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AVTA Federal Fleet PEV Readiness Data Logging and Characterization Study for Idaho National Laboratory

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May 2015

Idaho National Laboratory

The INL is a U.S. Department of Energy National Laboratory
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ABSTRACT

Battelle Energy Alliance, LLC, managing and operating contractor for the U.S. Department of Energy's Idaho National Laboratory, is the lead laboratory for U.S. Department of Energy Advanced Vehicle Testing. Battelle Energy Alliance, LLC contracted with Intertek Testing Services, North America (Intertek) to 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's study seeks to collect and evaluate data to validate use of advanced plug-in electric vehicle (PEV) transportation.

This report focuses on Idaho National Laboratory's 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 laboratory's fleet.

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 for participation in the study.

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 Idaho National Laboratory (INL) could convert part or all of their fleet of vehicles from petroleum-fueled vehicles to PEVs.

More fuel-efficient ICE vehicles, including hybrid electric vehicles, exist that could provide improvements for the current fleet; however, non-PEVs are not the focus of this study.

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 all or the majority of the motive power (depending on the PHEV design) but they also have the ability to extend their operating range with an onboard ICE. Because a PHEV can meet all transportation range needs, adoption of a PHEV will be dependent on its ability to meet other transportation needs such as cargo or passenger capability. Operation of PHEVs in the mode where all or the majority of the motive power is provided by the battery (i.e., charge-depleting mode) can be increased with opportunity charging at available charging stations. However, it should be noted that not all PHEVs have a mode where the battery provides all motive power at all speeds. This study focuses on the mission requirements of the fleet vehicles with the objective of identifying vehicles that may be replaced with PEVs, with emphasis on BEVs that provide maximum benefit.

In operation since 1949, INL is a science-based, applied engineering national laboratory dedicated to supporting the U.S. Department of Energy's missions in nuclear and energy research, science, and national defense. INL consists of several laboratory campuses located in Idaho Falls, Idaho and the 890-m^2 INL site in the high desert west of Idaho Falls.[a] INL employs approximately 4,125 full-time equivalent employees, along with approximately 300 user facility participants, researchers, and interns. INL currently supports 64 specific projects or topics, each with a specific research agenda. INL's vision is "to sustain core technological capabilities and develop innovative solutions that secure and advance nuclear and other clean energy choices for our future."[b]

Battelle Energy Alliance, operating contractor of INL, has 378 vehicles in its fleet for all INL activities that will be a part of this study. This list has screened out medium-duty and heavy-duty trucks, specialty vehicles, low-speed vehicles, and buses that are not candidates for near-term replacement by PEVs.

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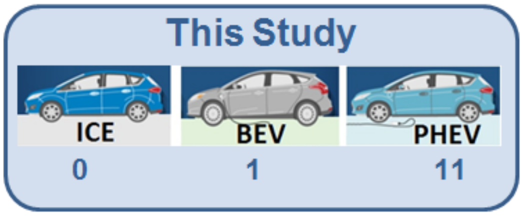
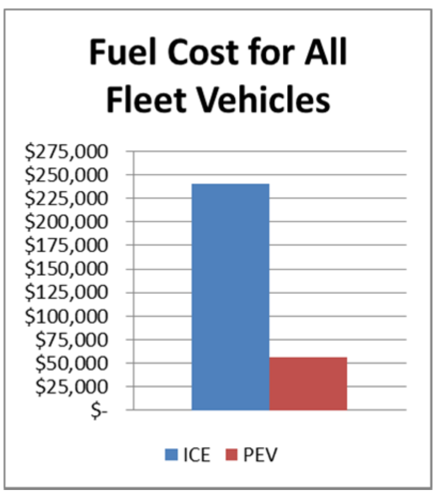
[a] http://www.inl.gov/publications/d/ten-year-site-plan.pdf "INL-AT-A-GLANCE" [accessed December 6, 2014].

[b] https://inlportal.inl.gov/portal/server.pt/community/about_inl/259 [accessed December 6, 2014].



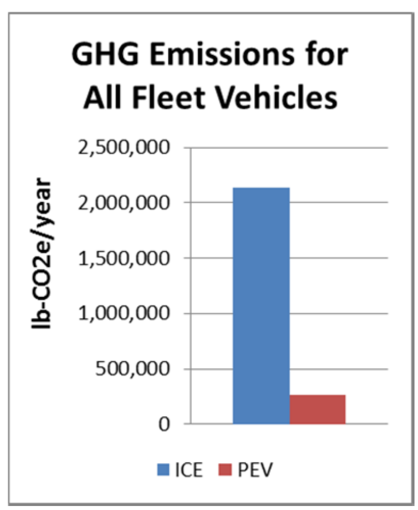
The vehicles for study do not include vehicles belonging to other companies that may have business on the INL Site. Twelve of the 378 vehicles were identified as representative of the fleet and instrumented for data collection and analysis. Fleet vehicle mission categories are defined in Section 4 of this report. While INL vehicles conduct many different missions, three missions (i.e., pool, support, and enforcement missions) are accomplished by these 12 fleet 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. While some vehicles travel long distances and cold winter months can reduce vehicle range in charge-depleting mode, the group could support some BEVs for the short trips and PHEVs for the longer trips. The recommended mix of vehicles should provide sufficient range for individual trips and time is available each day for charging to accommodate multiple trips per day. These charging events could occur at the vehicle's 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.



Data collected for the monitored vehicles suggests the 12-vehicle fleet subset could possibly consist of one BEVs and 11 PHEVs. Replacement of these 12 ICE vehicles with PEVs could result in an annual GHG savings over 48,497 lb-CO_2e (87% reduction) and an annual fuel cost savings of $4,721 (76% reduction).

Based on data collected from the monitored vehicles and extrapolated to the 378 total vehicles, a fleet consisting of 122 BEVs and 256 PHEVs may meet the agencies' needs. Replacement of the 378 ICE vehicles with PEVs could result in an annual GHG savings over 1,875,000 lb-CO_2e (88% reduction) and an annual fuel cost savings of over $180,000 (76% reduction).



PEV charging stations could be placed in various locations across the INL sites and support not only those vehicles home based at the site but the frequent PEVs that travel between sites.

Intertek suggests that INL may wish to move forward in the near future with 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.

Replacement of ICE vehicles not only supports the major programmatic sustainability goals identified in the Executive Orders and Department of Energy policies of the federal government but also the specific goals identified by INL in support of those directives.

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ACRONYMS

AC	alternating current
BEV	battery electric vehicle
CD	charge depleting
CS	charge sustaining
DC	direct current
EPA	U.S. Environmental Protection Agency
EVSE	electric vehicle supply equipment
GHG	greenhouse gas emissions
GSA	General Services Administration
ICE	internal combustion engine
INL	Idaho National Laboratory
Intertek	Intertek Testing Services, North America
OEM	original equipment manufacturers
PEV	plug-in electric vehicle (includes BEVs and PHEVs, but not hybrid electric vehicles)
PHEV	plug-in hybrid electric vehicle
SUV	sport utility vehicle

AVTA Federal Fleet PEV Readiness Data Logging and Characterization Study for Idaho National Laboratory

1. INTRODUCTION

Federal agencies are mandated by the Energy Policy Act of 1992,[3] Energy Policy Act of 2005,[4] Executive Order 13423 (President Bush 2007),[5] Executive Order 13514 (President Obama),[6]and the Energy Independence and Security Act of 2007[7] to purchase alternative fuel vehicles, increase consumption of alternative fuels, reduce petroleum consumption, and reduce greenhouse gas (GHG) emissions. This was recently augmented by another executive order signed by President Obama on March 19, 2015, to specifically focus passenger vehicle replacements with zero emission or plug-in hybrid electric vehicles and for development of the appropriate charging infrastructure.[8]

> *Executive Order 13514: "...makes reduction of GHG emissions a priority for Federal Agencies"*

Battelle Energy Alliance, LLC, managing and operating contractor for Idaho National Laboratory (INL), is the lead laboratory for the U.S. Department of Energy's advanced vehicle testing and manages the Advanced Vehicle Testing Activity's Federal Fleet Vehicle Data Logging and Characterization Study, which promotes use 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. Battelle Energy Alliance, LLC 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 successful introduction of PEVs into federal fleets. In this report, INL focuses on its own fleet of vehicles.

More fuel-efficient internal combustion engine (ICE) vehicles, including hybrid electric vehicles, exist that may provide improvements for the current fleet; however, non-PEVs are not the focus of this study.

Because of the large number of vehicles in federal fleets in the United States, these fleets provide a substantial opportunity for 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.

In operation since 1949, INL is a science-based, applied engineering national laboratory dedicated to supporting the U.S. Department of Energy's missions in nuclear and energy research, science, and national defense. INL consists of several laboratory campuses located in Idaho Falls, Idaho and the INL site in the high desert west of Idaho Falls (Figures 1and 2).[9] INL employs approximately 4,125 full-time equivalent employees, along with approximately 300 user facility participants, researchers, and interns.

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3 http://thomas.loc.gov/cgi-bin/query/z?c102:h.r.776.enr [accessed March 16, 2015].

4 http://www.gpo.gov/fdsys/pkg/BILLS-109hr6enr/pdf/BILLS-109hr6enr.pdf [accessed March 16, 2015].

5 http://www.gsa.gov/portal/content/102452 [accessed March 16, 2015].

6 https://www.fedcenter.gov/programs/eo13514/ [accessed March 16, 2015].

7 http://www.gpo.gov/fdsys/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf [accessed March 16, 2015].

8 https://www.whitehouse.gov/the-press-office/2015/03/19/executive-order-planning-federal-sustainability-next-decade [accessed March 27, 2015].

9 http://www.inl.gov/publications/d/ten-year-site-plan.pdf "INL-AT-A-GLANCE" [accessed December 6, 2014].

INL currently supports 64 specific projects or topics, each with a specific research agenda. The INL mission is "to sustain core technological capabilities and develop innovative solutions that secure and advance nuclear and other clean energy choices for our future."[10]

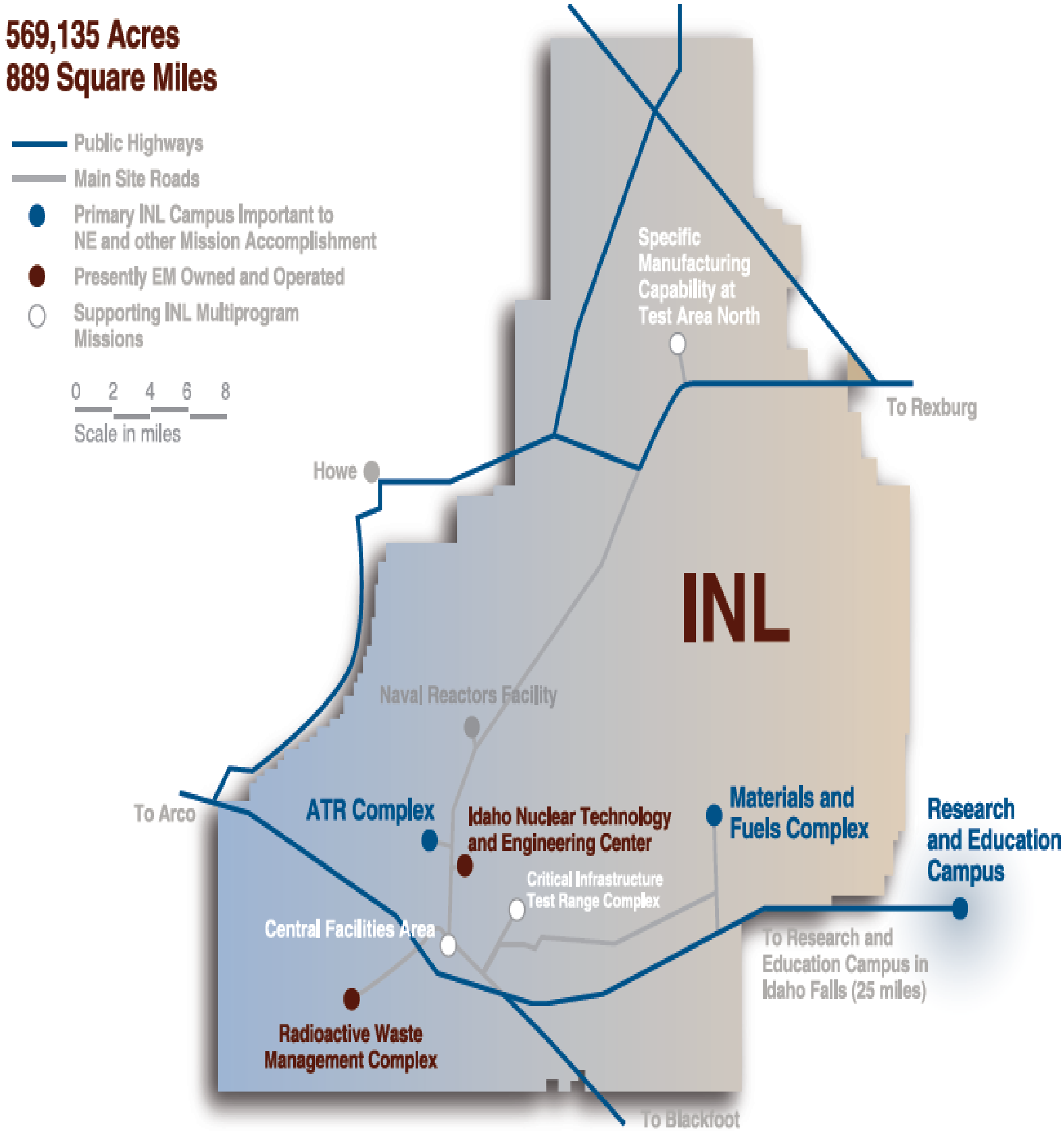

Figure 1. Graphical representation of INL facilities.[11.]

[10] https://inlportal.inl.gov/portal/server.pt/community/about_inl/259 [accessed December 6, 2014].

[11] op. cit. ten-year-site-plan Figure 2-1 [accessed December 6, 2014].

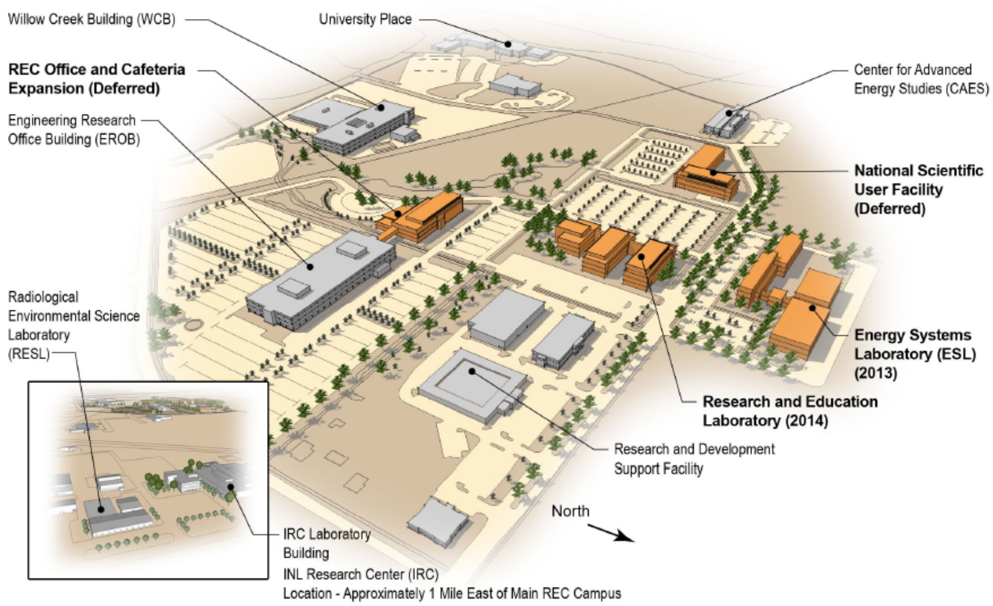

Figure 2. INL Research and Education Campus.[12]

INL is an excellent site for fleet evaluation because of its size, location, and travel between this site, other local destinations, affiliated remote sites, and travel within INL's remote sites perimeters. INL has an opportunity to be a leader in the adoption of BEVs and PHEVs for its fleet. Visitor entrance requirements exist; therefore, electric vehicle charging stations that may be installed at INL may not be generally available for public use.

INL has adopted the major programmatic sustainability goals from the executive and U.S. Department of Energy orders, including the following specific major goals:[13]

- Petroleum fuels usage reduced 20% by FY 2015 compared to FY 2005
- Alternative fuels usage increased 100% by FY 2015 compared to FY 2005
- GHG emissions reduced 28% by FY 2020 compared to base year FY 2008.

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 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.[14]

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[12] Ibid. Figure 2-2 [accessed December 6, 2014].

[13] Ibid. D-1.3 [accessed December 6, 2014].

Because of the large number of vehicles in federal fleets, a substantial opportunity for PHEV and BEV adoption exists. Federal fleets offer an opportunity as a first market replacement for alternative fuels due to their scale, refueling patterns, and regular vehicle turnover.[15]

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.
2. **Data analysis and review:** Examine data collected by data 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 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 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, but 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/INL and the U.S. Department of Energy. 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 department, primary vehicle mission, and recent odometer reading.

INL identified 378 vehicles in their fleet, with vehicle missions being identified by INL input (Table 1). (Note that Section 4 provides descriptions of vehicle mission types.) Intertek coordinated with the INL fleet manager to identify 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

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[14] http://energy.gov/sites/prod/files/2013/10/f3/eo13514.pdf [accessed March 16, 2015].

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

in the vehicle having a depleted battery. Intertek received no reports of depleted batteries during the study at INL. Twelve vehicles were selected: three pool, six support, and three enforcement vehicles.

Table 1. Fleet evaluation.

Vehicle Mission	Study Vehicles	Total Fleet Reported	Percentage Studied
Pool Vehicles	3	75	4%
Support Vehicles	6	244	2%
Enforcement Vehicles	3	59	5%
Transport	—	—	—
Bus	—	—	—
Specialty Vehicles	—	—	—
Total Fleet Vehicles	12	378	3%

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 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[16] (depicted in Figure 3), were inserted into the vehicle's onboard diagnostic port to collect and transmit 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 (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

[16] www.intouchmvc.com [accessed March 16, 2015].

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 statistics on this validation process.

INL installed twelve 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
- 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 definitions 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.

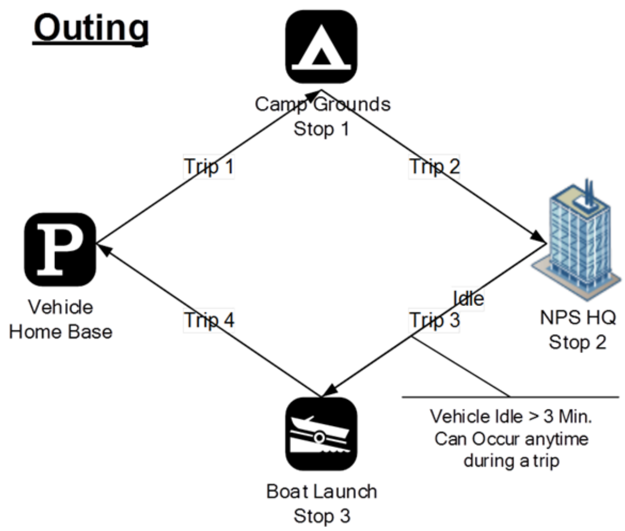

Figure 4. Vehicle outing.

Definitions of additional analysis and survey terms are as follows:

1. **Operating shift**: Fleet manager-defined period worked.
2. **Study days**: Days during which 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.

3.3.2 Data Evaluation

Processing 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 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 Microsoft® Excel and Tableau® software. 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

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

Figure 5. Vehicle missions.

4.2 Alternative Fuel Vehicles

As the operating agency, INL has a unique opportunity to plan for adoption of BEVs and PHEVs, along with planning for 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 2presents 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.”

Table 2. GSA vehicle replacement requirements.

GSA Vehicle Replacement Requirements[17]			
	Fuel Type	Years	Miles
Passenger vehicles	Gasoline or	3	36,000
	Alternative Fuel	4	24,000
	Vehicle	5	Any mileage
		Any age	75,000
	Hybrid	5	Any miles
	Low Speed Electric Vehicle	6	Any miles
Light trucks 4 x 2	Non-Diesel	7 or	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

[17] http://www.gsa.gov/graphics/fas/VehicleReplacementStandardsJune2011Redux.pdf [accessed March 16, 2015].

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 batteries in hybrid electric vehicles.

PHEVs obtain power from at least two energy sources. The typical PHEV configuration uses a battery and an ICE powered by either gasoline or diesel. PHEV designs differ between manufacturers. All PHEVs have a charge-depleting (CD) mode, where the battery is depleted of its stored energy to propel the vehicle, and a charge-sustaining (CS) mode (or extended-range mode), which is entered after CD mode is complete and where the battery and ICE work together to provide propulsion. The state of charge of the battery is maintained between set limits. Some PHEVs' operation in CD mode is purely electric, while others employ the engine to supplement 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:[18]

- **Energy efficient:** Electric vehicles convert about 59 to 62% of electrical energy from the grid to power at the wheels, whereas conventional gasoline vehicles only convert about 17 to 21% of 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, and some much further, before refueling.
- **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.

[18] http://www.fueleconomy.gov/feg/evtech.shtml [accessed March 16, 2015].

4.3.2 Plug-in Hybrid Electric Vehicle Benefits/Challenges

EPA identifies the following benefits of PHEVs:[19]

- **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 driving is done on the off-board electrical energy.
- **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 (CS mode), electric-only operation (all-electric CD mode), or combined gasoline and electric operation (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 the 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,[20] 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 EPA fuel economy values for the CD and CS modes of PHEVs, while the city and highway fuel economy values are provided for BEVs. The fuel economy of PHEV CD mode and BEVs is provided in units of miles-per-gallon-of-gasoline-equivalent (MPGe). This metric allows the electricity consumption 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.

OEMs) provide information related to a vehicle's range in CD mode and EPA provides test results. However, actual results may vary depending on several factors other than travel that may also deplete a vehicle's battery. Such factors include changes in the battery's capacity over time, area topography, weather conditions (e.g., cabin cooling/heating), payload, etc. This report will identify a BEV's "safe

[19] http://www.fueleconomy.gov/feg/phevtech.shtml [accessed March 16, 2015].

[20] http://www.gsa.gov/portal/content/104224 [accessed March 16, 2015].

range" as 70 miles, because this is typically less than the advertised range of most BEV OEMs; a PHEV's safe range in CD mode is 40 miles.

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 for 2014.

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	88 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	88 MPGe/38 mpg	$19,289.99

Note that EPA differs from GSA in vehicle class designations. 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.[21]

Table 4. OEM PHEV cars and availability.

Make	EPA Class	Model	Model Year/Estimated Year for Commercialization
Chevrolet	Compact	Volt	2011
Ford	Midsize	C-MAX Energi	2013
Ford	Midsize	Fusion Energi	2013
Toyota	Midsize	Prius PHEV	2012
Honda	Midsize	Accord PHEV	2014
BMW	Subcompact	i3 REx	2014
BMW	Subcompact	i8	2014
Audi	Compact	A3 eTron PHEV	2015 (estimate)
Volvo	Sport Utility Vehicle (SUV)	V60 Plug-in	2016 (estimate)

Table 5. OEM BEV cars and availability.

Make	EPA Class	Model	Model Year/Estimated Year for Commercialization
Nissan	Midsize	Leaf	2011
Ford	Compact	Focus Electric	2012
Tesla	Large	Model S	2012
Fiat	Mini	500e	2013
Honda	Small Station Wagon	Fit EV	2013
BMW	Subcompact	i3	2014
Chevrolet	Subcompact	Spark EV	2014
smart	Two Seater	ED	2014
Kia	Small Station Wagon	Soul EV	2014

[21] http://www.fueleconomy.gov/feg/Find.do?action=sbs&id=34130 [accessed March 16, 2015].

