29. Vehicle I510187 history.

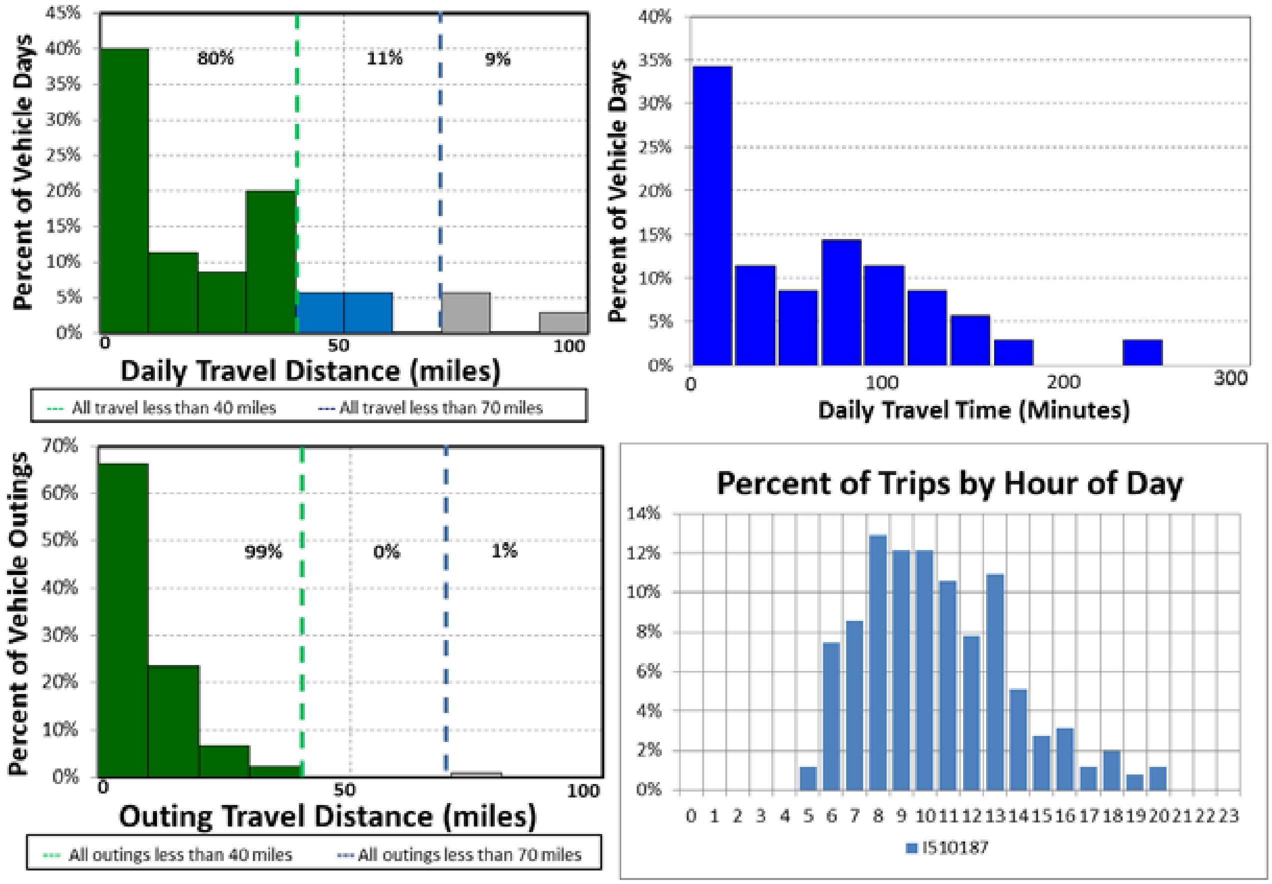


Figure B-12. Vehicle I510187 travel graphs.

Vehicle I510187 Observations

Logger 31 collected data on this vehicle for a period of 35 days of the 91-day study period. Validation occurred on 99.3% of the input data. Information provided on the vehicle survey for this vehicle indicated that this is a support vehicle used for Leelanau Fees. Data indicate the home base appears to be in Glen Arbor.

