INL/EXT-15-36477

Micro-Climate Assessment of Grid-Connected Electric Drive Vehicles and Charging Infrastructure: Final Report

Stephen Schey
Jim Francfort

December 2015

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

INL/EXT-15-36477

Micro-Climate Assessment of Grid-Connected Electric Drive Vehicles and Charging Infrastructure: Final Report

Stephen Schey
Jim Francfort[2]

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

December 2015

Idaho National Laboratory
Idaho Falls, Idaho 83415

http://avt.inl.gov

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

ABSTRACT

Battelle Energy Alliance, LLC, managing and operating contractor for the U.S. Department of Energy's Idaho National Laboratory, is the lead laboratory for the U.S. Department of Energy's advanced vehicle testing. Battelle Energy Alliance, LLC contracted with Intertek Testing Services, North America to conduct several U.S. Department of Defense-based micro-climate studies to identify potential U.S. Department of Defense transportation systems that are strong candidates for introduction or expansion of plug-in electric vehicles (PEVs). The study included Joint Base Lewis McChord, located in Washington State; Naval Air Station Whidbey Island, located in Washington State; and United States Marine Corp Base Camp Lejeune, located in North Carolina.

The project was divided into four tasks for each of the three bases studied. Task 1 consisted of surveying the non-tactical fleet of vehicles to begin review of vehicle mission assignments and types of vehicles in service. In Task 2, the daily operational characteristics of the vehicles were identified to select vehicles for further monitoring and attachment of data loggers. Task 3 recorded vehicle movements in order to characterize the vehicles' missions. Results of the data analysis and observations were provided. Individual observations of these selected vehicles provided the basis for recommendations related to PEV adoption (i.e., whether a battery electric vehicle or plug-in hybrid electric vehicle [collectively referred to as PEVs] can fulfill the mission requirements). It also provided the basis for recommendations related to placement of PEV charging infrastructure. In Task 4, an implementation approach was provided for near-term adoption of PEVs into the respective fleets. Each facility was provided detailed reports on each of these tasks. This paper summarizes and provides observations on the project and completes Intertek's required actions.

Intertek and Idaho National Laboratory were encouraged by enthusiasm and support from U.S. Department of Defense personnel at each of the bases and their respective headquarters.

EXECUTIVE SUMMARY

Federal agencies are mandated[a] 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 emissions, and they provide performance benefits with quieter, smoother operation. This study evaluated the extent to which each of the three selected facilities 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 may 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 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 a majority of the motive power (depending on the PHEV design); however, they also have the ability to extend their operating range with an onboard ICE. Because a PHEV can meet all transportation range needs, the adoption of a PHEV will be dependent on its ability to meet other transportation needs such as cargo or passenger capability. Operation of PHEVs in the charge-depleting mode, where all or a majority of the motive power is provided by the battery, 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.

Through consultation with the United States Department of Defense's branch leadership, the facilities participating in this study included Joint Base Lewis McChord, located in Washington State; Naval Air Station Whidbey Island, located in Washington State; and United States Marine Corps Base Camp Lejeune, located in North Carolina.

This project began with an assessment of the existing non-tactical fleet of vehicles at each facility to characterize their current components in order to select representative vehicles for an in-depth assessment. Analysis of that subset of vehicles led to identification of specific results for those selected vehicles and wider extrapolation to the full fleet of vehicles. Specific benefits in terms of reduced consumption of petroleum products, reduced fuel costs, and reduced emission of greenhouse gases were identified for each facility assuming PEV replacement. Finally, an approach for introducing PEVs into the non-tactical fleet at each facility was provided based on the individual study's results. This report summarizes the information provided to each facility.

---

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

Intertek and Idaho National Laboratory appreciate the opportunity to present this report and acknowledge the excellent support and cooperation of personnel from the United States Department of Defense bases that were involved. This work was supported by the Advanced Vehicle Testing Activity at Idaho National Laboratory and the Vehicle Technologies Office, which is located within the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

CONTENTS

FIGURES

TABLES

ACRONYMS

AC	alternating current
BEV	battery electric vehicle
CD	Charge depleting
DC	direct current
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
JBLM	Joint Base Lewis McChord
MCBCL	Marine Corp Base Camp Lejeune
NASWI	Naval Air Station Whidbey Island
PEV	plug-in electric vehicle
PHEV	plug-in hybrid electric vehicle

Micro-Climate Assessment of Grid-Connected Electric Drive Vehicles and Charging Infrastructure: Final Report

1. INTRODUCTION

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

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

- Task 1: Conduct a non-tactical fleet and infrastructure assessment
- Task 2: Select vehicles for mission and fleet characterizations
- Task 3: Perform detailed assessment of selected vehicles and charging infrastructure needs
- Task 4: Prepare adoption approach for PEV and charging infrastructure.