Make	EPA Class	Model	Model Year/Estimated Year for Commercialization
Volkswagen	Compact	Golf e-Golf	2015
Mercedes-Benz	Midsize	B-Class ED	2015 (estimate)
Volvo	Compact	C30 Electric	2016 (estimate)

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

Make	EPA Class	Model	Model Year/Estimated Year for Commercialization
Via	Standard Pickup Truck	VTRUX VR300	2013
Via	Special Purpose Vehicle	VTRUX Cargo Van	2013
Via	Vans, Cargo Type	VTRUX Pass Van	2013
Mitsubishi	Small SUV	Outlander PHEV	2015 (estimate)
Land Rover	Standard SUV	C30 Electric	2016 (estimate)

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

Make	EPA Class	Model	Model Year/Estimated Year for Commercialization
Toyota	SUV	RAV4 EV	2013 (California only-nationwide release date unknown)
Tesla	Standard SUV	Model X	2015 (estimate)
Land Rover	Standard SUV	C30 Electric	2016 (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 offers 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."[22] EVAOS conducts upgrades of Ford F-series pickup trucks to PHEV models and has delivered vehicles to the US Air Force.[23]. Options such as this company's conversions might be of benefit to INL fleet vehicles 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 alternating current (AC) Level 2 EVSE unit.

[22] http://www.echoautomotive.com/index.php?option=com_content&view=article&id=8 [accessed March 15, 2015].

[23] http://www.evaos.com [accessed March 16, 2015].

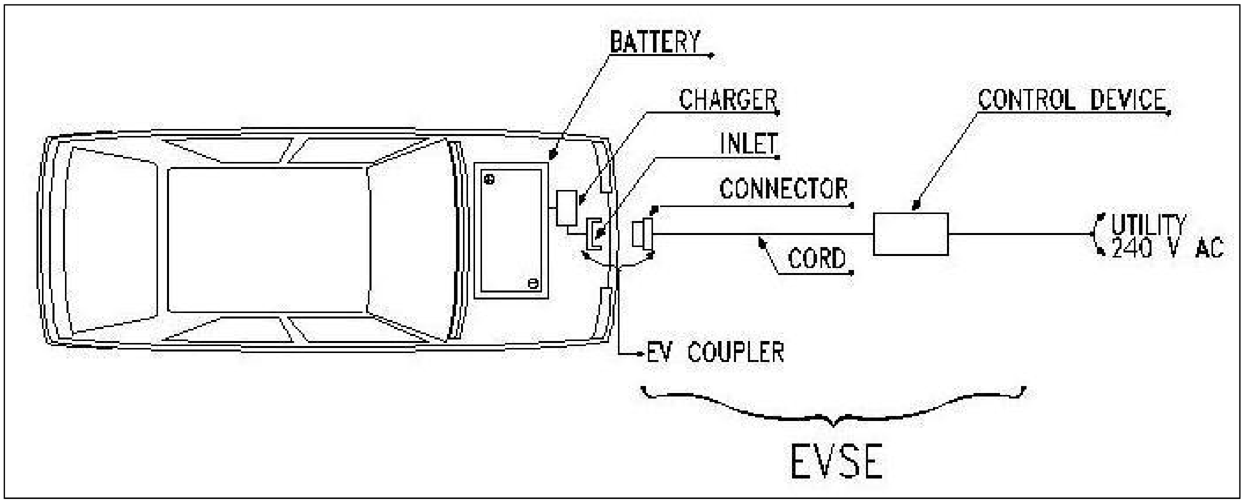

Figure 6. AC Level 2 charging diagram.[24]

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 on board 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.

PEVs are typically sold with an ACL1 cordset included. This cordset is generally intended to be used in emergencies when the vehicle is away from installed EVSE and any 120-volt electrical outlet may be available for recharge. A typical cordset is shown in Figure 8.

AC recharging capabilities found in the public arena more typically are AC Level 2. Figure 9 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 10), 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 11 shows this connector. EVSE units that are either J1772-compliant or CHAdeMO-compliant are both known as DCFCs.

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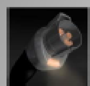
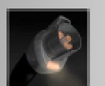
[24] http://avt.inl.gov/pdf/EVProj/EVChrgInfraDeployGuidelinesPhoenixVer3.2.pdf [accessed March 16, 2015].

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

Figure 1. Society of Automotive Engineers charging configurations and ratings terminology.[25]

Figure 8. Chevrolet Volt ACL1 cordset.[26]

[25] http://www.sae.org/smartgrid/chargingspeeds.pdf [accessed March 16, 2015].

[26] www.pluginamerica.org.

Figure 9. J1772 connector and inlet.[27]

Figure 10. J1772-compliant combo connector.[28]

Figure 11. CHAdeMO-compliant connector.[29]

[27] http://carstations.com/types/j09 [accessed March 16, 2015].

[28] http://www.zemotoring.com/news/2012/10/sae-standardizes-j1772-fast-dc-charging-up-to-100-kw [accessed March 16, 2015].

[29] https://radio.azpm.org/p/azspot/2012/5/10/1632-electric-cars/ [accessed March 16, 2015].

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, because the rapid recharging provides opportunities for expanded vehicle range with minimal operator wait times. PHEV suppliers have not provided DC inlets, because 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 and no announced plans exist for one to be introduced. It is noted that DC Level 1 and DC Level 2 charging are commonly combined and labeled "DC fast charging" or DCFC.

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 12 provides an example of a public AC Level 2 EVSE unit.

Figure 12. Public AC Level 2 EVSE.[30]

[30] http://www.eaton.com/ecm/groups/public/@pub/@electrical/documents/content/pa00401002e.pdf/ [accessed March 16, 2015].

DCFCs also are available from several manufacturers. Figure 13 illustrates one such charger. This particular charger uses the CHAdeMO connector standard.

Figure 13. Public DCFC unit.[31]

In general, installation costs are higher for DCFCs because of the higher voltage requirements and 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.

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. IDAHO NATIONAL LABORATORY ANALYSIS

5.1 Idaho National Laboratory Fleet

INL reports 378 vehicles in their complete fleet for all departments, with 55% of the vehicles being held by six departments. Table 8 shows the breakdown of these vehicles by EPA vehicle class and by department for those departments holding 15 or more vehicles and Figure 14 shows this breakdown graphically.

Based on INL input on fleet vehicles, an assessment of mission by vehicle type was completed. Table 9 shows the results of that assessment and Figure 15 shows this graphically.

[31] http://evsolutions.avinc.com/products/public_charging/public_charging_b [March 16, 2015].

Table 8. INL fleet vehicles.

Department	Description	Sedan Compact	Sedan Midsize	SUV	Mini-van	Van - Cargo	Van - Pass	Pickup Truck	Total
0001	U.S. Department of Energy	2	—	14	—	—	—	2	18
5761	Motor Pool	9	3	16	4	—	4	18	54
J110	Facility Support	—	—	1	—	—	—	38	39
J150	Construction Management	—	—	7	—	—	—	8	15
J520	Facility Management Services	2	—	3	1	—	1	15	22
M400	Enforcement	—	—	34	1	—	5	19	59
Other Inst.		8	1	39	6	1	9	107	171
Total		21	4	114	12	1	19	207	378

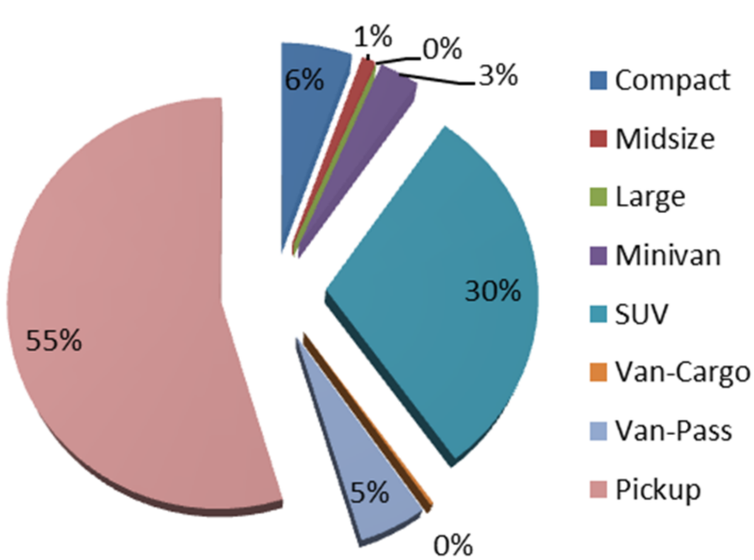


Figure 14. INL vehicle types.

Table 9. INL fleet mission assessment.

Mission	Sedan Compact	Sedan Midsize	SUV	Mini-van	Van - Cargo	Van - Pass	Pickup Truck	Total
Pool	11	3	19	5	—	5	32	75
Support	10	1	61	6	1	9	156	244
Enforcement	—	—	34	1	—	5	19	59
Total	21	4	114	12	1	19	207	378

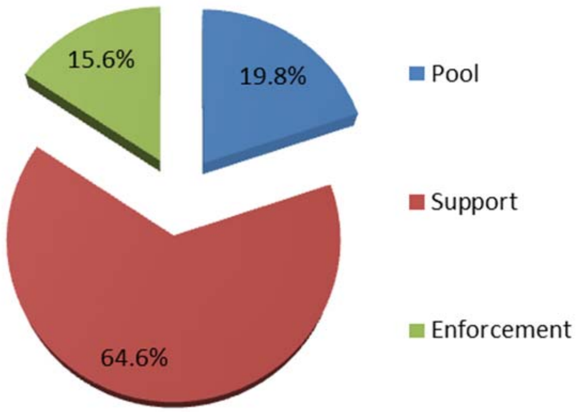


Figure 15. INL vehicle missions.

5.2 Vehicles Selected for Monitoring

Twelve vehicles were included in the study at INL. Three vehicles have pool missions, six have support missions, and three have law enforcement missions. Table 10 presents a summary of these vehicles by vehicle type, while Figure 16 compares mission selection to the full fleet. Table 11 provides details about the monitored vehicles, while Figure 17 compares the vehicle type to the full fleet.

Table 10. Vehicle study summary.

Mission	Sedan Compact	Sedan Midsize	SUV	Mini-van	Van - Cargo	Van - Pass	Pickup Truck	Total
Pool	1	—	—	—	—	2	—	3
Support	1	—	—	1	—	—	4	6
Enforcement	—	—	2	—	—	—	1	3
Total	2	—	2	1	—	2	5	12

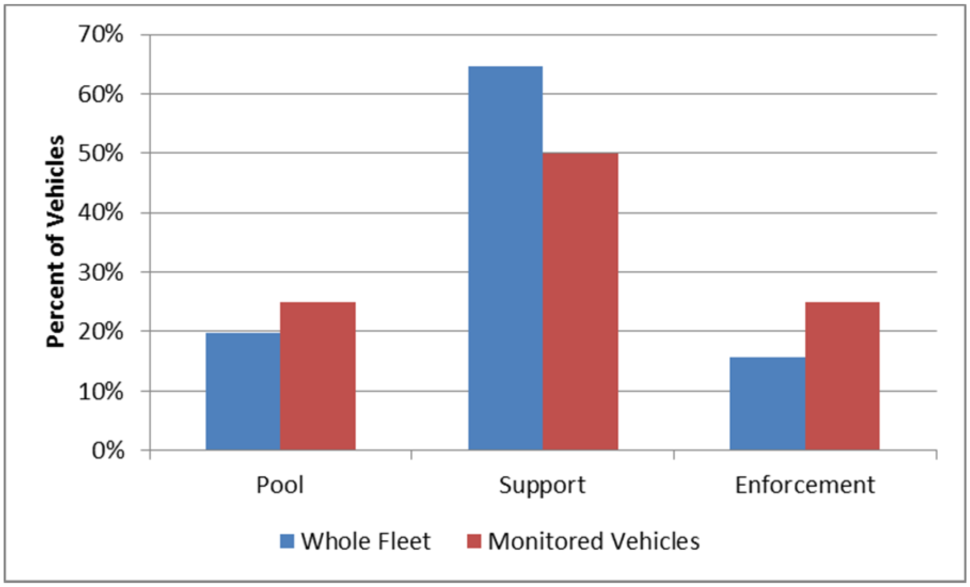


Figure 16. Mission comparison of monitored vehicles to full fleet.

Table 11. Detailed INL vehicle index.

Vehicle Index						
Log	Fleet Vehicle Id	Make	Model	Year	EPA Class	Mission
48	G63-0421H	Chevrolet	Suburban	2010	SUV	Enforcement
49	G61-0392H	Dodge	Dakota	2009	Pickup	Enforcement
50	G13-2193P	Ford	Focus	2014	Sedan - Compact	Support
51	G41-3181P	Dodge	Caravan	2014	Minivan	Support
52	G13-5142P	Ford	Focus	2014	Sedan - Compact	Pool
53	G63-1386G	Ford	F350	2015	Pickup	Support
54	G63-0410M	Ford	F350	2012	Pickup	Support
55	G43-0880H	Ford	E350	2009	Van - Pass	Pool
56	G43-0877H	Ford	E350	2011	Van - Pass	Pool
57	G62-3940L	Ford	Expedition XLT	2012	SUV	Enforcement
58	G61-1443G	Dodge	Dakota	2010	Pickup	Support
61	G62-1726L	Chevrolet	K1500H	2011	Pickup	Support

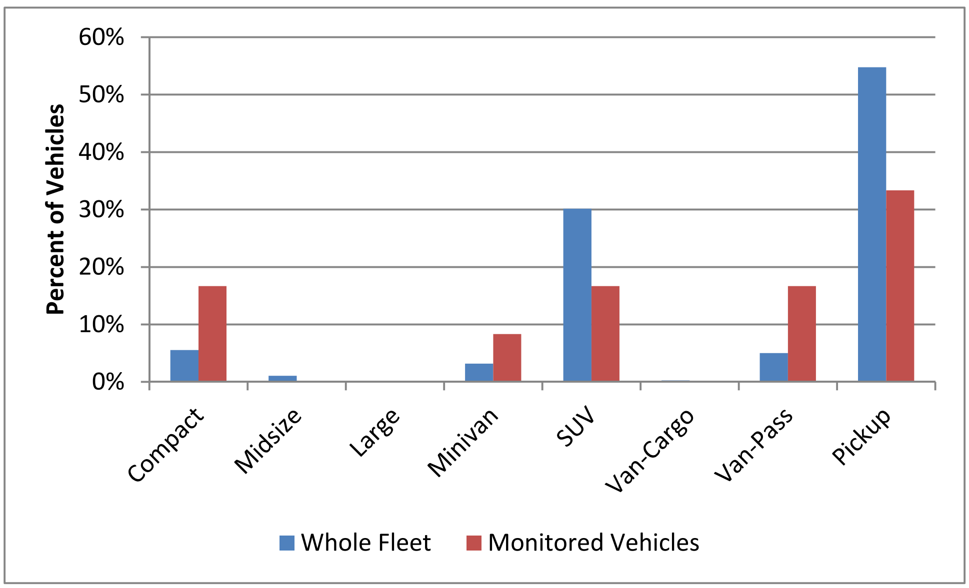


Figure 17. Vehicle type comparison of monitored vehicles to full fleet.

Figure 18 compares the model year of the selected vehicles to the full fleet and Figure 19 compares the annual mileage of the selected vehicles to the full fleet.

Selection of monitored vehicles was completed by INL and Intertek personnel. While certain vehicles were specifically identified for inclusion, the overall goal was to select vehicles that represented the overall fleet to allow an extrapolation of results to the full fleet. Figures 16 through 19 show the comparisons. In general, there is an excellent match between the monitored and full fleet vehicles. Some minor differences occurred in vehicle type, where less of an emphasis was placed on pickup trucks and more on passenger vans and sedans. Sedans are the only vehicle represented on the current GSA vehicle schedule for PEVs. Selection also slightly favored newer model year vehicles as more representative of vehicles that will be replacing the current fleet. The annual mileage of the monitored vehicles was slightly shifted to higher mileage, because vehicles with higher mileage will be more difficult to replace with BEVs.

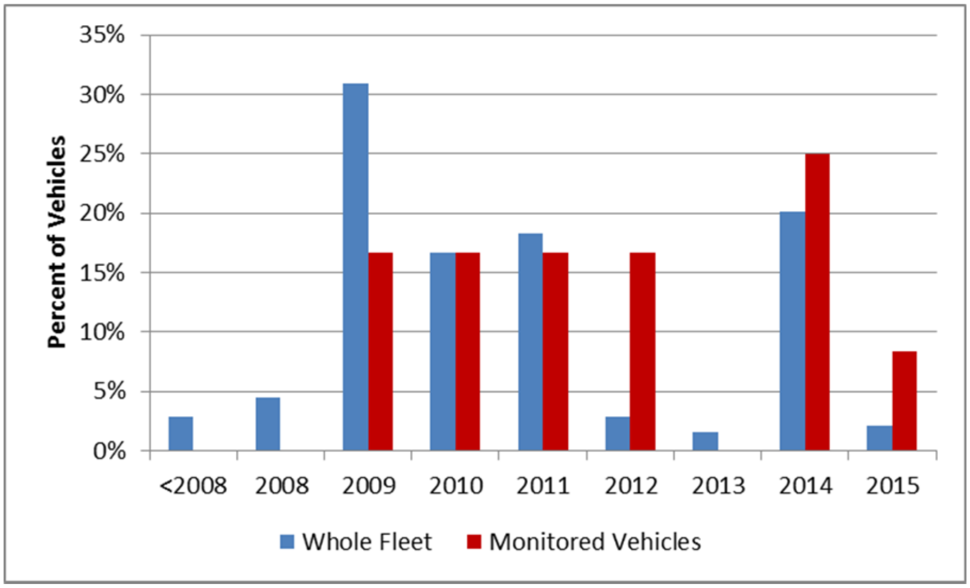


Figure 18. Model year comparison of monitored vehicles to full fleet.

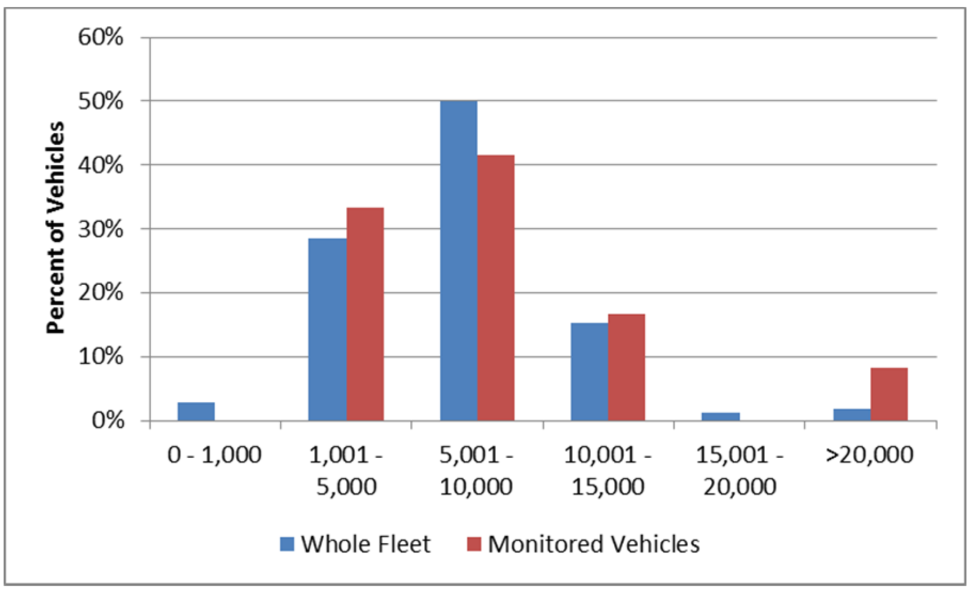


Figure 19. Annual mileage comparison of monitored vehicles to full fleet.

Appendix B provides analysis of each individual vehicle included in this study. Grouping the vehicles by mission creates an aggregated view of mission requirements to provide observations related to PEV replacement. The missions of these three categories vary considerably; therefore, these missions are evaluated separately.

5.3 Data Validity

INL data collection took place from February 9 through March 20, 2015. 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 99.9%, 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	99.6%	0.4%	100%
Support	99.5%	0.5%	100%
Enforcement	100%	0%	100%
All Vehicles	99.9%	0.1%	100%

5.4 Idaho National Laboratory 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 three vehicles (i.e., one compact sedan and two passenger vans).

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 for INL. Table 13 summarizes pool travel during the study period for those days in which the vehicle was driven. Vehicle use occurred primarily between 0800 and 2200 hours daily. The vehicles were driven 4,780 miles, logged 106 hours of operation, and idled 15 hours during the study period.

Table 13. INL pool vehicles travel summary.

Pool Vehicles Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	108.6/426.3	72.4/484.5	24.6/212.8	4,780
Travel Time (Minutes)	144.5/430.0	96.3/619.0	32.8/189.0	6,358
Idle Time (Minutes)	21.0/NA	14.0/NA	4.8/NA	926

5.4.3 Pool Vehicles Daily Summary

Figure 20 identifies daily travel distance and time for all pool vehicles. The green line and bars indicate the 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 21 and 22 show the composite history in distance and time traveled for the pool vehicles. In the stacked bar charts of Figures 21 and 22, the contribution of each vehicle is indicated by a different color.

When driven, the average travel distance per day for pool vehicles was 108.6 miles. On 30% of these vehicle days, the daily travel was less than the 70 miles considered to be within the BEV safe range (i.e., while BEV range can vary based on several factors, most BEVs provide at least 70 miles of vehicle range on a single battery charge), and 70% percent of pool daily travel was greater than 70 miles. Further, 25% of vehicle travel days were less than 40 miles considered to be within the CD range of a PHEV.

Figures 20 and 21 show that the vehicles were not used every day, although there are days when all vehicles were in use. Figure 22 displays the summary of use by time of day for all pool vehicles. Figure 24 shows the outing distances traveled, including data for all pool vehicles.

Appendix B provides details of each of the pool vehicle's outing travel. The average travel outing for pool vehicles was 72.4 miles. On 53% of these vehicle outings, the distance traveled was less than the 70 miles considered to be within the BEV safe range, and 47% of pool outing travel was greater than 70 miles. Further, 50% of vehicle travel outings were less than 40 miles considered to be within the CD range of a PHEV.

In summary, these vehicles can be characterized by either local travel within their home base region or long distances. Because of the distances to the remote laboratory sites, BEVs may not be suitable unless additional charge opportunities are available at the remote sites. For passenger vans that travel to locations away from INL areas, PHEVs provide the most suitable replacements. These vehicles may benefit from available public charging stations. Public charging opportunities are discussed in Section 5.4.5.

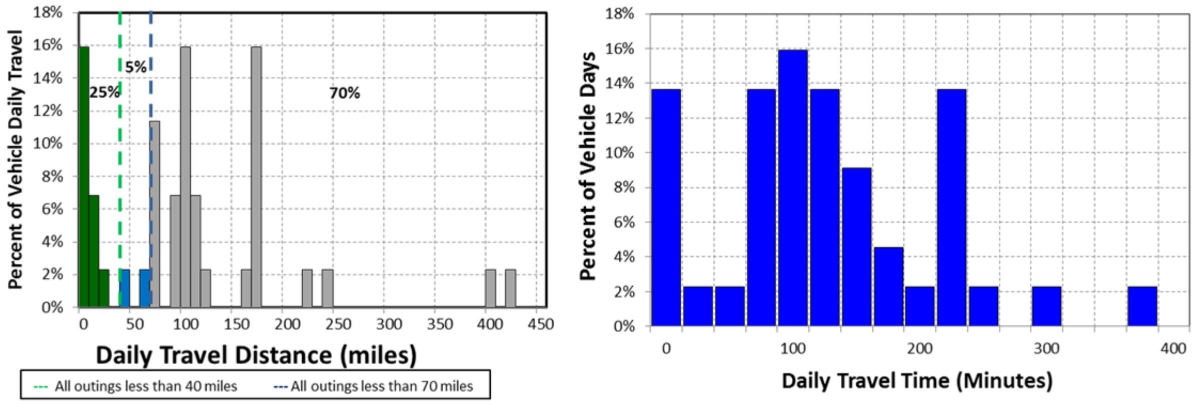


Figure 20. INL pool vehicle daily travel miles and time (all vehicles).