The reported odometer reading was 41,173 during the study period, with an estimated annual usage of 2,484 miles. The vehicle was used on 38% of the available days, with an average daily usage of 1.2 hours and a peak daily usage of 4.3 hours on the days it was used. The vehicle was used during typical day shift hours.

Figure B-28 shows stops exceeding the 2-hour duration occurred at three major locations, but 88% of stops occurred at the home base.

Figure B-30 shows 91% of daily travel and 99% of all outings are within the typically advertised range of a BEV of approximately 70 miles, with 9% of daily travel exceeding this range.

Eighty percent of daily travel and 99% of outings are within the typically advertised CD mode of 40 miles for PHEVs.

A BEV could meet 91% of the daily travel without additional charging opportunities. However, sufficient time exists daily for additional charging that could then meet 99% of all outings. This would work well in a fleet of BEVs and PHEVs to allow daily travel without requiring additional charge times, providing the PEV meets the other mission requirements. The survey information suggests that no other special requirements exist.

Vehicle I512719

Make/Model/Year	Chevrolet Impala/2010
EPA Class Size	Sedan - Large
Mission	Pool
VIN	2G1WA5EK2A1112733
Parking Location	HQ
Fleet Vehicle ID	I512719
Fuel Type	Gas
EPA Label/MPG (City/Hwy)	18/29/22
EPA GHG Emissions (Grams CO_2/Mi)	404
Study Logger ID	32
Total Vehicle Days/Total Study Days	75/92

Vehicle I512719 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	30.2/73.8	16.2/46.9	4.6/21.7	2,264
Travel Time (Minutes)	59/150.0	31.6/117.0	9.0/38.0	4,417
Idle Time (Minutes)	0.9/NA	0.5/NA	0.1/NA	70

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	439	95.4%	Less than 2	330
10 to 20	21	4.6%	2 to 4	52
20 to 40	0	0%	4 to 8	4
40 to 60	0	0%	Greater than 8	74

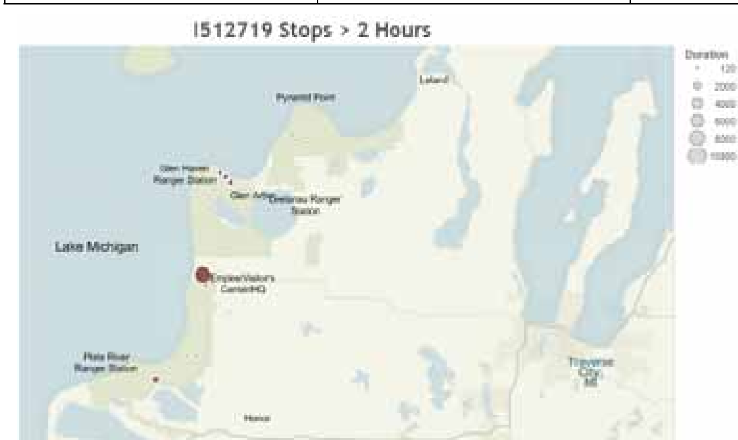


Figure B-31. Vehicle I512719 stops.

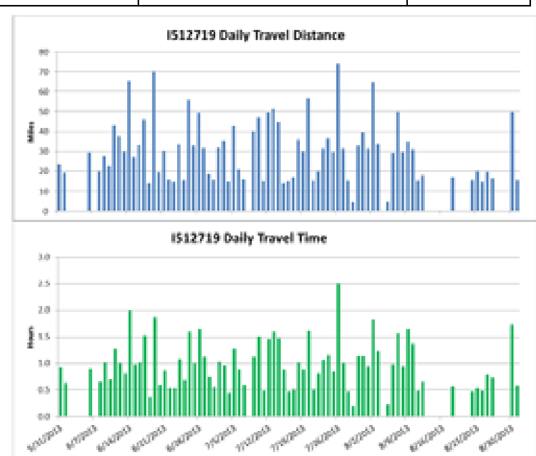


Figure B-32. Vehicle I512719 history.