Assessment of the potential for replacing fleet vehicles with PEVs starts with an assessment of the fleet vehicles' missions and vehicle characteristics. This assessment was conducted through correspondence with fleet managers and records analysis. The Task 1 report provided a summary and fleet assessment.

PEVs generally are classified into two vehicle types: battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). A BEV contains an onboard battery that provides all motive power. PHEVs also have an onboard battery that provides some motive power; however, there is also another motive power source (such as a gasoline engine). PHEVs have, in general, two modes: (1) charge-depleting (CD) mode, where the battery provides all or most (depending on the PHEV design) of the motive power and the battery is being depleted, and (2) charge-sustaining mode, where the non-battery power source provides the majority of the motive power while being supplemented by the battery power with the battery state of charge being maintained within a designed range. A BEV can be considered to operate solely in a CD mode. Collectively, BEVs and PHEVs are PEVs.

The Task 1 effort led to identification of fleet vehicles that appeared to be good candidates for replacement by PEVs. The Task 2 report identified the 60 vehicles within the candidate groups for further monitoring and analysis through addition of vehicle data loggers. The data loggers were installed and data collected on the selected vehicles. The Task 3 report provided a summary and details of data collection for the monitored vehicles and extrapolated that data to the entire non-tactical fleet of vehicles at the base. The other Task 3 report provided the related charging infrastructure assessment. The Task 4 report provides an implementation approach for adoption of PEVs at each base in the next few years. Each base participating in the study received draft copies of each report for review and comment and the final version of each report. In addition, these reports are posted on Idaho National Laboratory's website: http://avt.inel.gov/dod.shtml.

Through consultation with U.S. Department of Defense branch leadership, the facilities participating in this study included the Joint Base Lewis McChord (JBLM), located in Washington State; Naval Air

Station Whidbey Island (NASWI), located in Washington State; and United States Marine Corps Base Camp Lejeune (MCBCL), located in North Carolina. Naval Air Station Jacksonville and Naval Station Mayport were originally planned to be included in the project, but they declined to proceed past Task 1.

2. NON-TACTICAL VEHICLES ANALYSIS

The inventory of non-tactical fleet vehicles at each base was reviewed. In general, non-powered equipment, material-handling equipment, low-speed vehicles, heavy-duty trucks, and buses were excluded from consideration for replacement by PEVs. In addition, specialty vehicles (e.g., refrigeration trucks, ambulances, and bucket trucks) were excluded for all bases, except MCBCL, which specifically requested their consideration. Although PEV demonstrators of many of these vehicles exist, they are not current standard PEV models or may have special charging needs.

The General Services Administration's (GSA's) categories provide information on vehicles, but more common vehicle types are provided in the U.S. Environmental Protection Agency's classifications. Table 1 provides a summary of the vehicle types by U.S. Environmental Protection Agency category. Note that the base fleet inventory list does not always allow specific differentiation between cargo or passenger vans because the same body frame may be used for each. Consequently, some assumptions are made on type.

Table 1. U.S. Department of Defense bases non-tactical fleet summary.

Fleet	Sedan - Compact	Sedan - Midsize	Sedan - Large	Minivan	SUV	Van Cargo	Van Pass	Pickup	Other	Total
JBLM	54	44	81	129	171	150	288	475	172	1,564
NASWI	5	20	10	11	13	54	19	43	—	175
MCBCL	6	23	43	67	76	62	109	336	62	784
Total	65	87	134	207	260	266	416	854	234	2,523

Figure 1 shows vehicle type distribution for all vehicles for comparison.