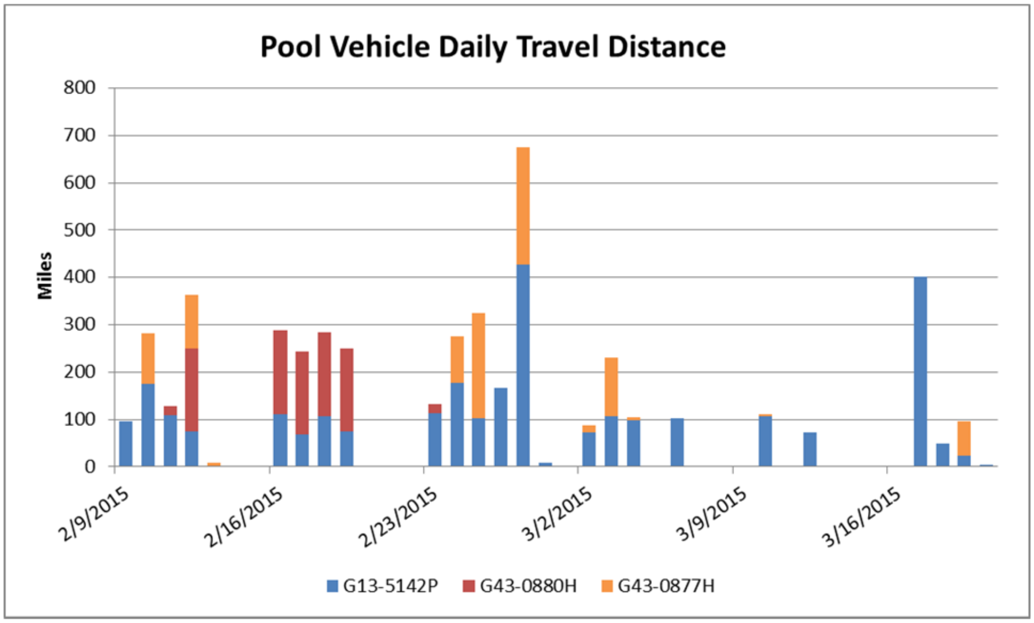


Figure 21. INL pool vehicle daily travel history (all vehicles).

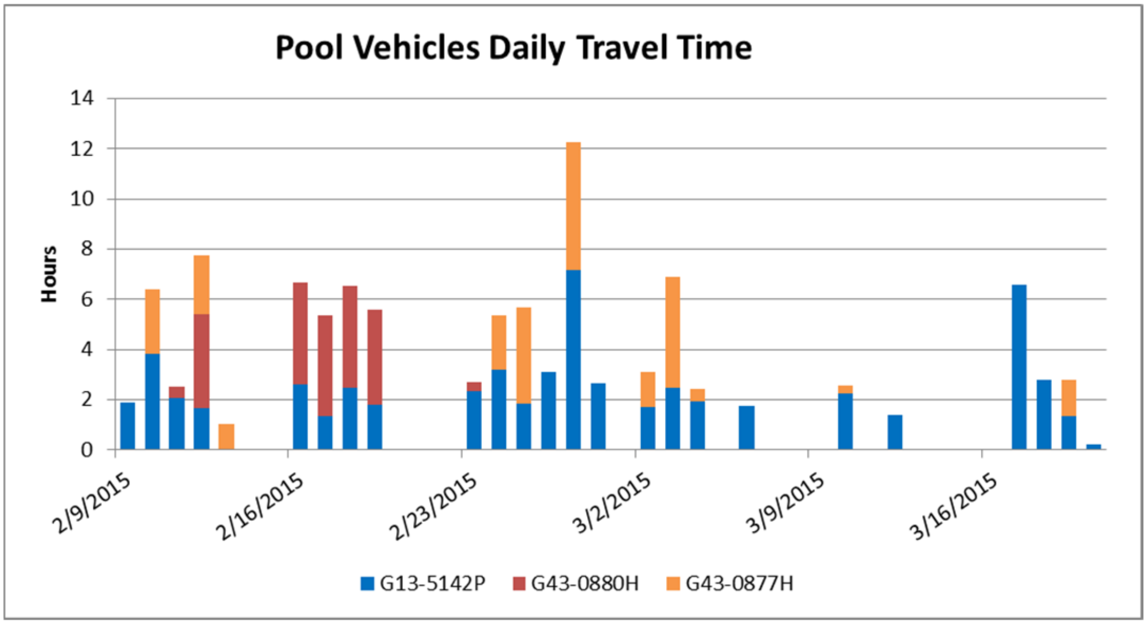


Figure 22. INL pool vehicles travel time (all vehicles).

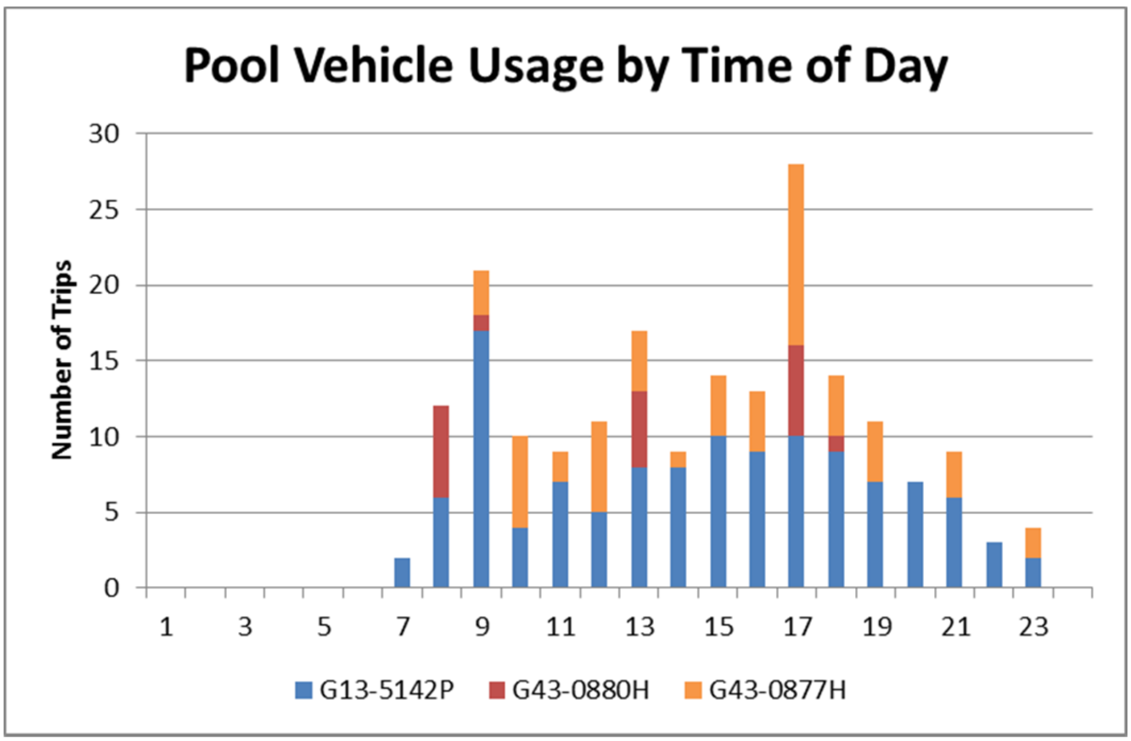


Figure 23. INL pool vehicles hourly usage.

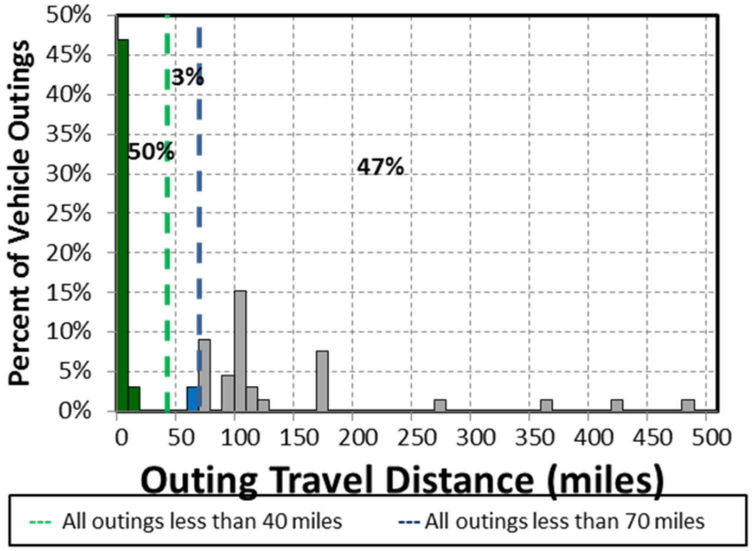


Figure 24. INL pool vehicle outings.

5.4.4 Pool Vehicle Observations/Summary

Generally, the following are three choices for INL in implementing PEVs into the pool fleet at INL, with an objective of incorporating 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 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 20 shows that on 25% 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, 50% 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, 53% of the outings are within the typical capability of a BEV; therefore, EVSE at the home base and at remote sites could provide recharge energy for another outing for pool vehicles that typically travel between INL sites. A mixed fleet requires fleet manager attention to assign vehicles appropriately for the anticipated use on that day.

   Figure 20 also shows 30% of daily travel is within the typical range of a BEV. This would suggest that 70% 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 30% of the fleet could be BEVs. However, this does not allow for 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 could conservatively meet the demand for these three pool vehicles. All monitored pool vehicles have PEV models currently available for potential replacement.

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 three 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; therefore, 25% 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 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 could extend operation in CD mode. Given the availability of daytime changing, with experience, INL may find that a greater fraction of BEVs within the pool vehicle fleet may meet their needs.

Considering a full complement of 75 pool vehicles in the total fleet, all have PEVs currently available as a potential replacement. All monitored vehicles suggest a full fleet of PHEVs for pool vehicles. However, assuming that some pool vehicles will either be assigned to local use or can take advantage of charging at remote locations, Intertek suggests that a fleet of 15 BEVs and 60 PHEVs could meet vehicle travel requirements.

5.4.5 Pool Vehicle Charging Needs

Upon review of these data, Intertek suggests replacement of the studied pool fleet with 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 in the full fleet, but appears to be unnecessary given that the data show sufficient daily recharge time when at the home base.

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. For these pool vehicles, AC Level 2 at the home bases provide additional charge opportunities for other visiting PEVs.

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 15 BEVs require 15 AC Level 2 EVSE units for overnight charging and the 60 PHEVs require 60 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.

At times, fleet vehicles obtain benefit from using public charging infrastructure. Figure 24 displays the availability of public charging at the time of this writing for the INL area. All three indicated stations are available to the public and provide AC Level 2 charging. The northernmost unit is located on the INL campus. The easternmost EVSE is located at the local Nissan dealership. The southernmost EVSE is located at Idaho Falls Power. The local charging infrastructure provides little support for INL vehicles transiting to remote sites or other cities.

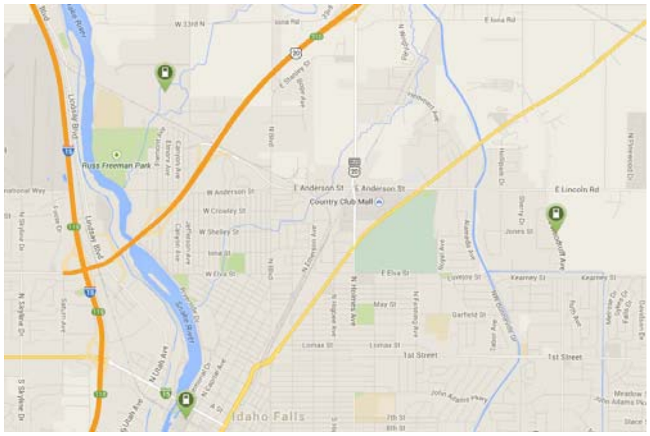


Figure 25. Public EVSE in INL region.[32]

5.5 Idaho National Laboratory Support Vehicles Evaluation

5.5.1 Survey and Site Information

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.

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

5.5.2 Summary for Support Vehicles

Appendix B provides vehicle data sheets for each of the support vehicles monitored. This section aggregates data for all support vehicles for INL. Table 14 summarizes support travel during the study period for those days when the vehicle was driven. Vehicle use occurred primarily between 0700 and 1900 hours daily. The vehicles were driven 8,775 miles, logged 250 hours, and idled 54 hours during the study period.

Table 14. INL support vehicles travel summary.

Support Vehicles Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	87.7/248.5	27.0/380.9	7.3/109.1	8,775
Travel Time (Minutes)	150.2/405.0	46.2/671.0	12.5/279.0	15,018
Idle Time (Minutes)	32.6/NA	10.0/NA	2.7/NA	3,263

5.5.3 Support Vehicles Daily Summary

Figure 26 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 (including the green bars) indicate the same for a BEV. Figures 27 and 28 the composite history in distance and time

[32] http://www.plugshare.com/ [accessed February 19, 2015]

traveled for the support vehicles. In the stacked bar charts of Figures 27 and 28, the contribution of each vehicle is indicated by a different color.

When driven, the average travel distance per day for support vehicles was 87.7 miles. On 49% of these vehicle days, the daily travel was less than the 70 miles considered to be within the BEV safe range (i.e., while BEV range can vary based on several factors, most BEVs provide at least 70 miles of vehicle range on a single battery charge), and 51% of support daily travel is greater than 70 miles. Further, 37% of vehicle travel days were less than 40 miles considered to be within the CD range of a PHEV.

Figures 27 and 28 show that the vehicles were not used every day although there are many days when many of the vehicles were in use. Figure 29 displays the summary of use by time of day for all support vehicles. Figure 30 shows the outing distances traveled for all support vehicles.

Appendix B provides the details of each of the support vehicle's outing travel. The average travel outing for support vehicles was 27 miles. On 86% of these vehicle outings, the distance traveled was less than the 70 miles considered to be within the BEV safe range, and 14% of support outing travel was greater than 70 miles. Further, 83% of vehicle travel outings were less than 40 miles considered to be within the CD range of a PHEV. In summary, these vehicles can be characterized by either short local travel within their home base region or long distances to other sites.

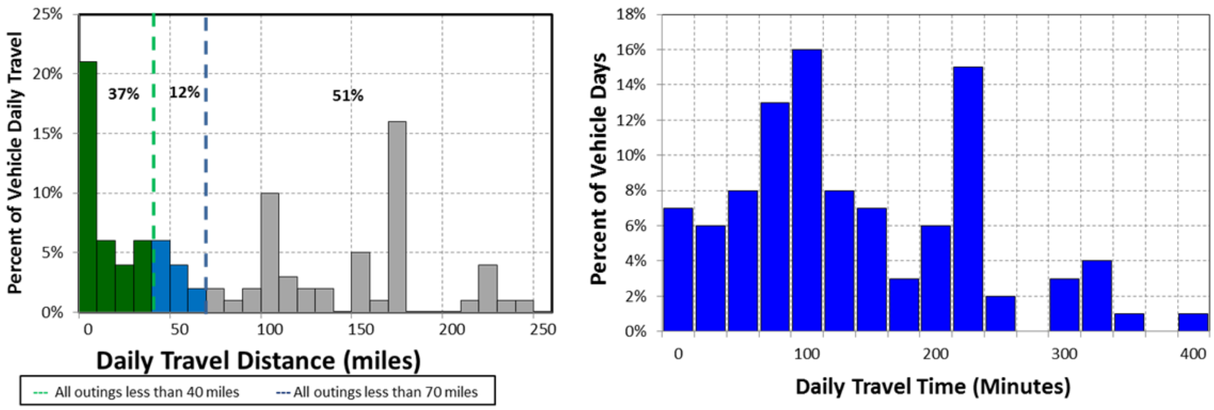


Figure 26. INL support vehicle daily travel miles and time (all vehicles).

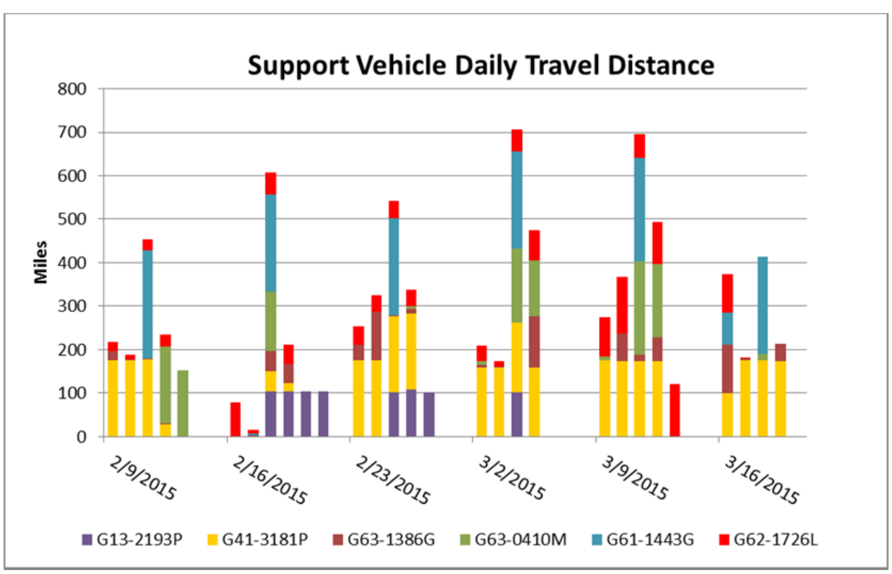


Figure 27. INL support vehicle daily travel history (all vehicles).

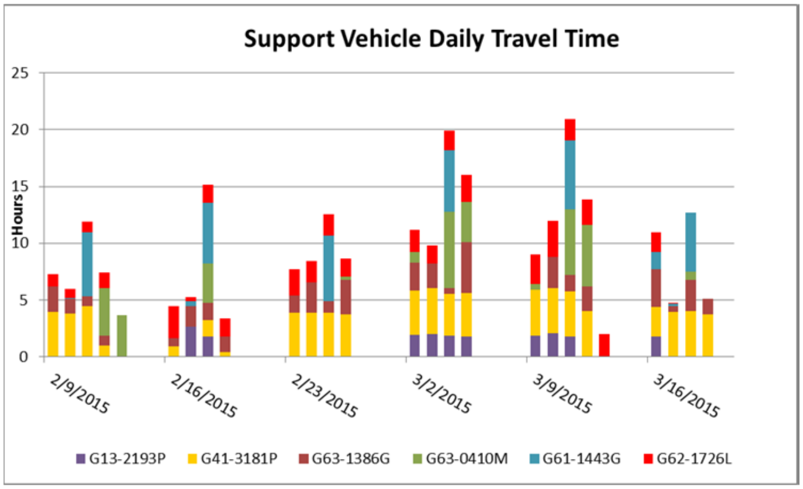


Figure 28. INL support vehicles travel time (all vehicles).

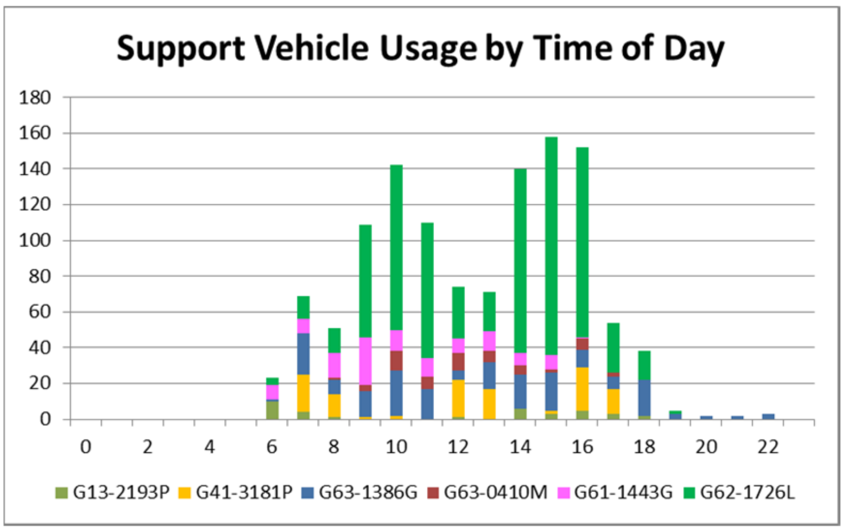


Figure 29. INL support vehicles hourly usage.

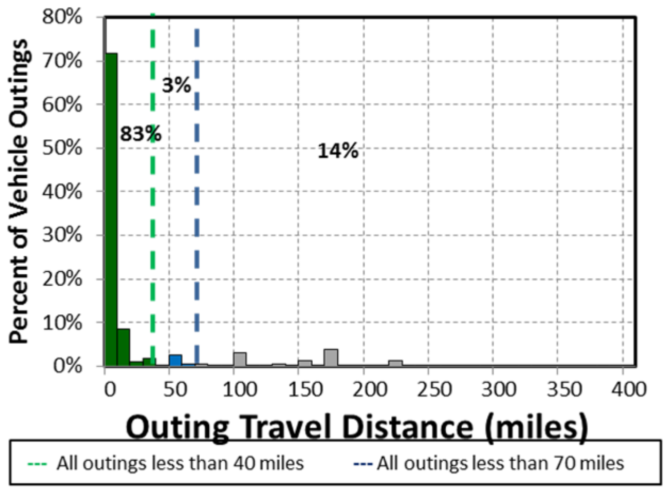


Figure 30. INL support vehicle outings.

5.5.4 Support Vehicle Observations/Summary

Generally, the following three are choices for implementing PEVs into the support fleet at INL, with an objective of incorporating 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 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 feasible.
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 26 shows that on 37% 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, 83% of the outings were less than 40 miles and could be completed in CD mode for certain PHEVs if the battery is fully charged prior to the outing.

   A mixed fleet requires fleet manager attention to assign vehicles appropriately for the anticipated use on that day.

   Figure 26 also shows 49% of daily travel was within the typical range of a BEV. This would suggest that approximately half 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, two BEVs and four PHEVs could conservatively meet the demand for these six support vehicles. All monitored support vehicles have potential replacement PEVs available.
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 requirements. These six support vehicles have replacement PEVs available. Data show that for a significant number of days, the PHEV would operate in CD mode. The first 40 miles of longer travel days would also be powered by (at least mostly) electricity, so that 37% of all support 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 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. Given the availability of daytime charging, with experience, INL may find that a greater fraction of BEVs within the support vehicle fleet may meet their needs.

The remaining 240 vehicles in the full complement of 244 support vehicles in the total fleet were not monitored during this study. However, it is likely that they have similar travel characteristics for the area. Thus, using the analysis for the monitored support vehicles and extrapolating to the 244 vehicles, Intertek suggests that 33% could be replaced by BEVs for a complement 81 BEVs and 163 PHEVs.

5.5.5 Support Vehicle Charging Needs

Upon review of these data, Intertek suggests replacement of the studied support fleet with two BEVs and four PHEVs. No available PHEVs at this writing provide for DCFC nor do data suggest that this would be a significant benefit for PHEVs in the support fleet. A DCFC at the home base will provide a more rapid recharge for BEVs, but it appears to be unnecessary, given that the data show that sufficient time for charging is available. DCFCs at each of the major INL sites may be beneficial because many vehicles transit between sites and rapid recharging may allow for more BEVs in the fleet.

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 support vehicles, the 81 BEVs require 81 AC Level 2 EVSE units for overnight charging and the 163 PHEVs require 163 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 use the AC Level 2 EVSE at the home base during the day to increase the amount of vehicle miles traveled in CD mode.

At times, fleet vehicles obtain benefits from using public charging infrastructure. Figure 25 displays the availability of public charging at the time of this writing for the INL area; however, data indicate it would be of very limited value in support of these vehicles.