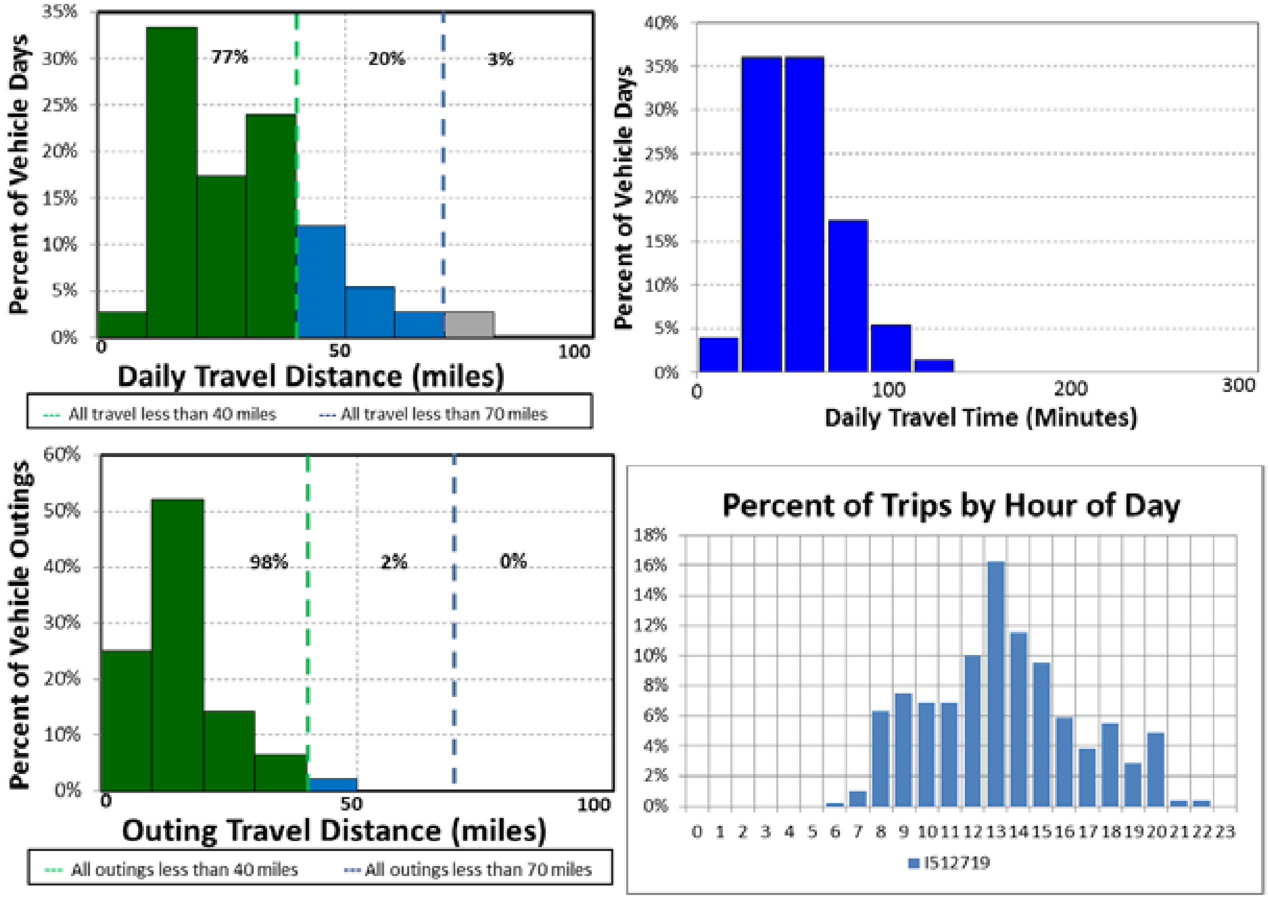


Figure B-13. Vehicle I512719 travel graphs.

Vehicle I512719 Observations

Logger 32 collected data on this vehicle for a period of 75 days of the 91-day study period. Validation occurred on 100% of the input data. Information provided on the vehicle survey for this vehicle indicated that this is a pool vehicle supporting Headquarters. Data indicate the home base appears to be in Empire.