5.6 Idaho National Laboratory 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 vehicle data sheets for the enforcement vehicles monitored. Table 15 summarizes the enforcement vehicles' travel during the study period. Vehicle use occurred during all hours of the day. The enforcement vehicle traveled 1,346 miles, logged 154 hours, and idled 77 hours during the study period.

Table 15. Support vehicle travel summary.

Enforcement Vehicle Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	13.7/85.0	1.3/61.0	1.2/39.1	1,346
Travel Time (Minutes)	94.6/509.0	8.9/346.0	8.0/346.0	9,266
Idle Time (Minutes)	47.1/NA	4.4/NA	4.0/NA	4,619

5.6.2 Enforcement Vehicle Daily Summary

Figure 31 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 32 and 33 show the composite history in distance and time traveled for enforcement vehicles.

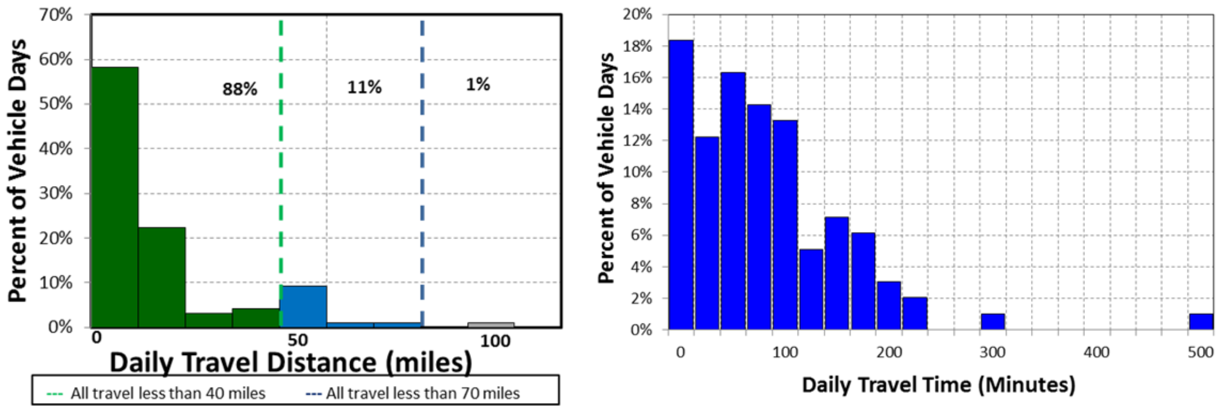


Figure 31. Enforcement vehicles percentage of daily use versus daily travel miles and time (all vehicles).

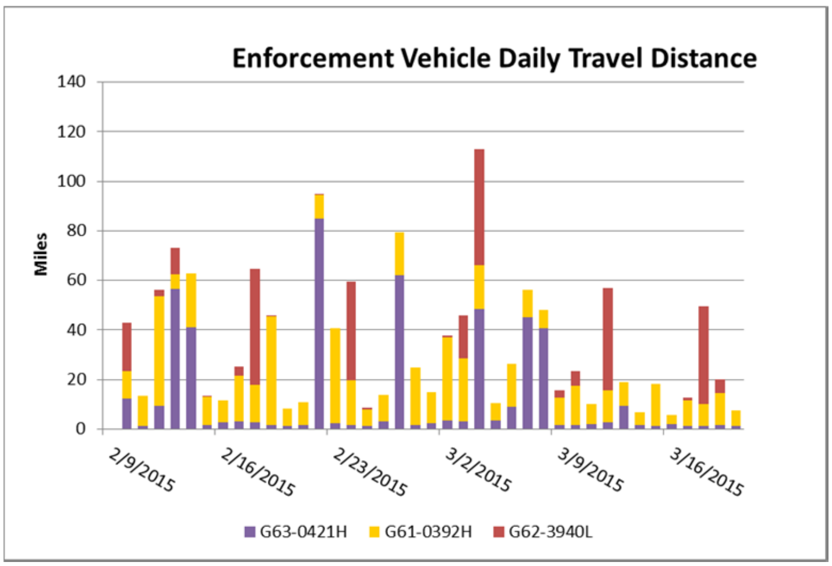


Figure 32. Enforcement vehicles daily travel miles.

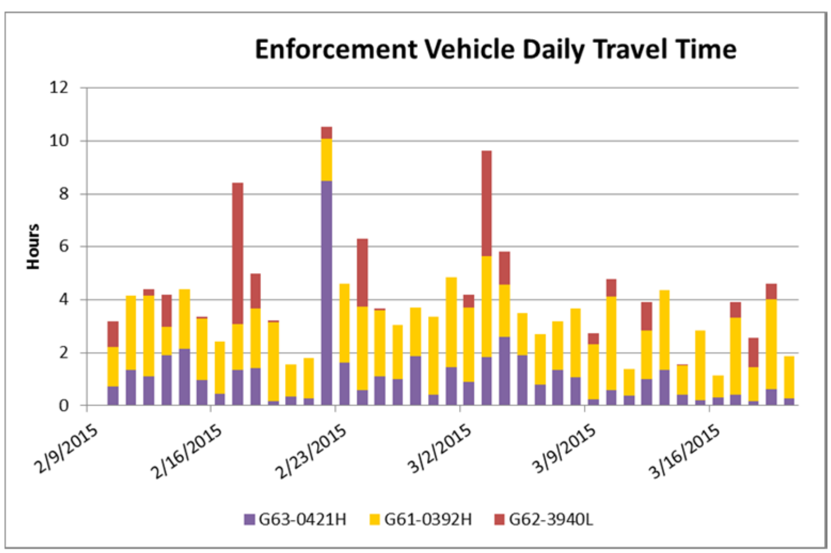


Figure 33. Enforcement vehicles daily travel time.

During the study period, the average travel distance per day, when driven, by the enforcement vehicle was 13.7 miles. On 99% of these vehicle days, the daily travel was less than the 70 miles considered to be within the BEV safe range, and 1% of enforcement vehicle daily travel was greater than 70 miles. Further, 88% of vehicle travel days were less than 40 miles considered to be within the CD mode range of a PHEV. See data sheets in Appendix B for details.

Figures 32 and 33 show that the vehicles are used often. Figure 34 shows the time of day during which trips started. Figure 35 shows the outing distances for the enforcement vehicles.

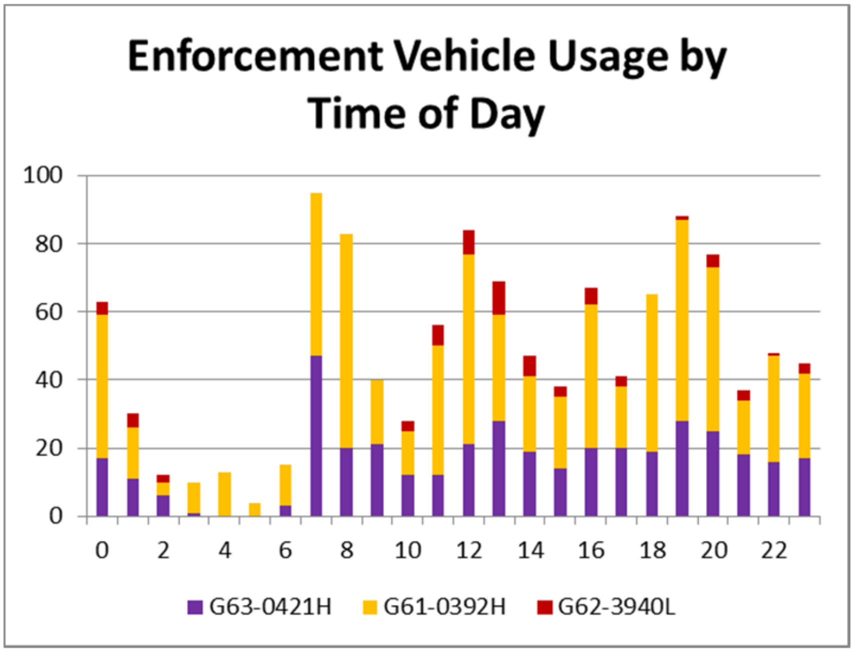


Figure 34. Enforcement vehicle hourly usage.

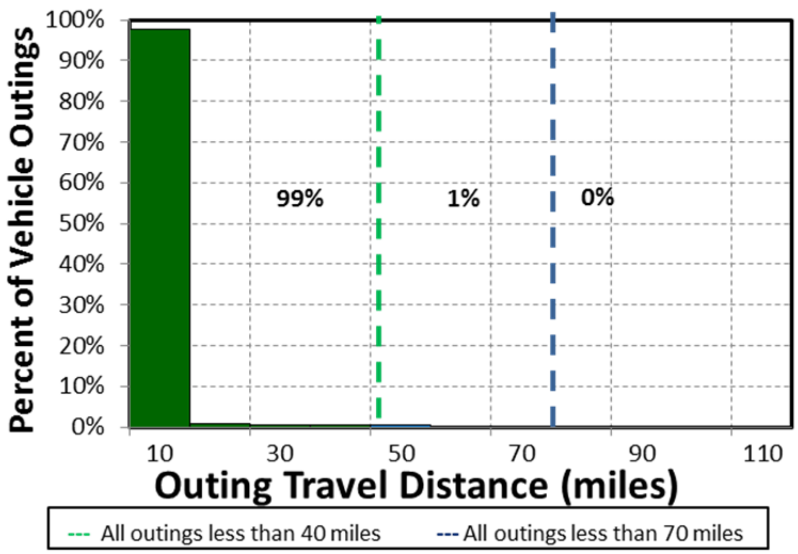


Figure 35. Enforcement vehicle outings.

Appendix B provides the details of the enforcement vehicle's daily travel. The average travel outing for the enforcement vehicles was 1.3 miles, with 99% of vehicle travel outings less than 40 miles and considered to be within the CD mode range of a PHEV.

5.6.3 Enforcement Vehicle Observations/Summary

As before, consideration of the following three possible options for INL in introducing PEVs into the enforcement vehicle fleet was evaluated, with an objective of incorporating 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 occasional long distances experienced by one of 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 PHEV's gasoline engine can provide motive power when the battery has been depleted. Figure 31 shows that on 88% 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, 99% of the outings were less than 40 miles and could be completed in CD mode for certain PHEVs if the battery is fully charged prior to the outing.

   All 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 appropriately assign vehicles for the anticipated use on that day.

   The data suggest that 1% 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 99% of the fleet could be BEVs. However, a more conservative approach for enforcement vehicles, for which range limitations may not be desirable, is to replace vehicles with more PHEVs. Thus, for these three enforcement vehicles, Intertek recommends using one BEV and two PHEVs.

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, although it is recognized that visitation by the public is limited because of INL operations.

The current fleet contains 59 enforcement vehicles, all of which have PEV replacement models currently available. While the above analysis suggests a high percentage of BEVs would meet mission requirements, it is recognized that additional PHEVs may provide greater confidence in meeting all mission needs. Thus, Intertek suggests that 26 BEVs and 33 PHEVs could replace these vehicles and continue to carry out the same mission.

5.6.4 Enforcement Vehicle Charging Needs

Upon review of these data, Intertek suggests replacement of the studied enforcement fleet with one BEVs and two 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 enforcement fleet. A DCFC at the home base will provide a more rapid recharge for BEVs but appears to be unnecessary for this specific travel. However, as noted above, DCFC at each of the major INL sites may be beneficial because many vehicles transit between sites and rapid recharging may allow more BEVs in the fleet.

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.

For the entire fleet of enforcement vehicles, the 26 BEVs require 26 AC Level 2 EVSE units for overnight charging and the 33 PHEVs require 33 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.

At times, fleet vehicles obtain benefits from using public charging infrastructure. Figure 25 displays the availability of public charging at the time of this writing for the INL area; however, data indicate it would be of very limited value in support of these vehicles.

5.7 Fleet Vehicle Summary

Figure 1 shows the major sites with INL responsibilities. There is significant distance between these sites and the monitored vehicles demonstrate that vehicles frequently transit between these sites. As such, daily travel can exceed the CD mode travel for most PEVs. While significant savings occur within the first 40 miles or so of CD mode, the balance of the trips would continue to use gasoline. Having recharge capabilities available at each of the sites would support a significant increase in the vehicles' CD mode. If BEVs are incorporated into the fleet, it may also be beneficial to install a DCFC at each of the sites to reduce the recharge time for a BEV and increase driver confidence that the vehicle will not deplete battery capability in transit.

This study found that for the 12 vehicles monitored, travel requirements would conservatively replace these with one BEV and 11 PHEVs. Such conservatism may not be necessary for the full fleet because several vehicles may be available for selection and, based on the intended travel (and the availability of recharge capabilities at a remote site), more BEVs may be possible.

6. GREENHOUSE GAS EMISSIONS AVOIDED AND FUEL COST REDUCTION ANALYSIS

6.1 General 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 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, but PEVs are more efficient than conventional ICE vehicles. Because fuel logs were not kept, the mileage accumulated by each vehicle and extrapolation to annual miles provide one source of annual miles estimates. INL also provided information related to anticipated annual miles; these are compared to that calculated miles 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.[33] Tables 17 and 18 provide these ratings. Ratings for the PHEVs in Table 18 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 additional charge time exists between most outings and benefits are realized for the first 40 miles of all trips from the home base. It is also conservative because the replacement PEV typically will have greater fuel economy when operating in CS mode. BEVs operate in electric mode for 100% of travel. The one exception in this report is for Vehicle G13-2193P, which was used almost exclusively for long distance travel; therefore, there were no days of daily travel less than 40 miles. However, a replacement PHEV will provide benefit for the first 40 miles of this long distance travel; therefore, this was calculated to be 41% of this vehicle's total travel.
2. Energy consumption for the Mitsubishi Outlander is assigned the same value as the RAV4 EV, and the Via Motors VTRUX PU and van consumptions are estimated because EPA has not yet created ratings for these vehicles.
3. Figure 25 suggests the PEVs to replace existing monitored vehicles. See Section 4.4 for vehicle availability. The PEV listed is a vehicle type and other make and model vehicles may be available for replacement.
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 as reported by INL for information. INL's annual miles are used for reduction calculations. Miles in CD mode are INL annual miles times percent of daily travel less than 40 miles for the PHEV replacement and full annual miles for the BEV replacement.
5. Fuel economy is based on gasoline usage. Although most of the INL fleet is E85 flexible and its use is encouraged by policy, its use is not required. Fuel costs for E85 are higher than gasoline; therefore, calculated fuel cost savings here using gasoline are conservative. Emissions using E85 are generally less than gasoline and such figures are included in the Appendix B data sheets. Gasoline figures also allow comparisons across all federal agency fleets.

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

Vehicle	Logger	Mission	Make & Model	Model Year	Fuel Economy-Combined (miles/gallon)
G63-0421H	48	Enforcement	Chevrolet Suburban	2010	17
G61-0392H	49	Enforcement	Dodge Dakota	2009	15
G13-2193P	50	Support	Ford Focus	2014	30
G41-3181P	51	Support	Dodge Caravan	2014	20
G13-5142P	52	Pool	Ford Focus	2014	30
G63-1386G	53	Support	Ford F350	2015	20
G63-0410M	54	Support	Ford F350	2012	18
G43-0880H	55	Pool	Ford E350	2009	17
G43-0877H	56	Pool	Ford E350	2011	12
G62-3940L	57	Enforcement	Ford Expedition XLT	2012	16
G61-1443G	58	Support	Dodge Dakota	2010	16
G62-1726L	61	Support	Chevrolet K1500H	2011	15

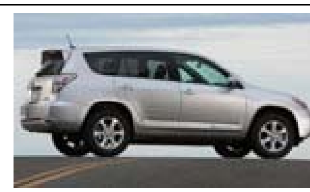
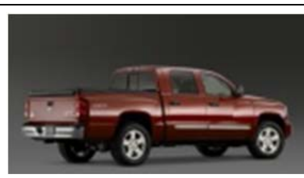
[33] http://www.fueleconomy.gov/feg/Find.do?action=sbs&id=33558 [March 16, 2015].

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

Vehicle	Mission	Replacement PEV	Wh/mile
G63-0421H	Enforcement	Toyota RAV4 EV	440
G61-0392H	Enforcement	Via VTRUX VR300	475
G13-2193P	Support	Chevrolet Volt	350
G41-3181P	Support	Mitsubishi Outlander	440
G13-5142P	Pool	Chevrolet Volt	350
G63-1386G	Support	Via VTRUX VR300	475
G63-0410M	Support	Via VTRUX VR300	475
G43-0880H	Pool	Via eREV van	475
G43-0877H	Pool	Via eREV van	475
G62-3940L	Enforcement	Mitsubishi Outlander	440
G61-1443G	Support	Via VTRUX VR300	475
G62-1726L	Support	Via VTRUX VR300	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 – Compact/Subcompact	 Ford Focus	 Chevrolet Volt 350 Wh/mi	 Ford Focus Electric 310 Wh/mi
Sedan – Midsize	 Chevrolet Cruze	 Ford Fusion Energi 370 Wh/mi	 Nissan Leaf 300 Wh/mi
SUV and Minivan	 Ford Expedition	 Mitsubishi Outlander 440 wh/mi	 Toyota RAV4 440 wh/mi
Pickup Truck	 Dodge Dakota	 Via Motors VTRUX 475 wh/mi	 Nissan eNV200 400 wh/mi

Vehicle Class	Current Vehicle Example	Replacement PHEV	Replacement BEV
Sedan – Compact/Subcompact	 Ford Focus	 Chevrolet Volt 350 Wh/mi	 Ford Focus Electric 310 Wh/mi
Sedan – Midsize	 Chevrolet Cruze	 Ford Fusion Energi 370 Wh/mi	 Nissan Leaf 300 Wh/mi
Pickup Truck (alternate)	 Ford F150	 Mitsubishi Outlander 440 wh/mi	 Toyota RAV4 EV 440 wh/mi
Cargo Van	 Chevrolet G2500	 Via eREV Van 475 Wh/mi	 Nissan eNV200 400 Wh/mi
Passenger Van	 Ford E350	 Via eREV VAN 475 Wh/mi	 Nissan eNV200 400 Wh/mi

Calculations provided for GHG emissions and fuel savings include both a total U.S. perspective and a perspective 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 INL 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 summarizing results from all sites studied across the United States from Intertek to INL 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, which also accounts for other GHGs such as methane and nitrous oxide, $lb\text{-}CO_2e$)

from combustion of gasoline is 20.1 lb-CO_2e/gallon.[34] The United States averages for GHG emissions for the production of electricity is 1.53 lb-CO_2e/kWh.[35]

Idaho Falls Power provides electrical services to Idaho Falls. It is a member of the Idaho Consumer-owned Utilities Association. Idaho Consumer-owned Utilities Association represents 22 of Idaho's rural electric cooperatives and municipalities that provide electrical services in Idaho. The Bonneville Power Administration supplies over 96% of the wholesale electric power that Idaho Consumer-owned Utilities Association member utilities deliver to their customers.[36] 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[37]. Using the information provided for the Bonneville Power Administration, emissions for 2010 for the production of electricity were 0.323lb-CO_2e/kWh. Note that this emissions rate is approximately one-fifth of the national average for production and reflects Bonneville Power Administration's heavy reliance on renewable generation.

GHG emissions avoided are the GHGs 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 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 19 shows the calculation of annual miles based on the recorded and extrapolated miles in this study. INL's reported annual miles are also shown for comparison. A 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 are the percentage of INL reported annual miles. Several vehicles had much higher mileage during the study than the average usage, while a few had much lower mileage. Further calculations are based on the annual miles provided by INL.

Table 19. CD mode miles calculations.

Vehicle	Replacement Vehicle	Study Calculated Annual Miles	INL Reported Annual Miles	Percent of Miles CD Mode	CD Mode Miles
G63-0421H	Toyota RAV4 EV	4,436	5,561	100%	5,561
G61-0392H	Via VTRUX VR300	5,487	3,434	95%	3,262
G13-2193P	Chevrolet Volt	9,222	2,657	41%	1,089
G41-3181P	Mitsubishi Outlander	30,667	11,900	13%	1,547
G13-5142P	Chevrolet Volt	26,659	4,350	13%	566
G63-1386G	Via VTRUX VR300	6,508	21,736	70%	15,215
G63-0410M	Via VTRUX VR300	11,113	5,922	36%	2,132
G43-0880H	Via eREV van	8,578	3,620	29%	1,050
G43-0877H	Via eREV van	9,504	7,161	46%	3,294
G62-3940L	Mitsubishi Outlander	2,670	6,428	85%	5,464
G61-1443G	Via VTRUX VR300	13,638	11,276	30%	3,383
G62-1726L	Via VTRUX VR300	10,973	9,945	48%	4,774

[34] http://avt.inl.gov/pdf/EVProj/106077-891082.ghg.pdf [accessed March 16, 2015].

[35] ibid.

[36] http://www.icua.coop/about-icua/ [accessed February 19, 2015].

[37] http://www.epa.gov/cleanenergy/energy-resources/egrid/ [accessed March 16, 2015].

For the cost-avoided piece of the analysis, fuel cost assumptions are $2.420/gallon of regular gasoline for the United States, $2.41/gallon in Idaho, and $2.255/gallon in Idaho Falls area.[38] Electrical costs are 0.0984 $/kWh for the United States and 0.0692 $/kWh in Idaho.[39] 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 yield estimates for yearly GHG emissions avoided and fuel cost reductions. The results of this analysis (shown in Table 20) demonstrate that the substitution of a conventional ICE vehicle with a PEV can reduce 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 the Dodge Caravan support vehicle G41-3181P, an 86% reduction in GHG emissions in Idaho occurs. The Caravan traveling 1,547 miles per year produces 1,555 lb-CO_2e/year, whereas the Outlander produces 220 lb-CO_2e/year for that same distance for a reduction of 1,335 lb-CO_2e/year.

Table 20. GHG 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
Enforcement	RAV4 EV	5,785	88%	$568	77%
Enforcement	Via VR300	3,871	89%	$383	78%
Support	Volt	607	83%	$55	68%
Support	Outlander	1,335	86%	$127	73%
Pool	Volt	315	83%	$29	68%
Support	Via VR300	12,957	85%	$1,215	71%
Support	Via VR300	2,054	86%	$197	74%
Pool	Via eREV	1,080	87%	$105	75%
Pool	Via eREV	5,012	91%	$511	83%
Enforcement	Outlander	6,087	89%	$604	78%
Support	Via VR300	3,731	88%	$366	77%
Support	Via VR300	5,664	89%	$561	78%
Total		**48,497**	**87%**	**$4,712**	**76%**
Total Pool		**6,407**	**90%**	**$644**	**80%**
Total Support		**26,347**	**86%**	**$2,522**	**73%**
Total Enforcement		**15,743**	**88%**	**$1,555**	**78%**

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

As projected in Section 5, 15 BEVs and 60 PHEVs may be able to replace the pool fleet of 75 vehicles. The support fleet of 244 vehicles may be able to be replaced with 81 BEVs and 163 PHEVs. Further, 26 BEVs and 33 PHEVs can replace the enforcement fleet of 59 vehicles. Using an average savings per vehicle, Table 21 provides the avoided GHG and fuel cost savings should these replacements

[38] http://www.idahogasprices.com/Idaho_Falls/index.aspx [Accessed March 6, 2015]

[39] http://www.eia.gov/electricity/state/ [Accessed February 19, 2015]

occur. The table also shows the percentage of reduction in GHG emissions and fuel costs for ease of comparison. Only local Idaho savings are projected in this table; national figures are presented in Appendix C.

Table 21. Extrapolated GHG avoided and fuel cost savings for the entire fleet.

Mission	Extrapolated Local Yearly CO_2e Avoided ($lb\text{-}CO_2e$/year)	% reduction	Extrapolated Local Yearly Fuel Cost Reduction ($/year)	% reduction
Pool	457,873	88%	$45,073	77%
Support	1,117,118	87%	$108,506	75%
Enforcement	311,159	89%	$30,907	79%
Total	1,886,149	88%	$184,485	76%

6.2 Weather Effects

Ambient temperatures affect energy consumption for BEVs and PHEVs. Charged Magazine reported on these effects in the January/February 2015 edition. Figures 35 and 36, (which come from that article) illustrate the changes in energy consumption with temperature.

Charged Magazine identified the major effects from cold and hot temperatures that are primarily due to cabin heating and cooling (i.e., air conditioning required in hot weather and cabin heating in cold weather had the greatest effect). "Reduced battery efficiency was only significant below -4°F."[40]

Table 22 shows the average summer and winter temperatures in the relevant cities of Idaho. While summer temperatures in Idaho have little effect on performance, the winter temperatures will have an effect.

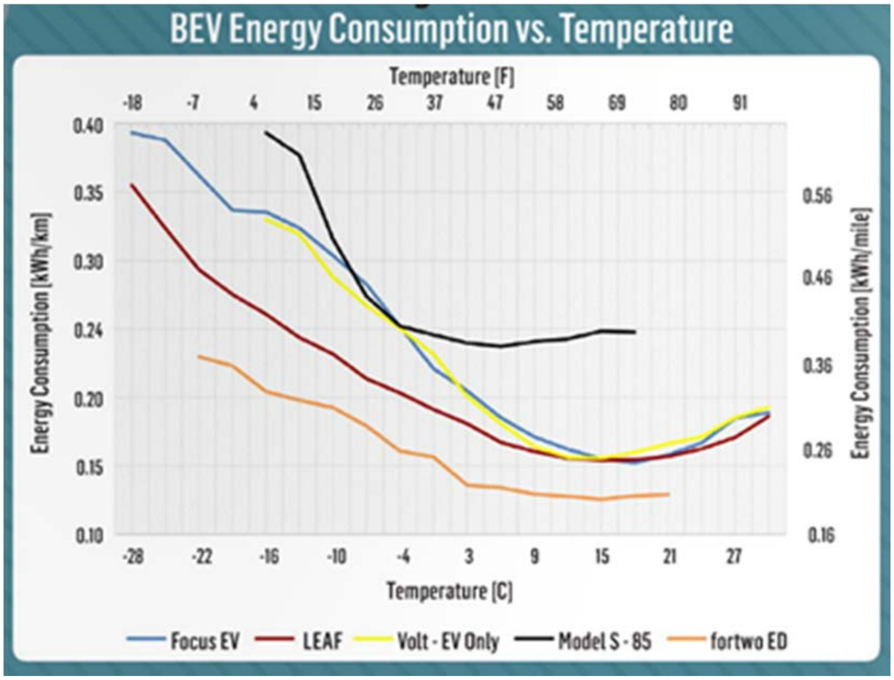


Figure 36. Temperature effects on BEVs.[41]

[40] Ibid.

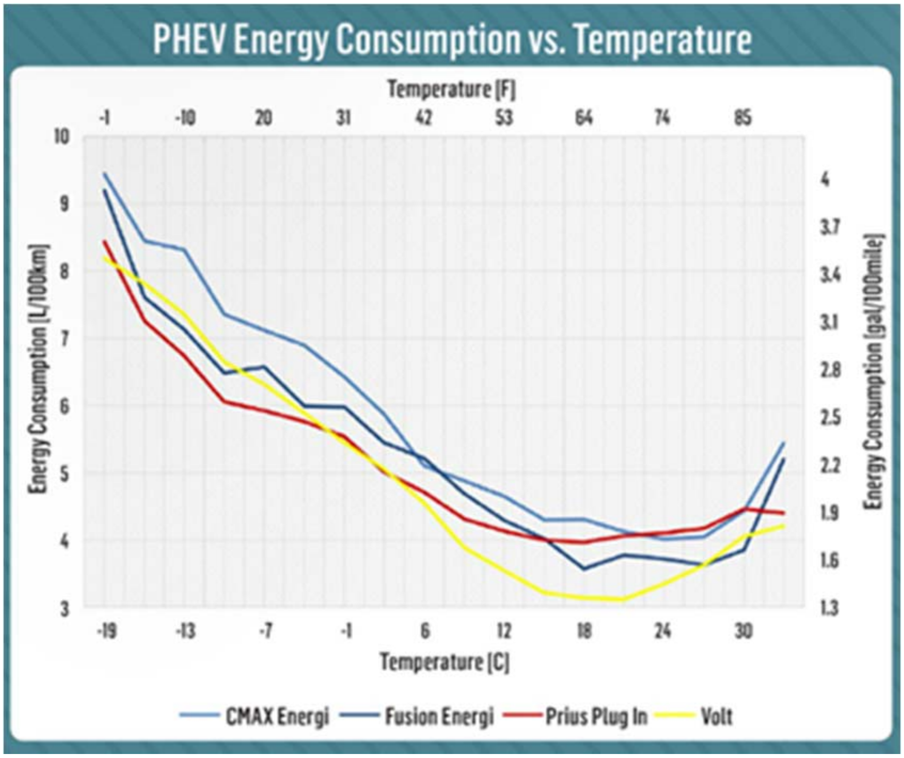


Figure 37. Temperature effects on PHEVs.[42]

Table 22. High and low temperatures for INL.[43]

City	Elevation	July High Temperature	January Low Temperature
Idaho Falls	4,730 ft	86.0	10.0
Pocatello	4,450 ft	88.1	14.4

The effects on the vehicle will be some shortening of CD mode range on both BEVs and PHEVs during colder months, resulting in lower savings than those identified in Section 6.1. Preconditioning the cabin, if possible, garaging the vehicles prior to travel can lessen this effect.

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: INL can move forward in the near future with 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 are candidates for immediate replacement.

[41] Charged Magazine, January/February 2015, page 57.
[42] ibid.
[43] http://www.visitidaho.org/climate/ [accessed May 27, 2015].

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 particular, investigating vehicles that essentially stay within one INL site and those that regularly transit between sites may be helpful.

Observation #3:

Vehicle Replacement Plan: Development of a detailed vehicle replacement plan could be beneficial; this plan would include a 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 INL sites for placement of PEV charging infrastructure could be beneficial. Intertek has significant experience in this area and such plans will consider not only fleet vehicle charging needs, but the convenience that charging infrastructure provides employees and visitors. This planning also considers the existing facility electrical distribution system. Vehicle home base considerations factor into the ratio of PEVs to EVSE units to maintain all vehicles at operational readiness.

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_2H_5OH) 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
Idaho National Lab Vehicle Data Sheets

Table B-1. INL vehicle index.

Vehicle Index						
Log	INL Vehicle Id	Make	Model	Year	EPA Class	Mission
48	G63-0421H	Chevrolet	Suburban	2010	SUV	Enforcement
49	G61-0392H	Dodge	Dakota	2009	Pickup	Enforcement
50	G13-2193P	Ford	Focus	2014	Sedan - Compact	Support
51	G41-3181P	Dodge	Caravan	2014	Minivan	Support
52	G13-5142P	Ford	Focus	2014	Sedan - Compact	Pool
53	G63-1386G	Ford	F350	2015	Pickup	Support
54	G63-0410M	Ford	F350	2012	Pickup	Support
55	G43-0880H	Ford	E350	2009	Van - Pass	Pool
56	G43-0877H	Ford	E350	2011	Van - Pass	Pool
57	G62-3940L	Ford	Expedition XLT	2012	SUV	Enforcement
58	G61-1443G	Dodge	Dakota	2010	Pickup	Support
61	G62-1726L	Chevrolet	K1500H	2011	Pickup	Support

Vehicle G63-0421H

Make Model/Year	Chevrolet Suburban – 2010
EPA Class Size	SUV
Mission	Enforcement
Department Assigned	Protective Force Services
Parking Location	Materials and Fuels Complex
Fleet Vehicle ID	G63-0421H
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy/Combined)	15/21/17 11/16/13
EPA GHG Emissions (Grams CO_2/Mi)	523/477
Study Logger ID	48
Total Vehicle Days/Total Study Days	39/39

Vehicle G63-0421H Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	12.2/85.0	1.4/61.0	1.2/39.1	474
Travel Time (Minutes)	70.0/509.0	8.0/346.0	6.9/346.0	2,714
Idle Time (Minutes)	39.8/NA	4.6/NA	3.9/NA	1,554

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	357	97.3	Less than 2	218
10 to 20	10	2.7	2 to 4	77
20 to 40	0	0	4 to 8	63
Greater than 40	0	0	Greater than 8	9

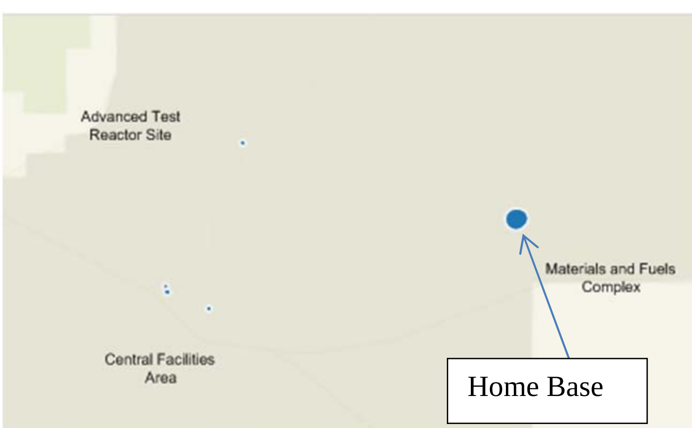


Figure B-1. Vehicle G63-0421H stops.

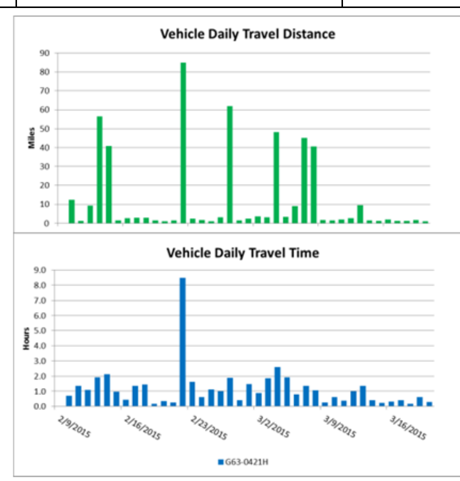


Figure B-2. Vehicle G63-0421H history.

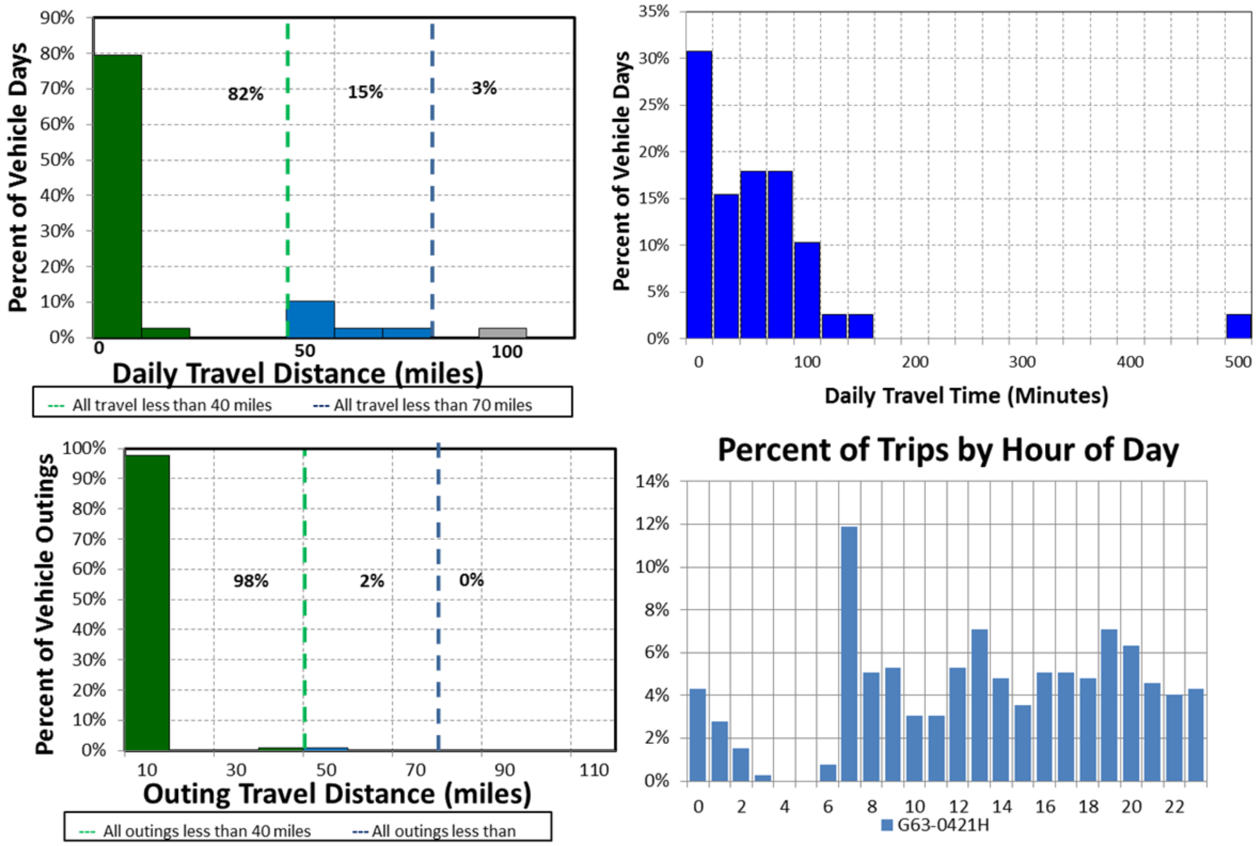


Figure B-3. Vehicle G63-0421H travel graphs.

Vehicle G63-0421H Observations

Logger 48 collected data on this vehicle for a period of 39 days of the 39-day study period. Validation occurred on 100% of the input data. INL reports that this vehicle has an enforcement mission for Protective Force Services. This vehicle's data indicate it typically parks overnight at the Materials and Fuels Complex on Harrison Boulevard as shown in Figure B-1 and the Google Earth figure to the right.

INL reports that the vehicle odometer indicated 27,804 miles during the study and its average annual mileage is 5,561 miles. The vehicle was used on 100% of the available days, with an average daily usage of 2.2 hours and a peak daily usage of 8.5 hours on the days it was used. The vehicle was used during all hours of the day.

Figure B-3 shows that 97% of daily travel was within the typically advertised range of a BEV of approximately 70 miles, and 98% of the outings were within this range. Further, 82% of daily travel and 98% of outings were within the typically advertised CD mode of 40 miles for PHEVs. All recorded stops were within 20 miles of the home base.

A BEV could meet most of the daily travel without additional charging opportunities, assuming the vehicle is charged at its home base. Charging at the Central Facilities Area could extend daily range to meet longer outings and daily travel events. However, fleet managers typically do not prefer enforcement vehicles that contain range limitations. Thus, a fleet of enforcement vehicles would likely contain a mix of BEVs and PHEVs.

Vehicle G61-0392H

Make/Model/Year	Dodge Dakota – 2010
EPA Class Size	Pickup
Mission	Enforcement
Department Assigned	Protective Force Services
Parking Location	Advanced Test Reactor Complex
Fleet Vehicle ID	G61-0392H
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy/Combined)	14/19/15 9/13/10
EPA GHG Emissions (Grams CO_2/Mi)	592/620
Study Logger ID	49
Total Vehicle Days/Total Study Days	39/39

Vehicle G61-0392H Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	15.0/44.3	0.9/25.8	0.8/17.7	586
Travel Time (Minutes)	134.0/228.0	7.8/114.0	7.5/74.0	5,208
Idle Time (Minutes)	58.4/NA	3.4/NA	3.3/NA	2,277

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	640	100	Less than 2	512
10 to 20	0	0	2 to 4	85
20 to 40	0	0	4 to 8	41
Greater than 40	0	0	Greater than 8	2

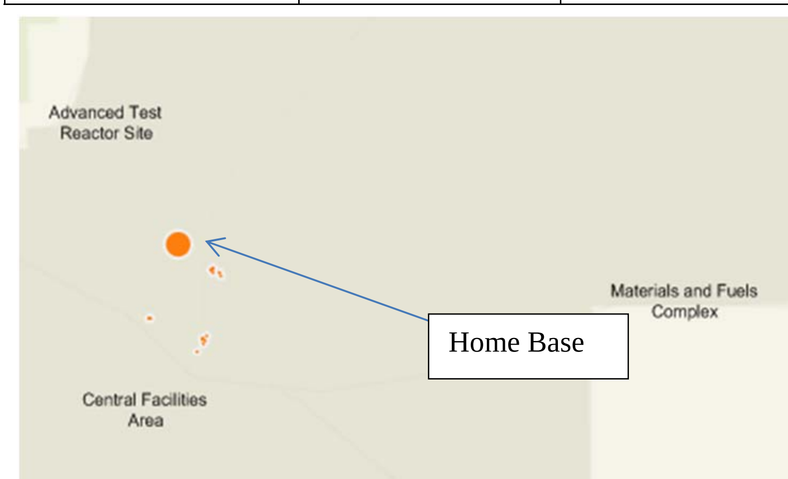


Figure B-4. Vehicle G61-0392H stops.

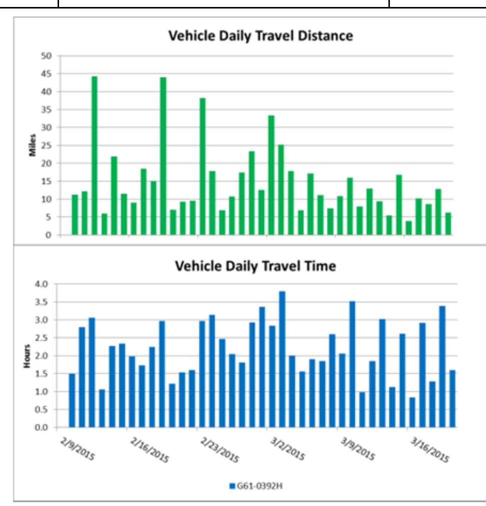


Figure B-5. Vehicle G61-0392H history.

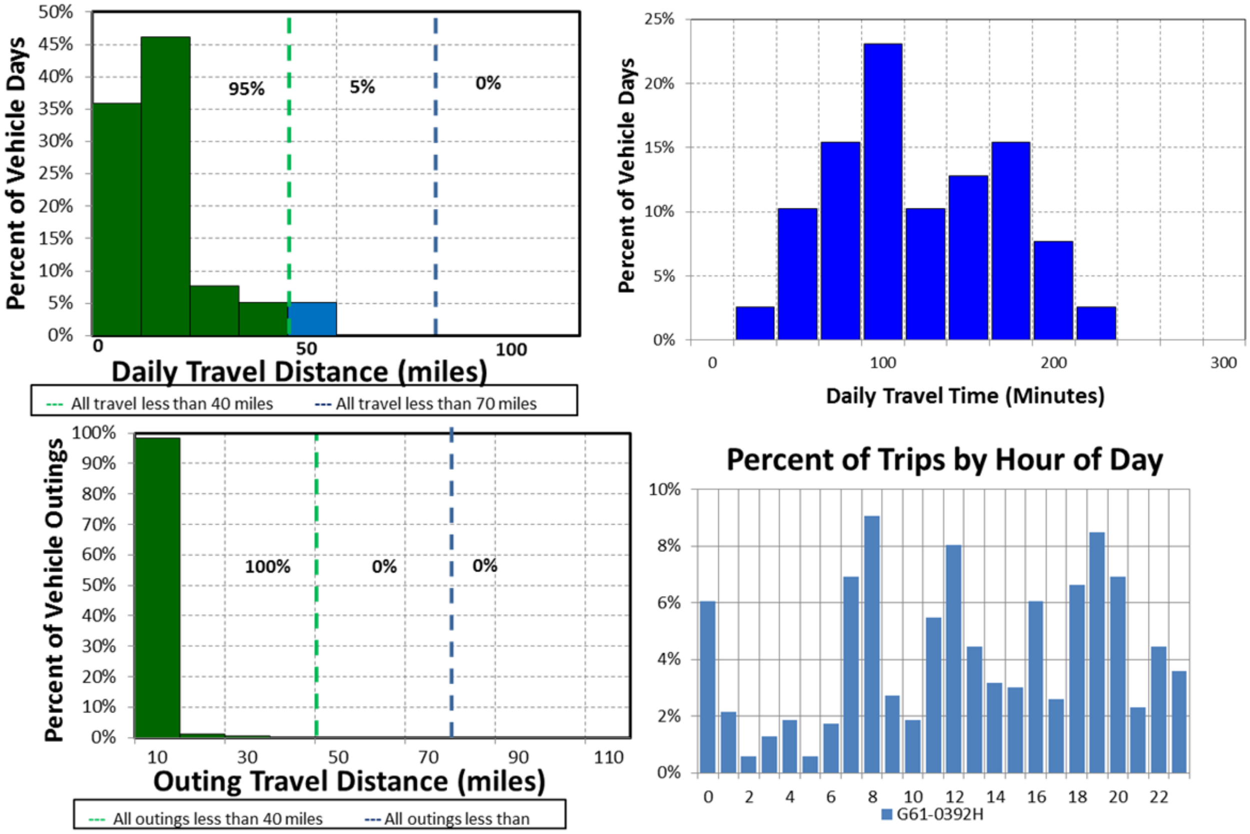


Figure B-6. Vehicle G61-0392H travel graphs.

Vehicle G61-0392H Observations

Logger 49 collected data on this vehicle for a period of 39 days of the 39-day study period. Validation occurred on 100% of the input data. INL reports this vehicle has an enforcement mission for Protective Force Services and typically parks overnight at the Advanced Test Reactor Complex on Monroe Boulevard as noted in Figure B-4 and the Google Earth figure to the right.

INL reports that the vehicle odometer indicated 20,606 miles during the study and it travels an average of 3,434 miles per year. The vehicle was used on 100% of the available days, with an average daily usage of 2.2 hours and a peak daily usage of 3.8 hours on the days it was used. The vehicle was used during all hours of the day.

Figure B-6 shows that all daily travel and all outings were within the typically advertised range of a BEV of approximately 70 miles. Further, 95% of daily travel and all outings were within the typically advertised CD mode of 40 miles for PHEVs. All recorded stops were within 10 miles of the home base.

A BEV can meet all daily travel without additional charging opportunities. BEVs are currently available as replacement vehicles for this vehicle. However, fleet managers typically do not prefer enforcement vehicles that may contain range limitations. Thus, a fleet of enforcement vehicles would likely contain a mix of BEVs and PHEVs.

Vehicle G13-2193P

Make/Model/Year	Ford Focus – 2014
EPA Class Size	Sedan – Compact
Mission	Support
Department Assigned	Corporate U.S. Department of Energy
Parking Location	INL Headquarters
Fleet Vehicle ID	G13-2193P
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy/Combined)	26/37/30 20/28/23
EPA GHG Emissions (Grams CO_2/Mi)	292/277
Study Logger ID	50
Total Vehicle Days/Total Study Days	10/39

Vehicle G13-2193P Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	98.5/107.8	89.6/104.4	28.2/51.8	985
Travel Time (Minutes)	118.0/160.0	107.4/160.0	33.7/105.0	1,181
Idle Time (Minutes)	0.6/NA	0.5/NA	0.2/NA	6

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	20	62.5	Less than 2	14
10 to 20	0	0	2 to 4	0
20 to 40	0	0	4 to 8	4
40 to 60	12	37.5	Greater than 8	14

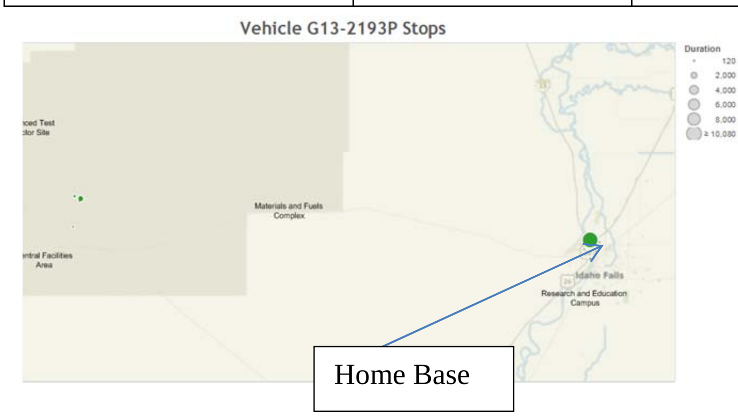


Figure B-7. Vehicle G13-2193P stops.