The reported odometer reading was 19,284 during the study period, with an estimated annual usage of 6,193 miles. The vehicle was used on 82% of the available days, with an average daily usage of 1 hour and a peak daily usage of 2.5 hours on the days it was used. The vehicle was used during typical day shift hours, with some usage in the early evenings.

Figure B-31 shows stops exceeding the 2-hour duration occurred primarily at the home base.

Figure B-33 shows 97% of daily travel and all outings are within the typically advertised range of a BEV of approximately 70 miles, with 3% of daily travel exceeding this range.

Seventy-seven percent of daily travel and 98% of outings are within the typically advertised CD mode of 40 miles for PHEVs.

A BEV could meet 97% of the daily travel without additional charging opportunities. However, sufficient time exists daily for additional charging that could meet all outings. The survey information suggests that no other special requirements exist and BEVs in sedans are readily available.

Vehicle I410690

Make/Model/Year	Ford F150/2007
EPA Class Size	Pickup
Mission	Pool
VIN	1FTPF12V77KD42264
Parking Location	MT Yard
Fleet Vehicle ID	I410690
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy)	13/18/15 10/13/11
EPA GHG Emissions (Grams CO_2/Mi)	592/572
Study Logger ID	33
Total Vehicle Days/Total Study Days	63/86

Vehicle I410690Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/10.0/Peak	Total
Travel Distance (Miles)	44.5/94.9	24.6/109.9	2.1/23.8	2,803
Travel Time (Minutes)	119/228.0	65.6/313.0	5.6/100.0	7,481
Idle Time (Minutes)	17.2/NA	9.5/NA	0.8/NA	1,084

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	889	88.0%	Less than 2	948
10 to 20	121	12.0%	2 to 4	11
20 to 40	0	0%	4 to 8	1
40 to 60	0	0%	Greater than 8	50

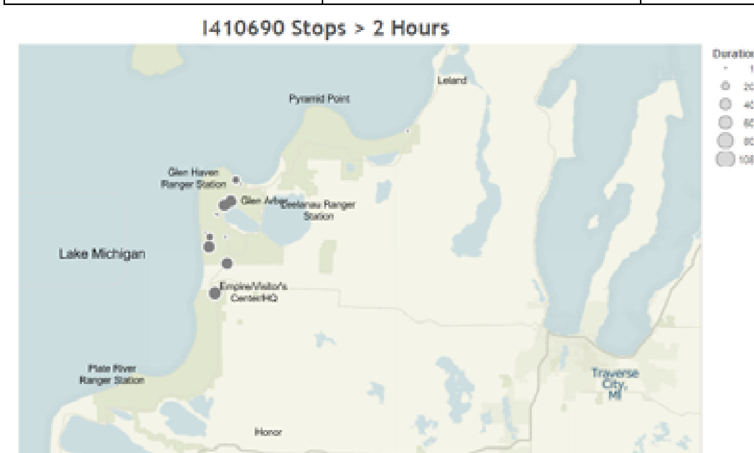


Figure B-34. Vehicle I410690 stops.

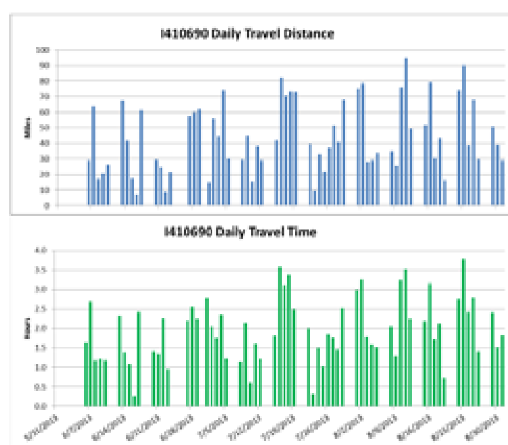


Figure B-35. Vehicle I410690 history.