Figure B-8. Vehicle G13-2193P history.

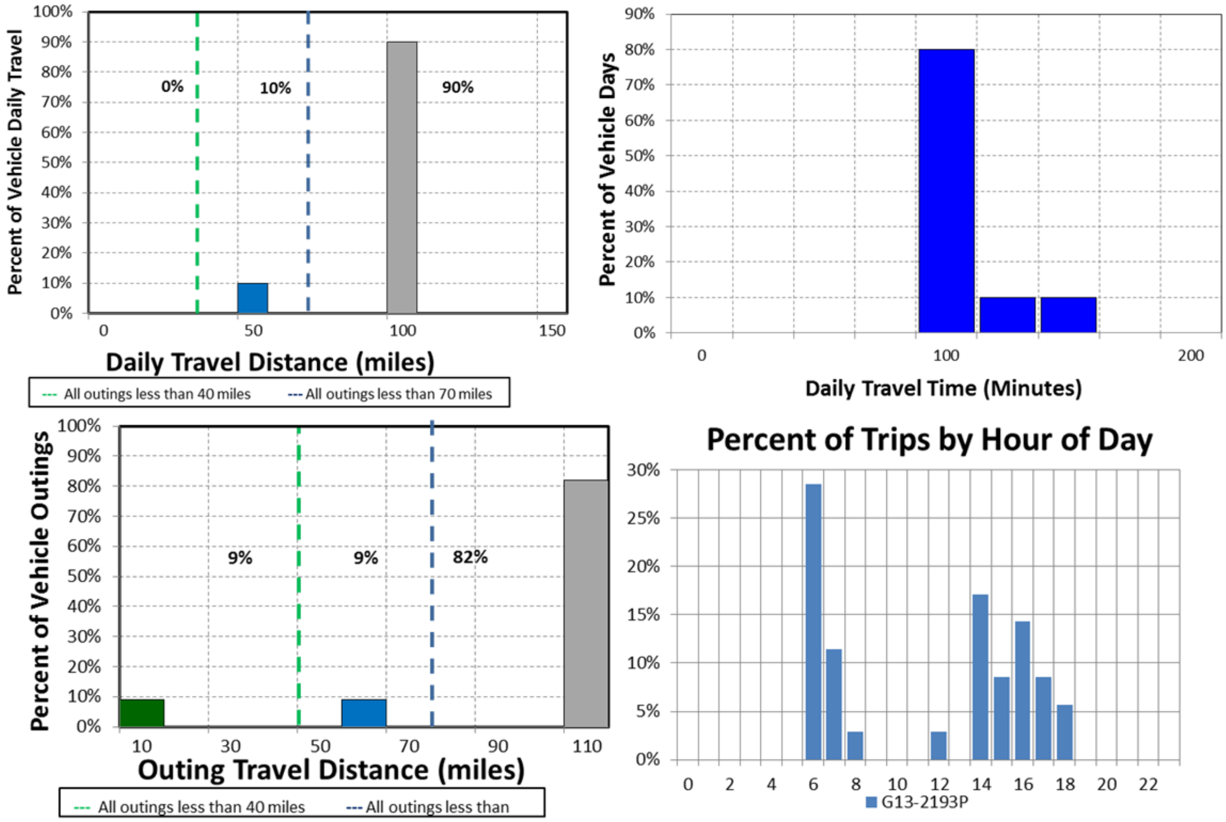


Figure B-9. Vehicle G13-2193P travel graphs.

Vehicle G13-2193P Observations

Logger 50 collected data on this vehicle for a period of 10 days of the 39-day study period. Validation occurred on 100% of the input data. INL reports this vehicle has a support mission and is used by the U.S. Department of Energy corporate. It typically parks near INL headquarters as shown in the Figure B-7 and the Google Earth figure to the right.

INL reports that the vehicle odometer indicated 2,657 miles during the study and it travels an average of 2,657 miles per year. The vehicle was used on 26% of the available days, with an average daily usage of 2.0 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-9 shows 10% of daily travel and 18% of outings were within the typically advertised range of a BEV of approximately 70 miles. Further, none of daily travel and 9% of the outings were within the typically advertised CD mode of 40 miles for PHEVs. Trips to the Central Facilities Area were common.

A BEV could not meet daily travel without additional charging opportunities (this charging may be available at the Central Facilities Area). Management may desire a fleet of BEVs and PHEVs to allow daily travel without requiring additional charge times, providing the PEV meets other mission requirements. The survey information suggests no other special requirements exist for this support activity. With a PHEV replacement, the first 40 miles of each trip could be in CD mode. While the daily travel shows no days fully within the range of a PHEV, benefit is achieved by the first 40 miles in DC mode. The vehicle was used on 10 days; therefore, the first 40 miles each day represents 41% of the vehicle’s travel.

Vehicle G41-3181P

Make/Model/Year	Dodge Caravan – 2014
EPA Class Size	Minivan
Mission	Support
Department Assigned	Transportation Services
Parking Location	Materials and Fuels Complex
Fleet Vehicle ID	G41-3181P
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy/Combined)	17/25/20 12/18/14
EPA GHG Emissions (Grams CO_2/Mi)	444/434
Study Logger ID	51
Total Vehicle Days/Total Study Days	23/39

Vehicle G41-3181P Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	142.5/178.2	131.1/178.1	28.5/82.8	3,277
Travel Time (Minutes)	202.0/268.0	185.6/244.0	40.3/97.0	4,639
Idle Time (Minutes)	26.6/NA	24.4/NA	5.3/NA	611

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	18	23.7	Less than 2	19
10 to 20	7	9.2	2 to 4	35
20 to 40	51	67.1	4 to 8	1
Greater than 40	0	0	Greater than 8	21

Figure B-10. Vehicle G41-3181P stops.

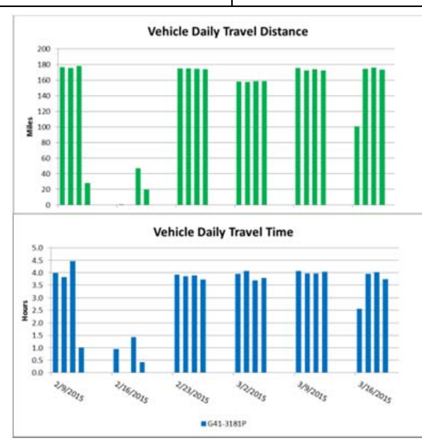


Figure B-11. Vehicle G41-3181P history.

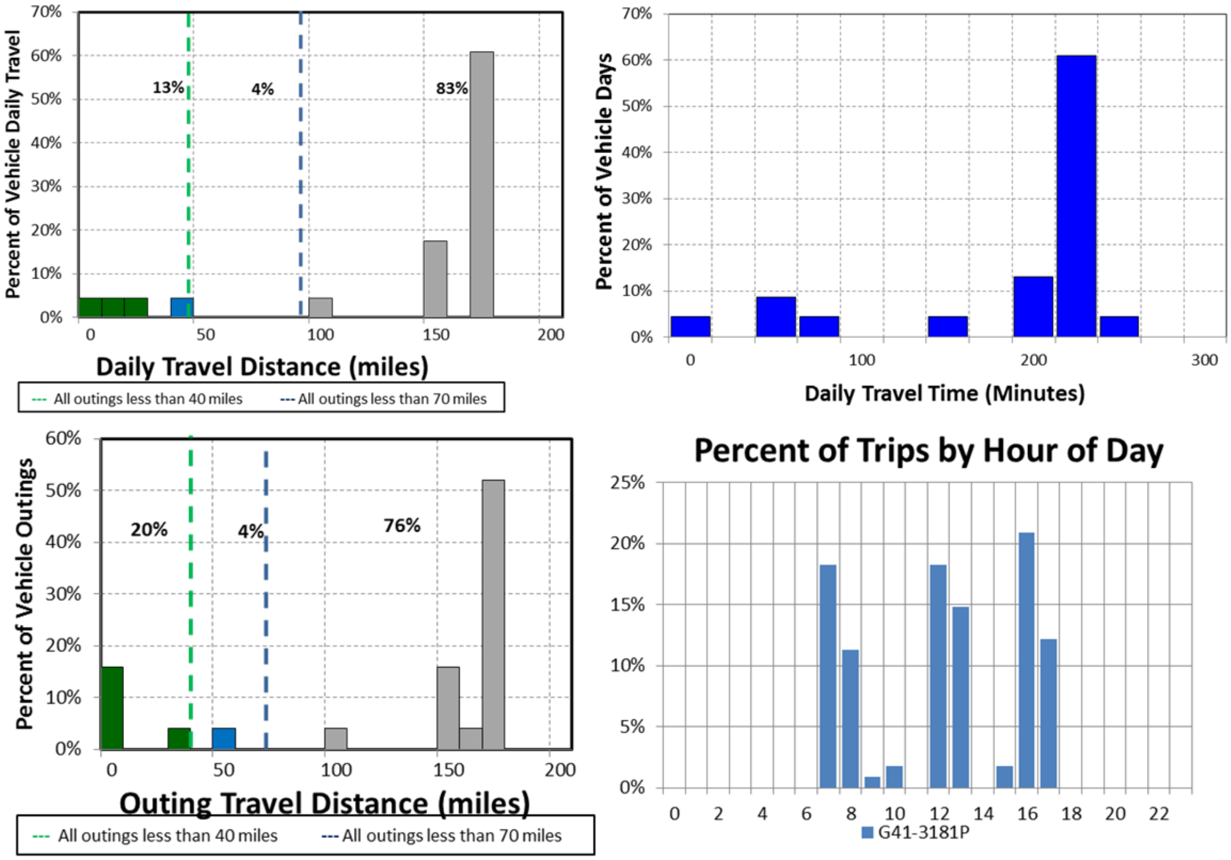


Figure B-12. Vehicle G41-3181P travel graphs.

Vehicle G41-3181P Observations

Logger 51 collected data on this vehicle for a period of 23 days of the 39-day study period. Validation occurred on 98.9% of the input data. INL reports that this vehicle is used to support the mission of the Transportation Services department. The data show it typically parks overnight at the Materials and Fuels Complex near Taylor Boulevard as shown in Figure B-10 and the Google Earth figure to the right.

INL reports that the vehicle odometer indicated 11,900 miles during the study and it travels an average of 11,900 miles per year. The vehicle was used on 59% of the available days prior to loss of the data logger, with an average daily usage of 3.4 hour and a peak daily usage of 4.5 hours on the days it was used. The vehicle was used primarily during typical day shift hours.

Figure B-12 shows that 17% of daily travel and 24% of outings were within the typically advertised range of a BEV of approximately 70 miles. Further, 13% of daily travel and 20% of outings were within the typically advertised CD mode of 40 miles for PHEVs.

A BEV could not meet the daily travel noted. Because significant travel is beyond the typical range of a BEV, a PHEV may be a more suitable replacement vehicle. The vehicle supports Transportation Services and the ability to carry cargo is not expected to be a factor.

Vehicle G13-5142P

		
	Make/Model/Year	Ford Focus – 2014
	EPA Class Size	Sedan – Compact
	Mission	Pool
	Department Assigned	Motor Pool
	Parking Location	INL Headquarters
	Fleet Vehicle ID	G13-5142P
	Fuel Type	Gas/E85
	EPA Label/MPG (City/Hwy)	26/37/30 20/28/23
	EPA GHG Emissions (Grams CO_2/Mi)	292/277
	Study Logger ID	52
	Total Vehicle Days/Total Study Days	24/39

Vehicle G13-5142P Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	118.7/426.3	69.5/426.5	23.7/212.8	2,849
Travel Time (Minutes)	151.0/430.0	88.2/547.0	30.1/189.0	3,617
Idle Time (Minutes)	21.9/NA	12.8/NA	4.4/NA	525

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	53	52	Less than 2	53
10 to 20	0	0	2 to 4	15
20 to 40	14	13.7	4 to 8	7
Greater than 40	35	34.3	Greater than 8	27

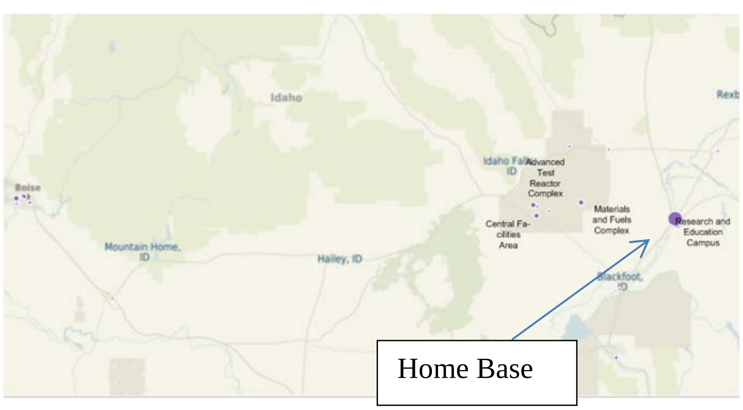


Figure B-13. Vehicle G13-5142P stops.

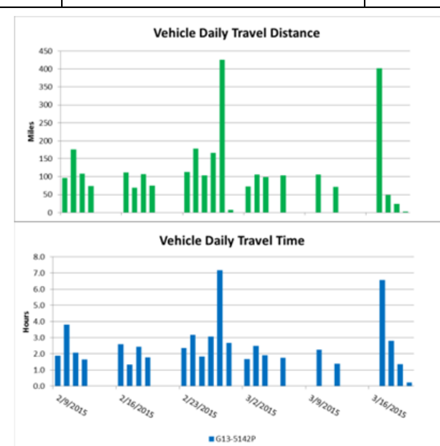


Figure B-14. Vehicle G13-5142P history.

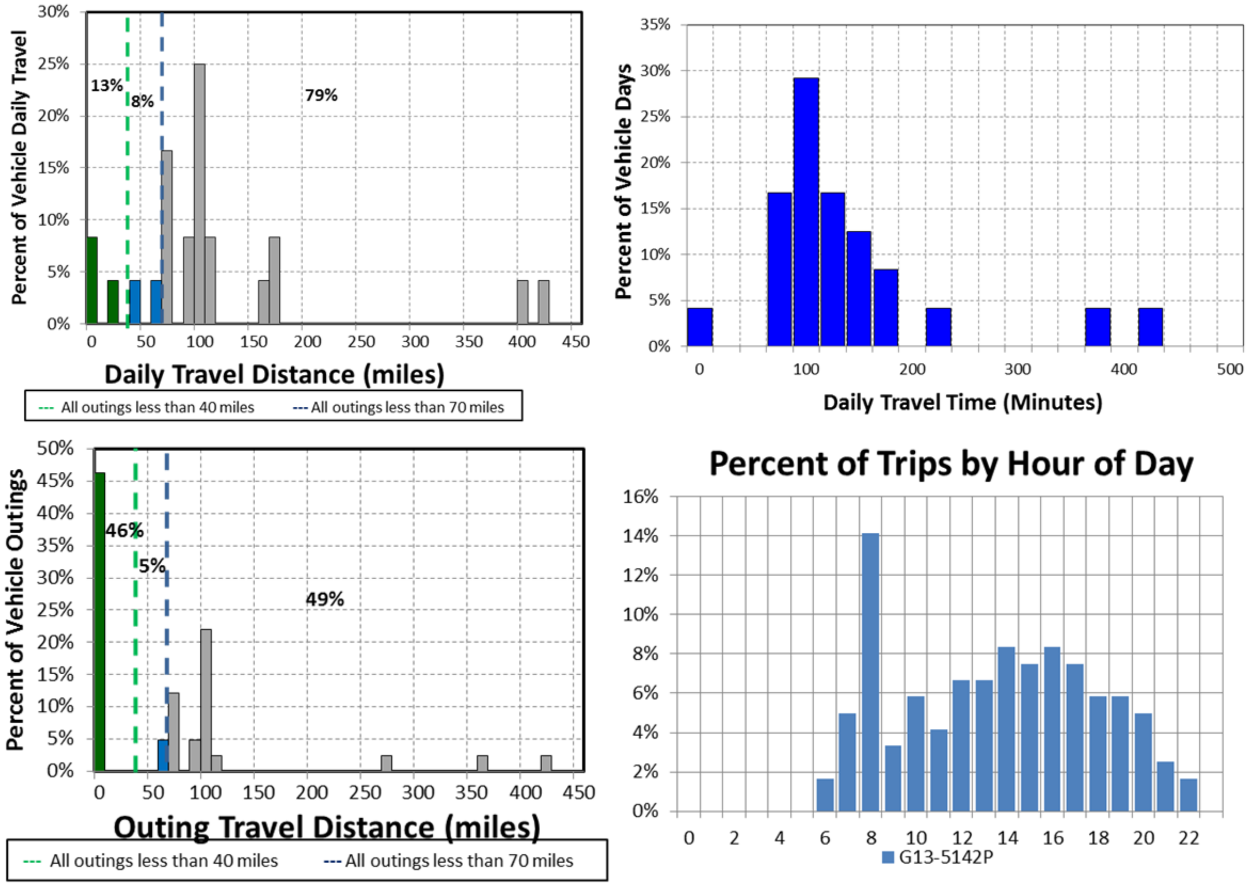
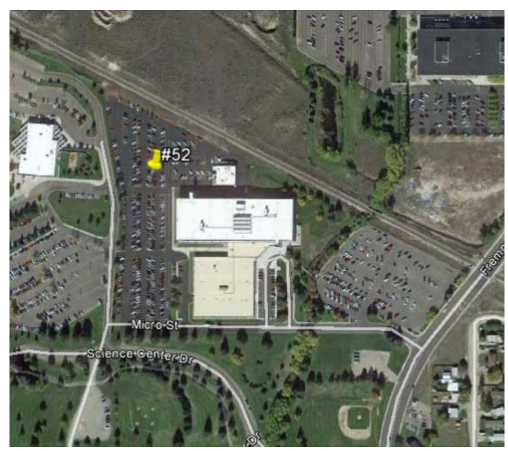


Figure B-15. Vehicle G13-5142P travel graphs.

Vehicle G13-5142P Observations

Logger 52 was installed on this vehicle for 24 days of the 39-day study. Validation occurred on 98.9% of the input data. INL reports that this vehicle has a pool mission and is available in the motor pool. The data show it typically parks overnight near INL headquarters as shown in Figure B-13 and the Google Earth figure to the right.



INL reports that the vehicle odometer indicated 4,350 miles during the study and it travels approximately 4,350 miles per year. The vehicle was used on 62% of the available days, with an average daily usage of 2.5 hour and a peak daily usage of 7.2 hours on the days it was used. The vehicle was used primarily during typical day shift hours.

Figure B-15 shows that 21% of daily travel and 51% of outings were within the typically advertised range of a BEV of approximately 70 miles. Further, 13% of daily travel and 46% of outings were within the typically advertised CD mode of 40 miles for PHEVs. This vehicle was used on extended trips to Salt Lake City and spent the last several days of the study period near Boise City.

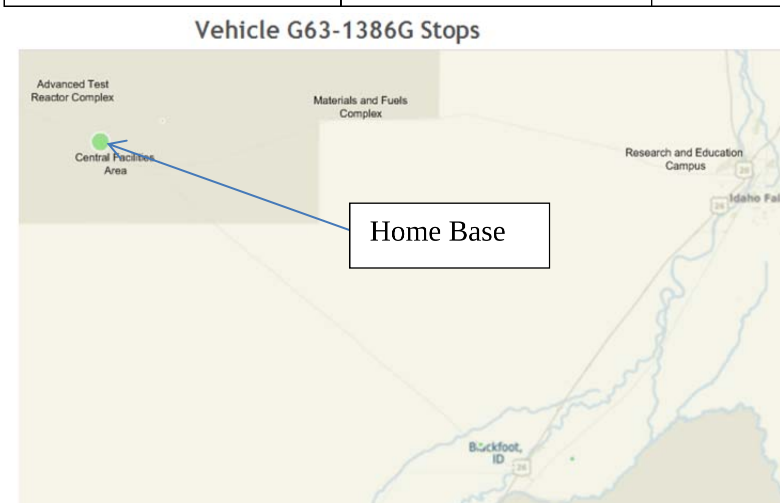
A BEV could not meet the daily travel noted. Because significant travel is beyond the typical range of a BEV, a PHEV may be a more suitable replacement vehicle. The vehicle supports the motor pool and the ability to carry cargo is not expected to be a factor.

Vehicle G63-1386G

Make/Model/Year	Ford F350 – 2015
EPA Class Size	Pickup
Mission	Support
Department Assigned	Power Management
Parking Location	Central Facilities Area
Fleet Vehicle ID	G63-1386G
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy/Combined)*	18/25/20 13/18/15
EPA GHG Emissions (Grams CO_2/Mi)*	436/419
Study Logger ID	53
Total Vehicle Days/Total Study Days	23/39

Vehicle G63-1386G Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	30.2/117.4	5.6/83.5	3.6/42.1	695
Travel Time (Minutes)	111.0/271.0	20.5/197.0	13.1/166.0	2,564
Idle Time (Minutes)	60.5/NA	11.1/NA	7.1/NA	1,392

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	142	92.2	Less than 2	108
10 to 20	0	0	2 to 4	20
20 to 40	12	7.8	4 to 8	7
Greater than 40	0	0	Greater than 8	19



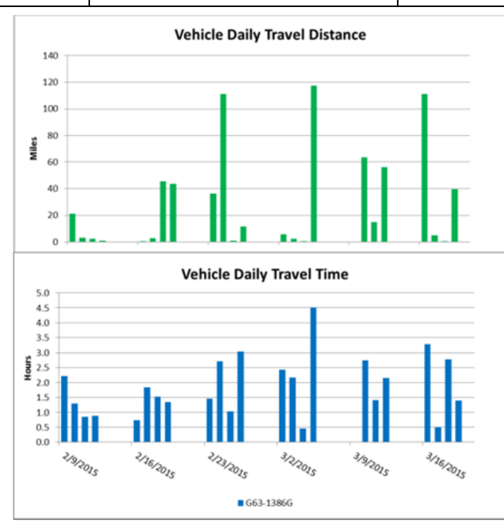


Figure B-16. Vehicle G63-1386G stops. Figure B-17. Vehicle G63-1386G history.

*Fuel economy for Ford F350 is not available. Economy used is for Ford F150 flex fuel vehicle.