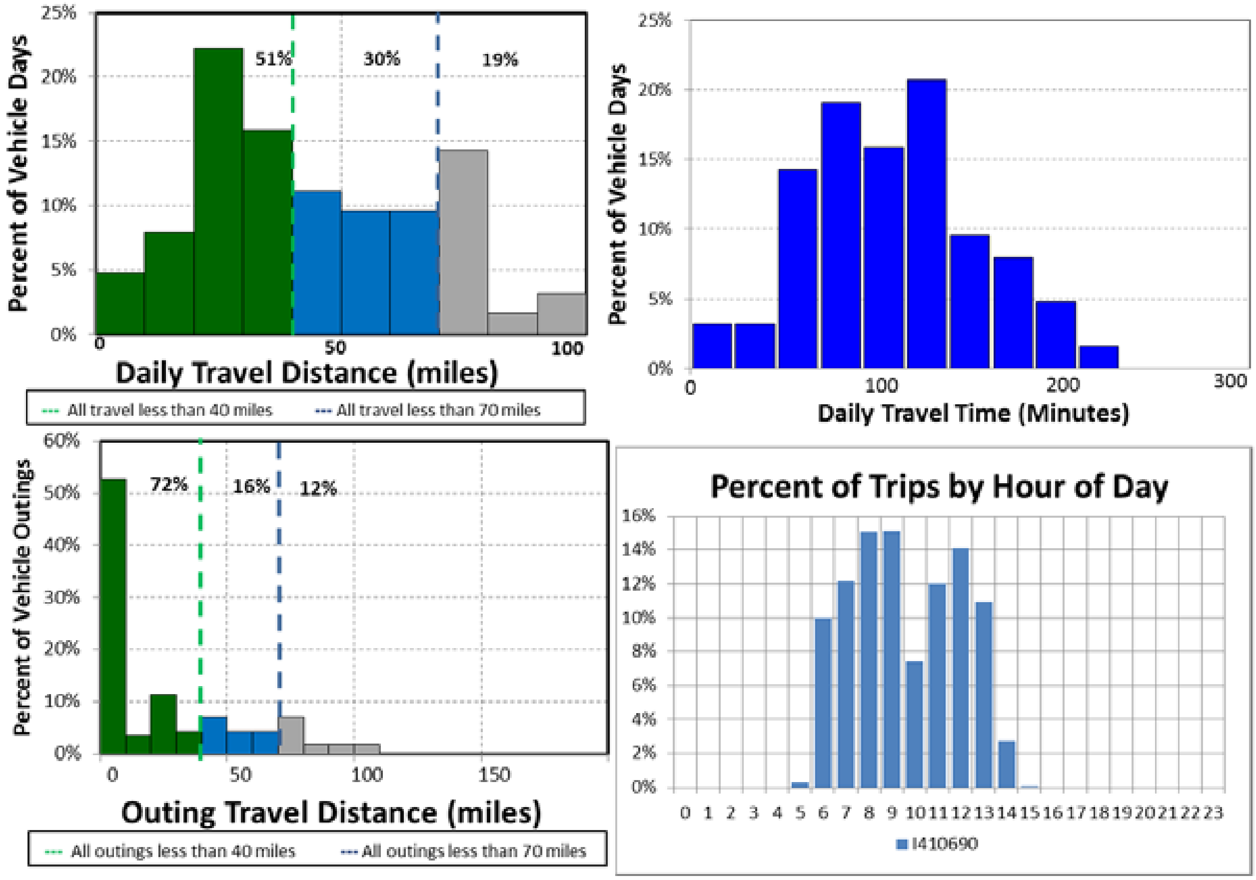


Figure B-36. Vehicle I410690 travel graphs.

Vehicle I410690 Observations

Logger 33 collected data on this vehicle for a period of 63 days of the 86-day study period. Validation occurred on 99.8% of the input data. Information provided on the vehicle survey for this vehicle indicated that this is a pool vehicle that typically parks at the MT Yard.

The reported odometer reading was 49,712 during the study period, with an estimated annual usage of 7,000 miles. The vehicle was used on 73% of the available days, with an average daily usage of 2 hours and a peak daily usage of 3.8 hours on the days it was used. The vehicle was used during typical day shift hours.