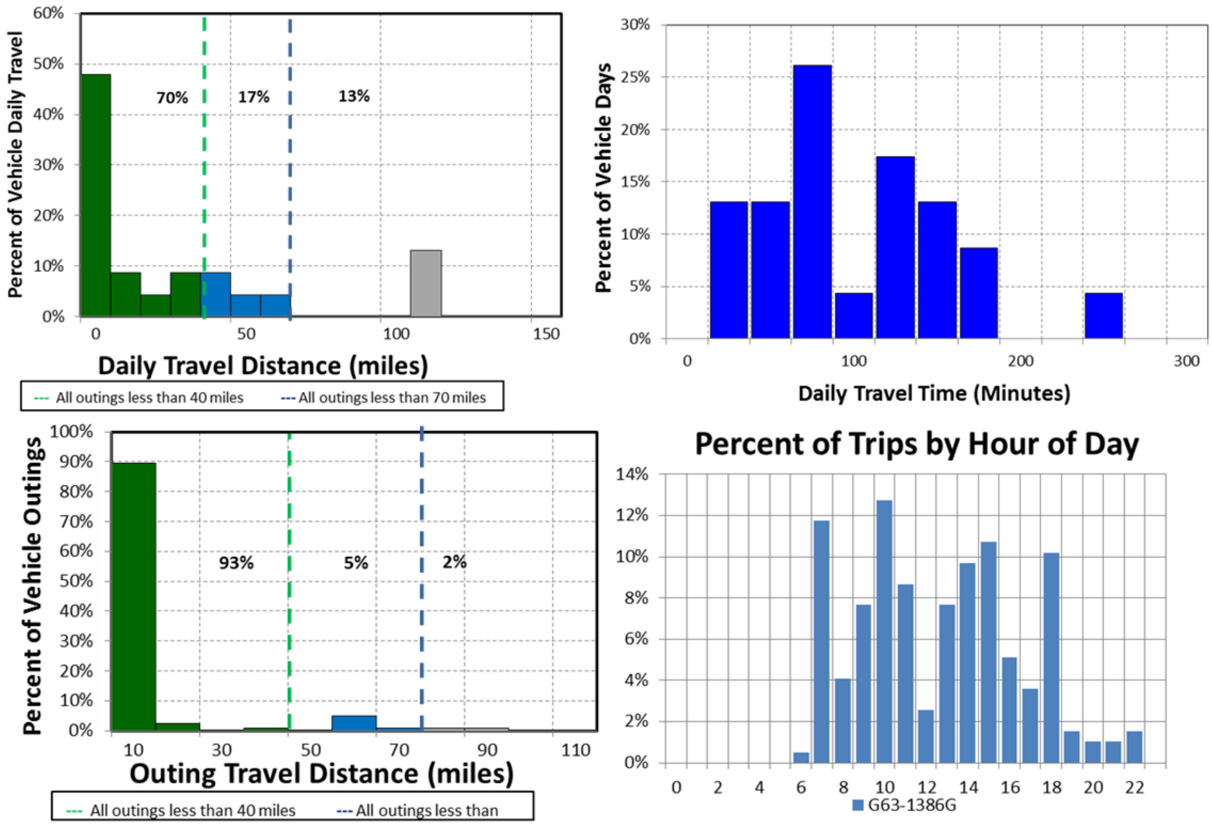


Figure B-18. Vehicle G63-1386G travel graphs.

Vehicle G63-1386G Observations

Logger 53 collected data on this vehicle for a period of 23 days of the 39-day study period. Validation occurred on 100% of the input data. INL reported that this vehicle has a support mission for Power Management. Data suggest it typically parks overnight in the Central Facilities Area as shown in the Figure B-16 and the Google Earth figure to the right.

INL reports that the vehicle odometer indicated 5,434 miles during the study and it travels an average of 21,736 miles per year. The vehicle was used on 59% of the available days, with an average daily usage of 1.9 hour and a peak daily usage of 4.5 hours on the days it was used. The vehicle was used during typical day shift hours.

Figure B-18 shows that 87% of daily travel and 98% of outings were within the typically advertised range of a BEV of approximately 70 miles. Further, 70% of daily travel and 93% of outings were within the typically advertised CD mode of 40 miles for PHEVs.

A BEV could not meet the daily travel noted. Because significant travel is beyond the typical range of a BEV, a PHEV may be a more suitable replacement vehicle, but a fleet composed of both types may be suitable.

Vehicle G63-0410M

Make/Model/Year	Ford F350 – 2012
EPA Class Size	Pickup
Mission	Support
Department Assigned	Nuclear Safety/Engr. Programs
Parking Location	Near INL Research Center
Fleet Vehicle ID	G63-0410M
Fuel Type	Gas
EPA Label/MPG (City/Hwy)*	16/22/18
EPA GHG Emissions (Grams CO_2/Mi)*	494
Study Logger ID	54
Total Vehicle Days/Total Study Days	11/39

Vehicle G63-0410M Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	107.9/215.0	99.0/380.9	22.4/109.1	1,187
Travel Time (Minutes)	193.0/405.0	176.6/671.0	40.0/279.0	2,119
Idle Time (Minutes)	31.2/NA	28.6/NA	6.5/NA	343

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	24	54.5	Less than 2	34
10 to 20	0	0	2 to 4	0
20 to 40	7	16.0	4 to 8	0
Greater than 40	13	29.5	Greater than 8	10

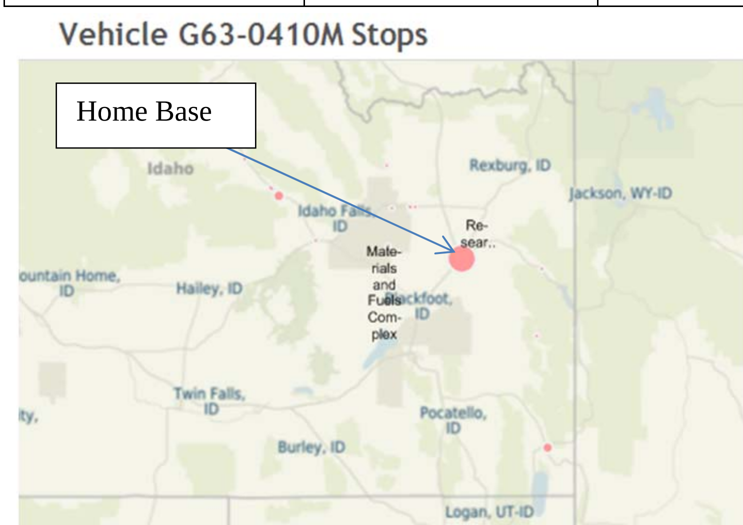


Figure B-19. Vehicle G63-0410M stops.

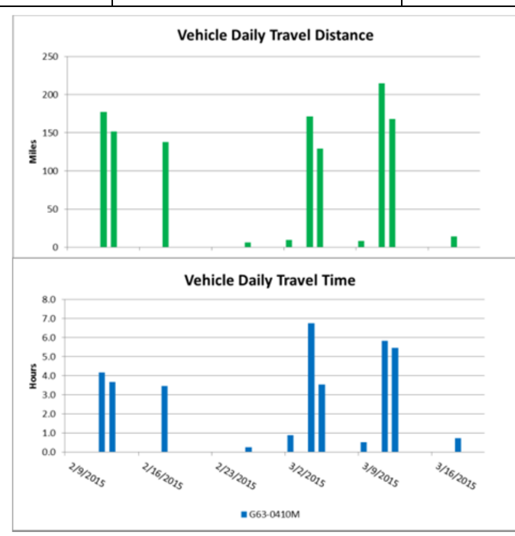


Figure B-20. Vehicle G63-0410M history.

*Fuel economy for Ford F350 is not available. Economy used is for Ford F150 gasoline vehicle.

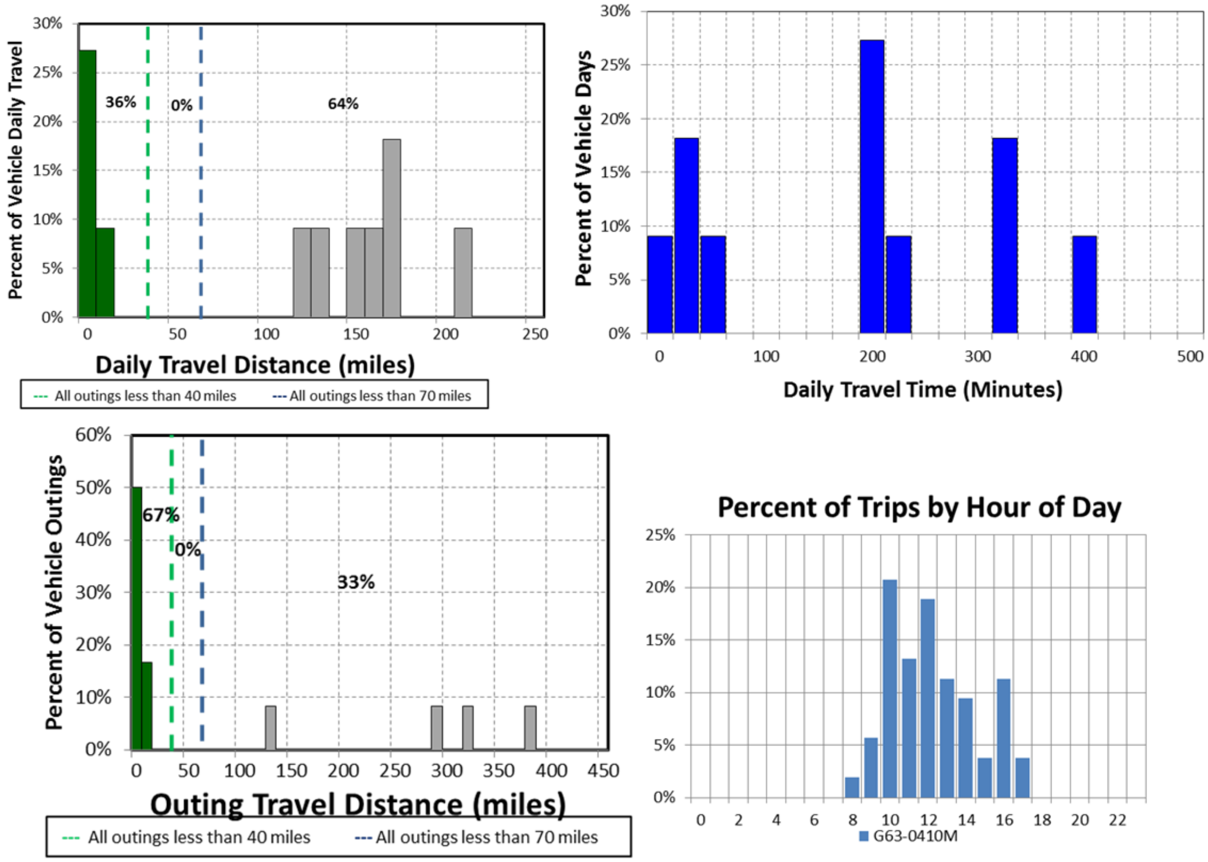


Figure B-21. Vehicle G63-0410M travel graphs.

Vehicle G63-0410M Observations

Logger 54 collected data on this vehicle for a period of 11 days of the 39-day study period. Validation occurred on 96.9% of the input data. INL reports that this vehicle has a support mission in the Nuclear Safety and Engineering Programs. Data indicate it typically parks near the INL Research Center on North Boulevard as noted in Figure B-19 and the Google Earth figure to the right.

INL reports that the vehicle odometer indicated 17,765 miles during the study and it travels an average of 5,922 miles per year. The vehicle was used on 28% of the available days, with an average daily usage of 3.2 hours and a peak daily usage of 6.8 hours on the days it was used. The vehicle was used during typical day shift hours.

Figure B-21 shows that 36% of daily travel and 67% of outings were within the typically advertised range of a BEV of approximately 70 miles. Further, 36% of daily travel and 67% of all outings were within the typically advertised CD mode for PHEVs of 40 miles.

A BEV could not meet the daily travel noted. Because significant travel is beyond the typical range of a BEV, a PHEV may be a more suitable replacement vehicle, but a fleet composed of both types may be possible.

Vehicle G43-0880H

www.edmunds.com

Make/Model/Year	Ford E350 – 2009
EPA Class Size	Van – Passenger
Mission	Pool
Department Assigned	Motor Pool
Parking Location	Materials and Fuels Complex
Fleet Vehicle ID	G43-0880H
Fuel Type	Gas
EPA Label/MPG (City/Hwy/Combined)*	15/20/17
EPA GHG Emissions (Grams CO_2/Mi)*	523
Study Logger ID	55
Total Vehicle Days/Total Study Days	7 39

Vehicle G43-0880H Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	130.9/176.7	130.9/176.7	48.2/82.9	917
Travel Time (Minutes)	176.0/245.0	175.7/245.0	64.7/94.0	1,230
Idle Time (Minutes)	19.0/NA	19.0/NA	7.0/NA	133

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	6	33.3	Less than 2	2
10 to 20	0	0	2 to 4	10
20 to 40	12	66.7	4 to 8	0
40 to 60	0	0	Greater than 8	6

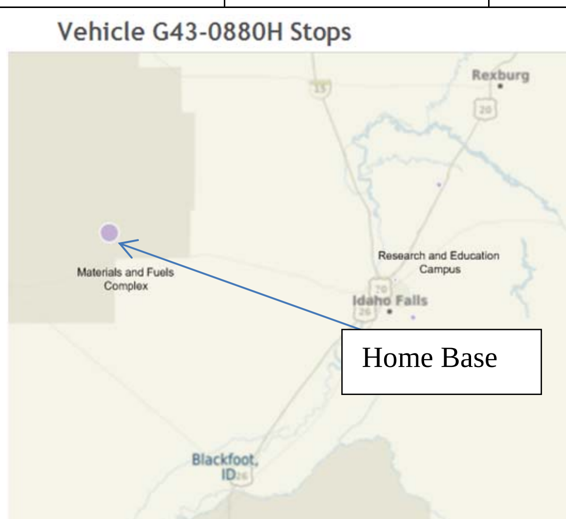


Figure B-22. Vehicle G43-0880H stops.

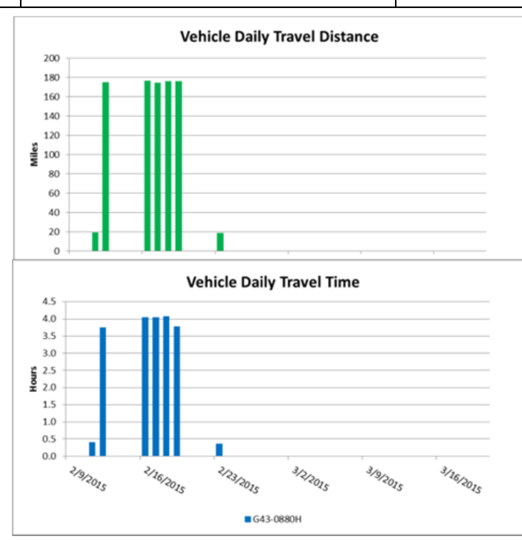


Figure B-23. Vehicle G43-0880H history.

*Fuel economy for Ford E350 is not available. Economy used is for Ford F150 gasoline vehicle.

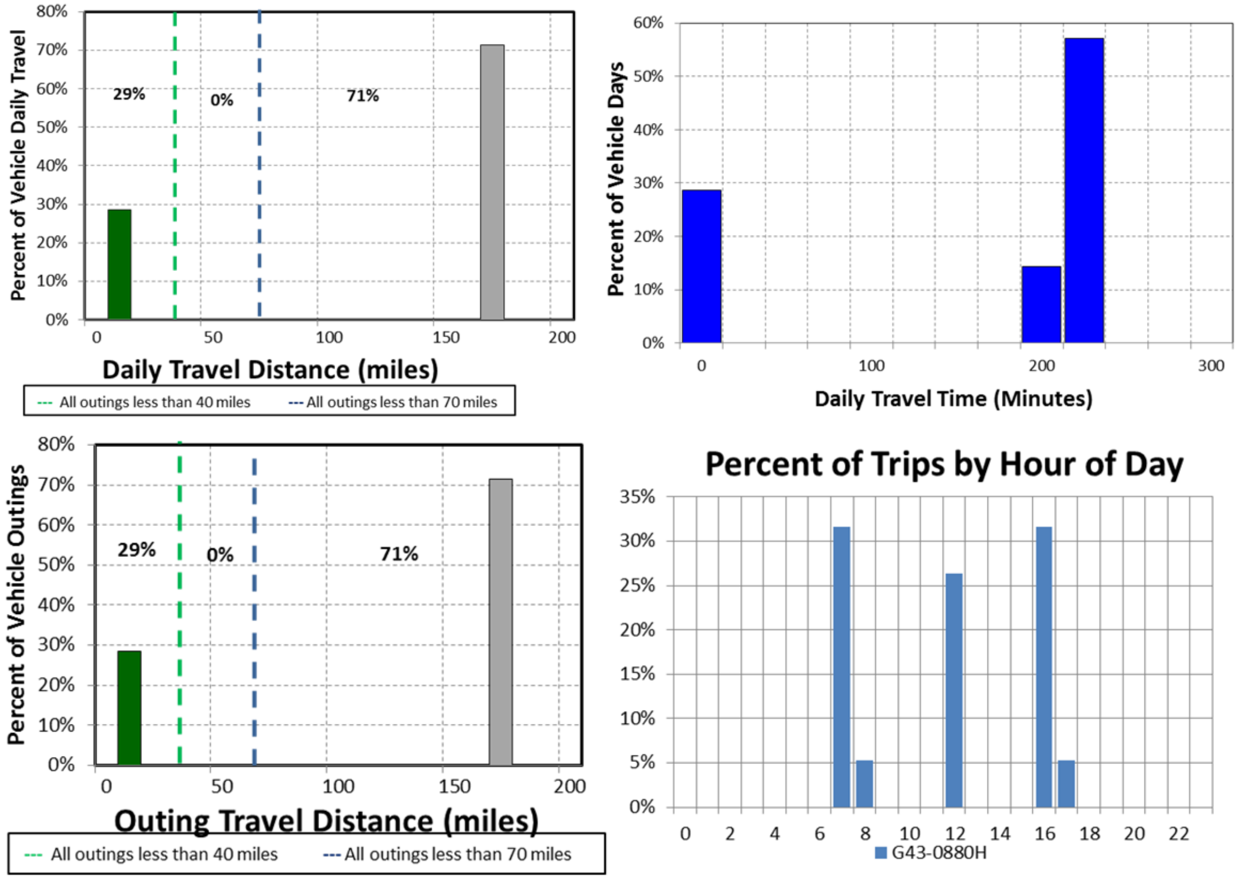


Figure B-24. Vehicle G43-0880H travel graphs.

Vehicle G43-0880H Observations

Logger 55 collected data on this vehicle for a period of 7 days of the 39-day study period. Validation occurred on 100% of the input data. INL reported that this vehicle has a pool mission and is available in the Motor Pool. Data indicate it typically parked overnight near Taylor Boulevard at the Materials and Fuels Complex as noted in Figure B-22 and the Google Earth figure to the right.

INL reports that the vehicle odometer indicated 21,717 miles during the study and it travels an average of 3,620 miles per year. The vehicle was used on 18% of the available days, with an average daily usage of 2.9 hours and a peak daily usage of 4.1 hours on the days it was used. The vehicle was used during typical day shift hours.

Figure B-24 shows that 29% of daily travel and 29% of outings were within the typically advertised range of a BEV of approximately 70 miles. Further, 29% of daily travel and 29% of all outings were within the typically advertised CD mode of 40 miles for PHEVs.

A BEV could not meet the daily travel noted. Because significant travel is beyond the typical range of a BEV, a PHEV may be a more suitable replacement vehicle.

Vehicle G43-0877H

Make/Model/Year	Ford E350 – 2011
EPA Class Size	Van – Passenger
Mission	Pool
Department Assigned	Motor Pool
Parking Location	INL Headquarters
Fleet Vehicle ID	G43-0877H
Fuel Type	Gas
EPA Label/MPG (City/Hwy)	10/14/12
EPA GHG Emissions (Grams CO_2/Mi)	741
Study Logger ID	56
Total Vehicle Days/Total Study Days	13/39

Vehicle G43-0877H Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	78.1/249.1	56.4/484.5	18.5/141.9	1,016
Travel Time (Minutes)	116.0/305.0	83.9/619.0	27.5/119.0	1,511
Idle Time (Minutes)	20.6/NA	14.9/NA	4.9/NA	268

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	27	60	Less than 2	28
10 to 20	1	2.2	2 to 4	5
20 to 40	4	8.9	4 to 8	1
Greater than 40	13	28.9	Greater than 8	11

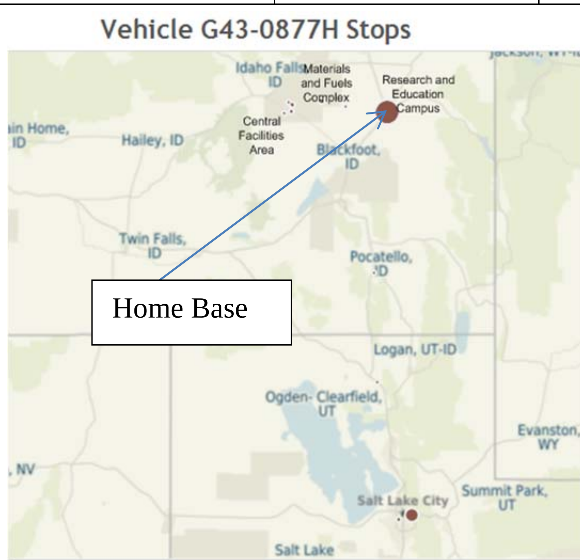


Figure B-25. Vehicle G43-0877H stops.

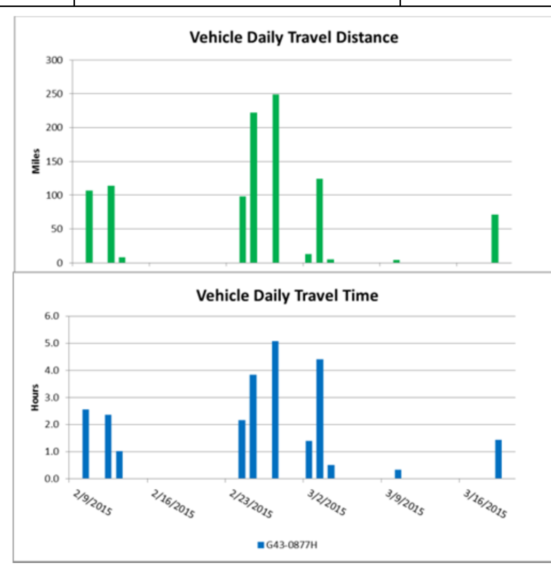


Figure B-26. Vehicle G43-0877H history.

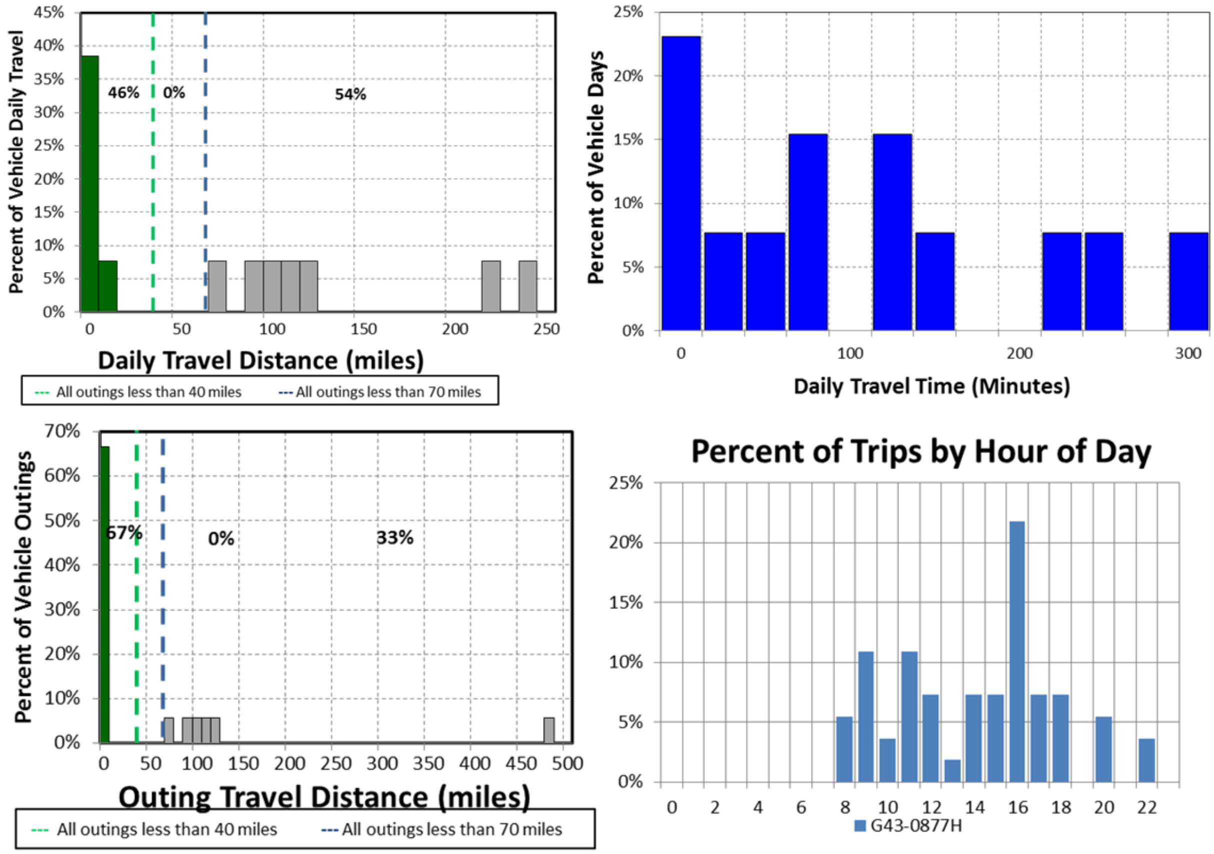


Figure B-27. Vehicle G43-0877H travel graphs.