Figure B-34 shows stops exceeding the 2-hour duration occurred at several locations. However, 70% of those stops occurred at the home base.

Figure B-36 shows 81% of daily travel and 88% of all outings are within the typically advertised range of a BEV of approximately 70 miles, with 5% of daily travel exceeding this range.

Fifty-one percent of daily travel and 72% of outings are within the typically advertised CD mode of 40 miles for PHEVs.

A BEV could meet 81% of the daily travel without additional charging opportunities. However, sufficient time exists daily for additional charging that could increase this percentage. This would work well in a fleet of BEVs and PHEVs to allow daily travel without requiring additional charge times, providing the PEV meets the other mission requirements. The survey information suggests that no other special requirements exist other than maintenance activities.

Vehicle I410691

Make/Model/Year	Ford F150/2007
EPA Class Size	Pickup
Mission	Pool
VIN	1FTPF122V97KD4226
Parking Location	MT Yard
Fleet Vehicle ID	I410691
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy)	13/18/15 10/13/11
EPA GHG Emissions (Grams CO_2/Mi)	592/572
Study Logger ID	34
Total Vehicle Days/Total Study Days	No data

Vehicle I410691 Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)				
Travel Time (Minutes)				
Idle Time (Minutes)				

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10			Less than 2	
10 to 20			2 to 4	
20 to 40			4 to 8	
40 to 60			Greater than 8	

Vehicle I410691 Observations

Data were not transmitted for unknown reasons.

Information provided on the vehicle survey for this vehicle indicated that this is a pool vehicle that typically parks at the MT Yard.

The reported odometer reading was 43,917 during the study period, with an estimated annual usage of 7,000 miles.

Appendix C

National Fuel Cost and GHG Savings

Section 5 notes that fuel cost and GHG savings are calculated on a local and a national basis. Local savings are of higher interest to the facility, while national figures are of higher interest in evaluating all sites. Section 5 provides the savings on the local level. Table C-1 presents these savings on a national basis for the PEV replacement of monitored vehicles.

Table C-1. Fuel cost and GHG savings on a national basis.

Mission	Replacement Model	Extrapolated U.S. Yearly CO_2e Avoided (lb-CO_2e/year)	% reduction	Extrapolated U.S. Yearly Fuel Cost Reduction	% reduction
Pool	RAV4	5,247	40%	$1,753	77%
Support	VTRUX PU	1,528	35%	$567	76%
Pool	eNV200	2,271	36%	$821	76%
Pool	VTRUX PU	563	46%	$168	80%
Law Enforce.	Outlander	509	43%	$159	79%
Pool	eNV200	4,091	48%	$1,172	81%
Pool	RAV4	2,261	43%	$708	79%
Support	VTRUX Van	1,968	39%	$674	77%
Support	eNV200	3,014	48%	$864	81%
Law Enforce.	Outlander	710	43%	$222	79%
Support	RAV4	705	30%	$300	74%
Pool	Leaf	2,816	50%	$788	81%
Pool	VTRUX PU	2,189	46%	$654	80%
Pool	VTRUX PU	1,932	46%	$577	80%
Total		**29,805**	**43%**	**$9,428**	**78%**
Total Pool		21,370	43%	$6,641	79%
Total Support		7,216	40%	$2,405	77%
Total Enforcement		1,219	43%	$382	79%

As presented in Section 5, 28 BEVs and 24 PHEVs could replace most ICE vehicles in the fleet of 52 vehicles, while retaining the two passenger vans, three heavy-duty trucks, and two specialty vehicles. Using an average savings per vehicle, Table C-2 provides the avoided GHG and fuel cost savings should these replacements occur.

Table C- 2. Extrapolated greenhouse gas emissions avoided and fuel cost savings for the entire fleet.

Mission	Extrapolated U.S. Yearly CO_2e Avoided (lb-CO_2e/year)	% reduction	Extrapolated U.S. Yearly Fuel Cost Reduction ($/year	% reduction
Pool	81,266	43%	$25,655	78%
Support	25,728	38%	$8,903	77%
Enforcement	1,219	43%	$382	79%
Total	108,213	41%	$34,941	78%