Vehicle G43-0877H Observations

Logger 56 collected data on this vehicle for a period of 13 days of the 39-day study period. Validation occurred on 100% of the input data. INL reports that this vehicle has a pool mission and is available in the Motor Pool. Data indicate it typically parks near INL headquarters as shown in Figure B-25 and the Google Earth figure to the right).

INL reports that the vehicle odometer indicated 28,643 miles during the study and has an annual average of 7,161 miles. The vehicle was used on 33% of the available days, with an average daily usage of 2.1 hours and a peak daily usage of 5.1 hours on the days it was used. The vehicle was used mostly during typical day shift hours.

Figure B-27 shows that 46% of daily travel and 67% of outings were within the typically advertised range of a BEV of approximately 70 miles. Further, 46% of daily travel and 67% of outings were within the typically advertised CD mode of 40 miles for PHEVs. The vehicle was used on an extended several day trip to Salt Lake City.

A BEV could not meet the daily travel noted. Because significant travel is beyond the typical range of a BEV, a PHEV may be a more suitable replacement vehicle. If the pool is sufficiently large with passenger vans, some BEVs might be possible.

Vehicle G62-3940L

Make/Model/Year	Ford Expedition – 2012
EPA Class Size	SUV
Mission	Enforcement
Department Assigned	Protective Force Services
Parking Location	Materials and Fuels Complex
Fleet Vehicle ID	G62-3940L
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy)	14/20/16 10/14/12
EPA GHG Emissions (Grams CO_2/Mi)	555/517
Study Logger ID	57
Total Vehicle Days/Total Study Days	20/39

Vehicle G62-3940L Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	14.3/46.8	7.1/44.0	4.4/22.5	285
Travel Time (Minutes)	67.0/319.0	33.6/319.0	20.7/319.0	1,344
Idle Time (Minutes)	39.4/NA	19.7/NA	12.1/NA	788

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	54	88.5	Less than 2	35
10 to 20	7	11.5	2 to 4	3
20 to 40	0	0	4 to 8	2
Greater than 40	0	0	Greater than 8	21

Figure B-28. Vehicle G62-3940L stops.

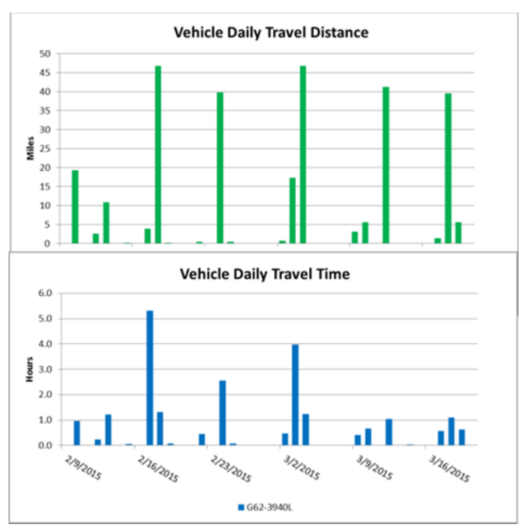


Figure B-29. Vehicle G62-3940L history.

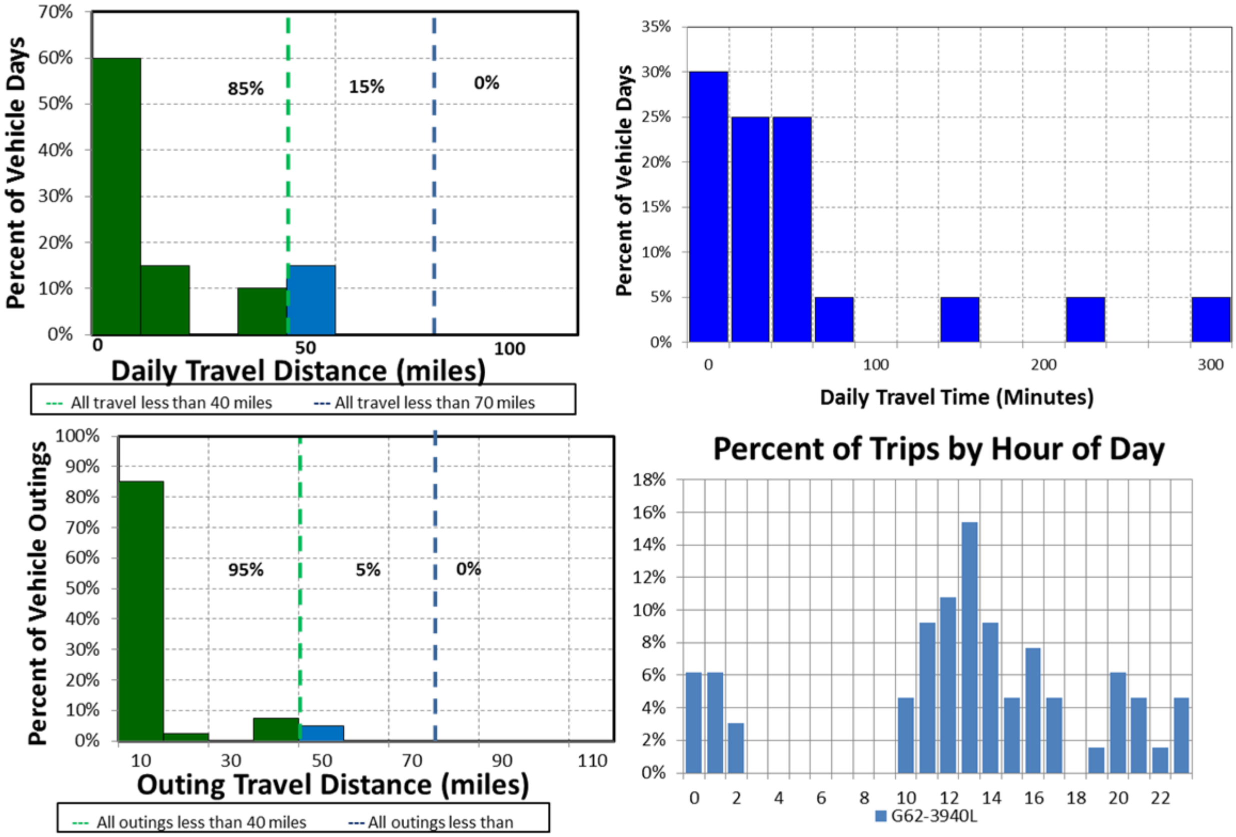


Figure B-30. Vehicle G62-3940L travel graphs.

Vehicle G62-3940L Observations

Logger 57 collected data on this vehicle for a period of 20 days of the 39-day study period. Validation occurred on 100% of the input data. INL reports that this vehicle has an enforcement mission supporting Protective Force Services. Data indicate it typically parks overnight near Harrison Boulevard at the Materials and Fuels Complex as shown in Figure B-28 and the Google Earth figure to the right.

INL reports that the vehicle odometer indicated 19,283 miles during the study and projected annual mileage at 6,428. The vehicle was used on 51% of the available days, with an average daily usage of 1.1 hour and a peak daily usage of 5.3 hours on the days it was used. The vehicle was used during all hours of the day, but primarily day shift.

Figure B-30 shows that all daily travel and all outings were within the typically advertised range of a BEV of approximately 70 miles. Further, 85% of daily travel and 95% of outings were within the typically advertised CD mode of 40 miles for PHEVs. Vehicle data shows all stops are within 20 miles of the vehicle's home base.

A BEV could meet all daily travel without additional charging opportunities assuming the vehicle had charging at its home base. However, fleet managers typically do not prefer enforcement vehicles that contain range limitations. Thus, a fleet of enforcement vehicles would likely contain a mix of BEVs and PHEVs.

Vehicle G61-1443G

Make/Model/Year	Dodge Dakota – 2010
EPA Class Size	Pickup
Mission	Support
Department Assigned	Radiation/Nuclear Emergency
Parking Location	Near INL Research Center
Fleet Vehicle ID	G61-1443G
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy)	14/19/15 9/13/10
EPA GHG Emissions (Grams CO_2/Mi)	592/620
Study Logger ID	58
Total Vehicle Days/Total Study Days	10/39

Vehicle G61-1443G Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	145.7/248.5	91.1/251.9	12.8/51.6	1,457
Travel Time (Minutes)	214.0/364.0	133.5/359.0	18.7/88.0	2,136
Idle Time (Minutes)	26.7/NA	16.7/NA	2.3/NA	267

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	25	24.5	Less than 2	91
10 to 20	0	0	2 to 4	1
20 to 40	22	21.6	4 to 8	1
Greater than 40	55	53.9	Greater than 8	9

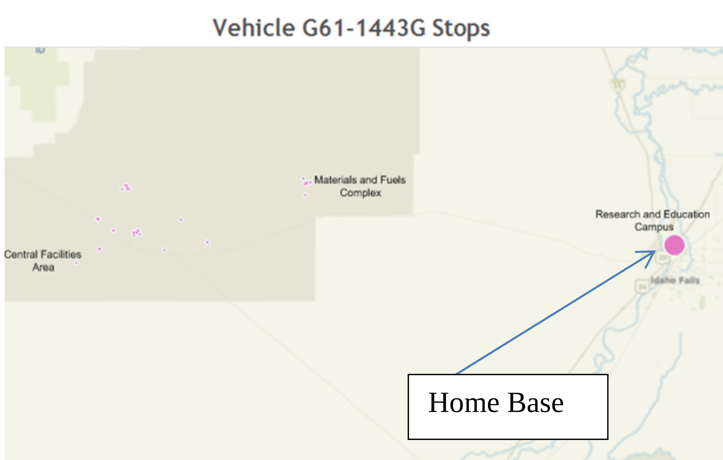


Figure B-31. Vehicle G61-1443G stops.

Figure B-32. Vehicle G61-1443G history.

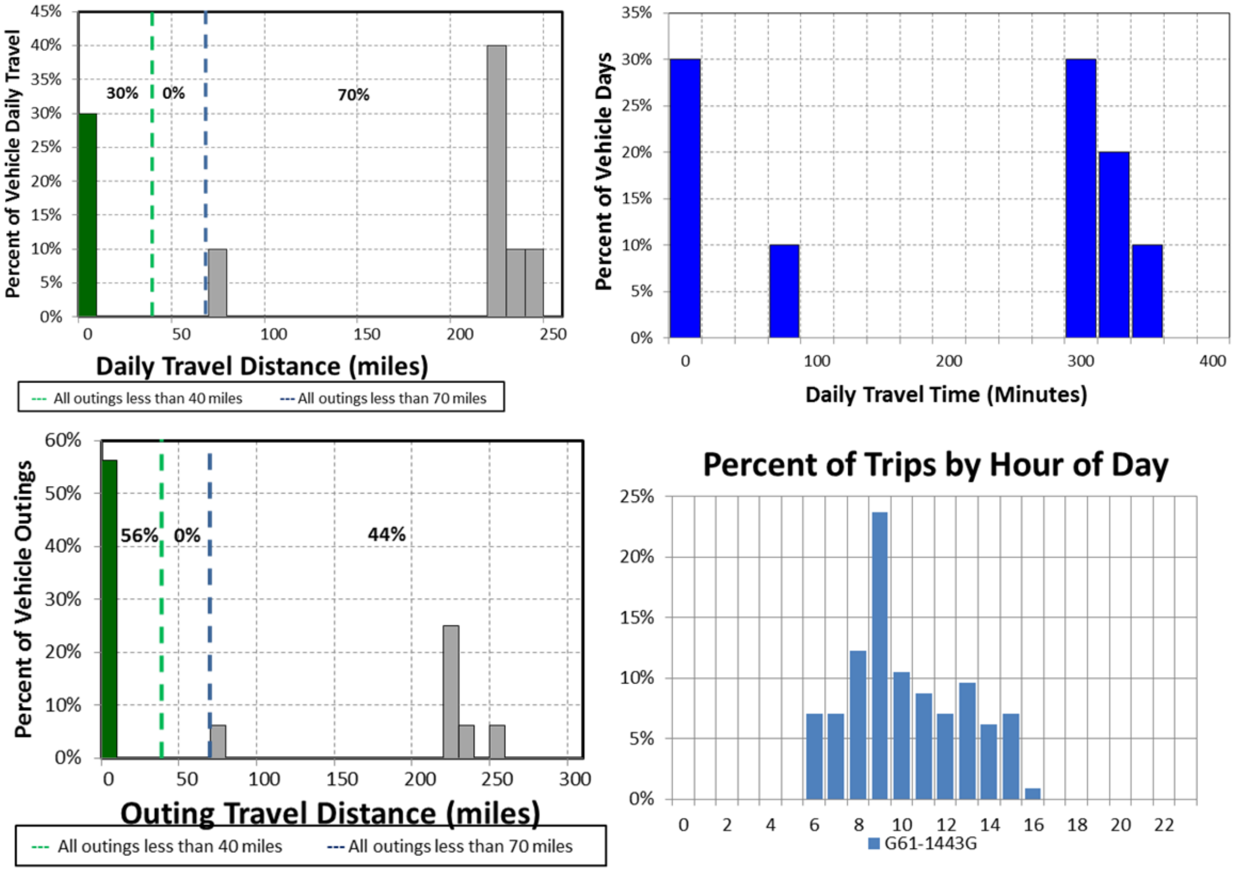


Figure B-33. Vehicle G61-1443G travel graphs.

Vehicle G61-1443G Observations

Logger 58 collected data on this vehicle for a period of 10 days of the 39-day study period. Validation occurred on 100% of the input data. INL reports that this vehicle has a support mission for Radiation/Nuclear Emergency Response/Readiness. Data indicate it typically parks overnight near the INL Research Center on North Boulevard as shown in Figure B-31 and the Google Earth figure to the right.

INL reports that the vehicle odometer indicated 56,378 miles during the study and a projected annual mileage at 11,276. The vehicle was used on 26% of the available days, with an average daily usage of 3.6 hours and a peak daily usage of 6.1 hours on the days it was used. The vehicle was used during day shift hours.

Figure B-33 shows that 30% of daily travel and 56% of outings were within the typically advertised range of a BEV of approximately 70 miles. Further, 30% of daily travel and 56% of outings were within the typically advertised CD mode of 40 miles for PHEVs. This vehicle takes frequent trips to the remote sites.

A BEV could not meet all daily travel without additional charging opportunities. Charging stations positioned at remote sites could assist. Cargo requirements for this vehicle were not specified.

Vehicle G62-1726L

Make/Model/Year	Chevrolet K1500H – 2011
EPA Class Size	Pickup
Mission	Support
Department Assigned	Power Management
Parking Location	Central Facilities Area
Fleet Vehicle ID	G62-1726L
Fuel Type	Gas/E85
EPA Label/MPG (City/Hwy)	15/21/17 11/16/13
EPA GHG Emissions (Grams CO_2/Mi)	523/477
Study Logger ID	61
Total Vehicle Days/Total Study Days	23/39

Vehicle G62-1726L Travel Summary				
	Per Day Average/Peak	Per Outing Average/Peak	Per Trip Average/Peak	Total
Travel Distance (Miles)	51.0/131.4	8.6/139.4	1.7/41.1	1,173
Travel Time (Minutes)	103.0/188.0	17.5/142.0	3.4/74.0	2,379
Idle Time (Minutes)	28.0/NA	4.7/NA	0.9/NA	644

Total Stops			Stop Duration	
Distance From Home Base (Miles)	Stops	Percentages	Stop Duration (Hours)	Stops
Less than 10	338	97.7	Less than 2	312
10 to 20	3	0.9	2 to 4	11
20 to 40	0	0	4 to 8	1
Greater than 40	5	1.4	Greater than 8	22

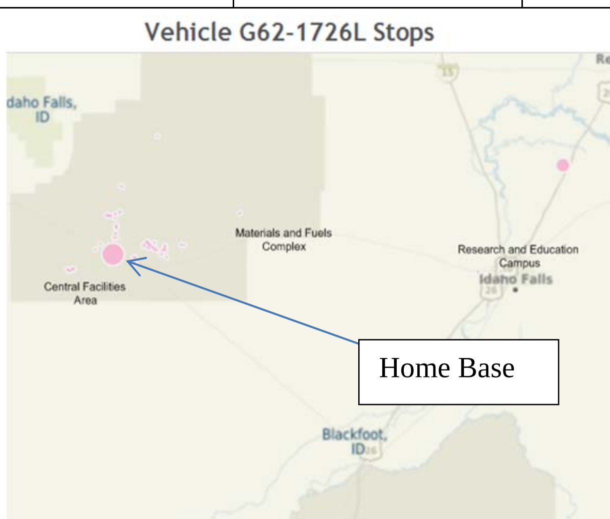


Figure B-34. Vehicle G62-1726L stops.

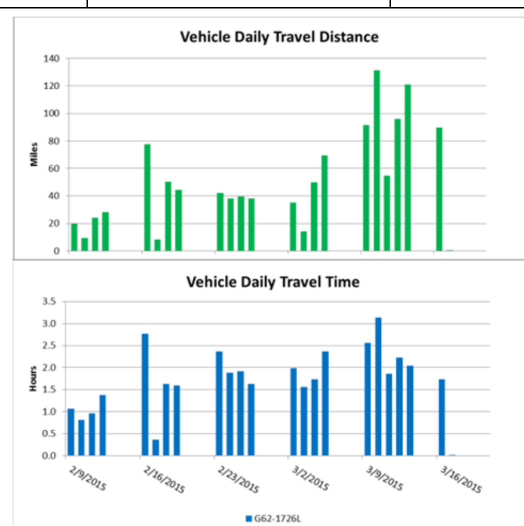


Figure B-35. Vehicle G62-1726L history.

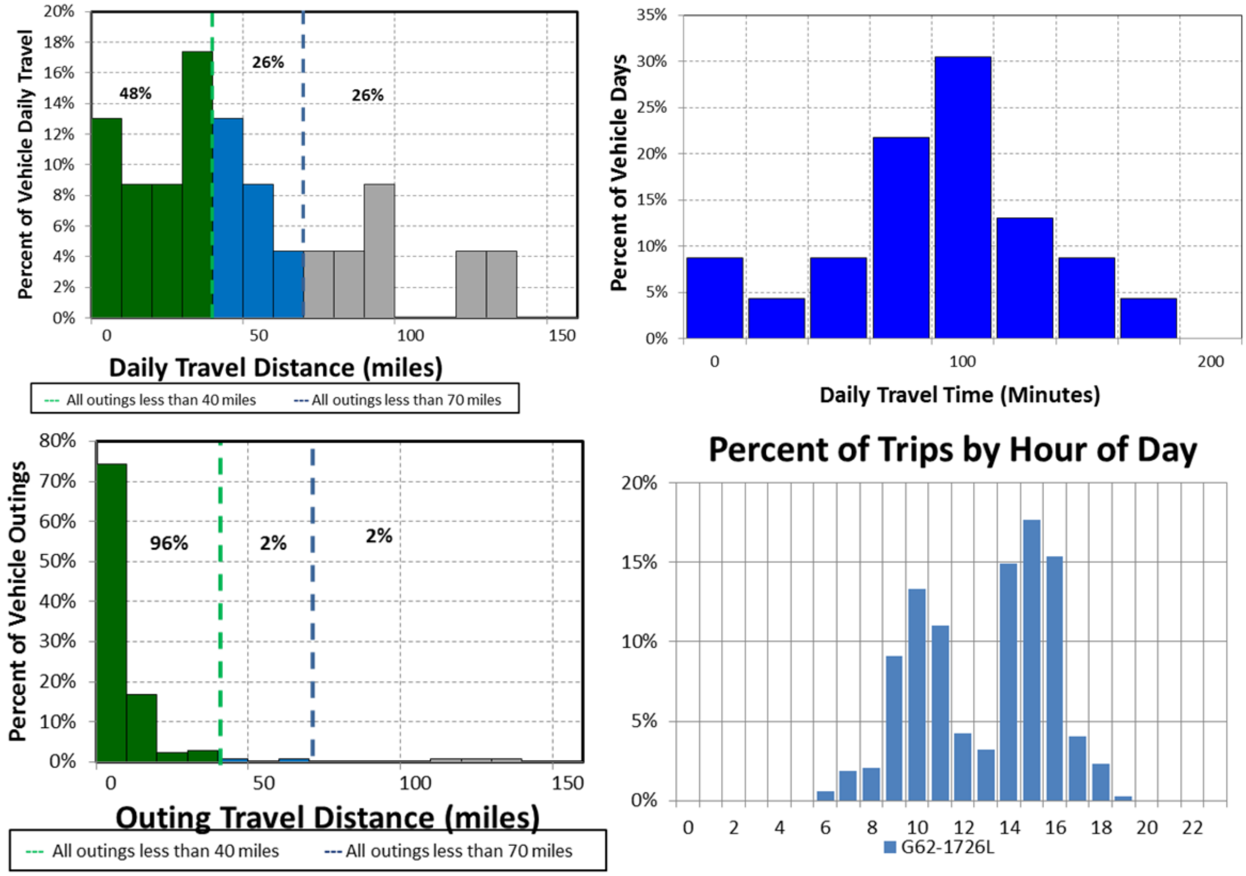


Figure B-36. Vehicle G62-1726L travel graphs.

Vehicle G62-1726L Observations

Logger 61collected data on this vehicle for a period of 23 days of the 39-day study period. Validation occurred on 100% of the input data. INL reports that this vehicle has a support mission for the Power Management department. Data indicate it typically parks overnight at the Central Facilities Area as shown in Figure B-34 and the Google Earth figure to the right.

INL reports that the vehicle odometer indicated 39,780 miles during the study and a projected annual mileage of 9,945. The vehicle was used on 59% of the available days, with an average daily usage of 1.7 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-36 shows that 74% of daily travel and 98% of outings were within the typically advertised range of a BEV of approximately 70 miles. Further, 48% of daily travel and 96% of outings were within the typically advertised CD mode of 40 miles for PHEVs.

A BEV could not meet all daily travel without additional charging opportunities. Several days of extended travel are recorded, suggesting a PHEV may be more suitable for replacement. The survey information suggests no other special requirements exist for this support activity.

Appendix C
National Fuel Cost and Greenhouse Gas Savings

Section 5 notes that fuel costs 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 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
Enforcement	RAV4 EV	2,831	43%	$551	70%
Enforcement	Via VR300	2,001	46%	$374	71%
Support	Volt	147	20%	$50	57%
Support	Outlander	513	33%	$120	64%
Pool	Volt	76	20%	$26	57%
Support	Via VR300	4,234	28%	$1,130	61%
Support	Via VR300	831	35%	$187	65%
Pool	Via eREV	478	39%	$100	67%
Pool	Via eREV	3,124	57%	$510	77%
Enforcement	Outlander	3,186	46%	$590	71%
Support	Via VR300	1,791	42%	$354	69%
Support	Via VR300	2,927	46%	$547	71%
Total		**22,139**	**40%**	**$4,539**	**68%**
Total Pool		**3,678**	**52%**	**$637**	**74%**
Total Support		**10,443**	**34%**	**$2,388**	**65%**
Total Enforcement		**8,018**	**45%**	**$1,515**	**71%**

As presented in Section 5, 122 BEVs and 256 PHEVs could potentially replace ICE vehicles in INL's fleet of 378 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 GHG 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	227,348	44%	$43,761	70%
Support	501,119	39%	$104,127	67%
Enforcement	164,629	47%	$30,238	72%
Total	893,096	42%	$178,126	69%