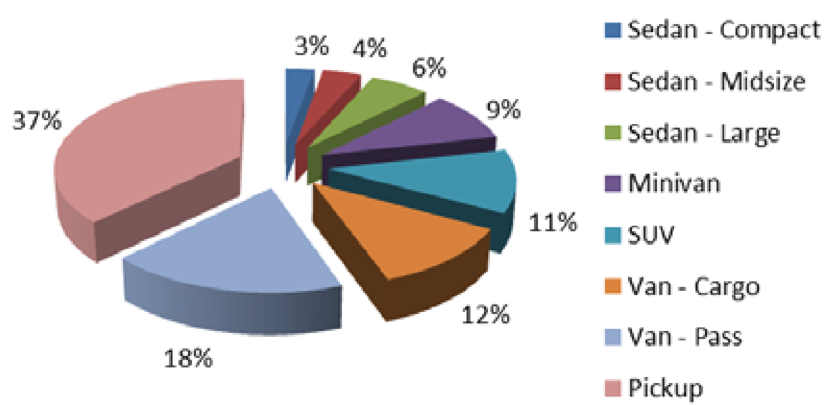


Figure 1. Vehicle type distribution for all non-tactical vehicles.

Each U.S. Department of Defense base identified 60 vehicles for further study, as described in their Task 2 reports. Six vehicles failed to provide sufficient data for analysis as detailed in the reports. This subset of vehicles is shown in Table 2. (Note that one vehicle monitored at JBLM was identified as assigned to two different fleet groups; therefore, the total in the Table 2 is greater than 180.) This distribution is approximately representative of the entire non-tactical fleet. A comparison is shown in Figure 2.

The vehicles were assigned to different groups on each of the U.S. Department of Defense bases and used for a variety of purposes. The individual base reports detail the classifications of purposes or missions required of these vehicles. The mission category can be helpful in identification of PEVs as potential replacements. Figure 3shows the percentages of vehicles in each of the major mission categories. Figure 4 shows comparison of the monitored vehicles to the entire fleets. In summary, the monitored vehicles were representative of the entire fleets of vehicles at the individual bases.

Table 2. U.S. Department of Defense base monitored vehicles by group.

Fleet	Sedan - Compact	Sedan - Midsize	Sedan - Large	Minivan	SUV	Van Cargo	Van Pass	Pickup	Other	Total
JBLM	1	3	4	8	4	7	11	20	3	61
NASWI	4	12	3	9	3	2	9	18	—	60
MCBCL	2	2	—	5	9	4	8	28	2	60
Total	7	17	7	22	16	13	28	66	5	181

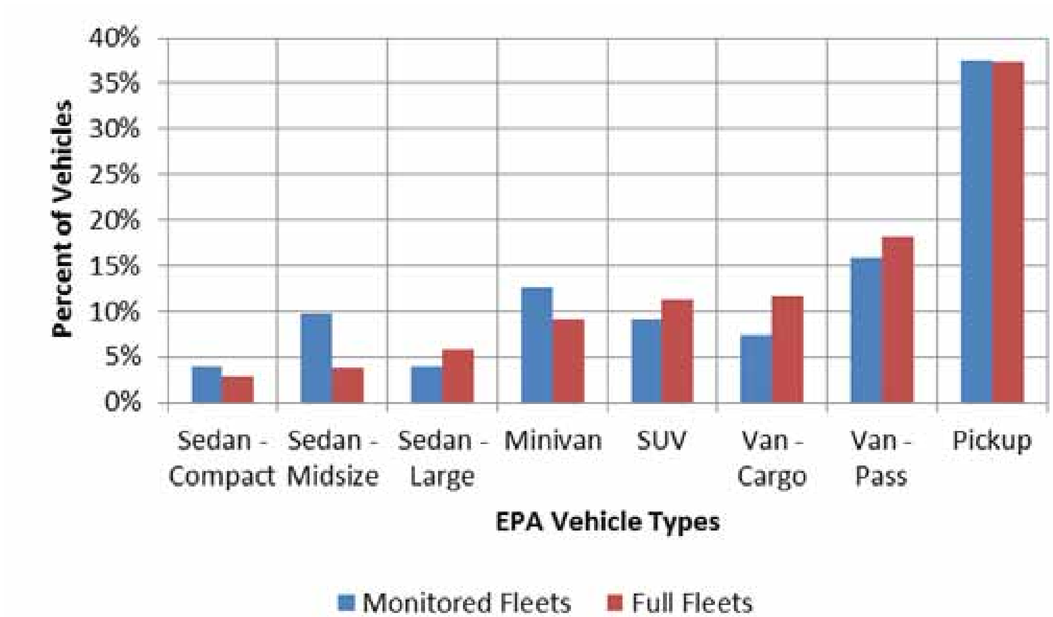


Figure 2. Monitored versus full fleet vehicle types.

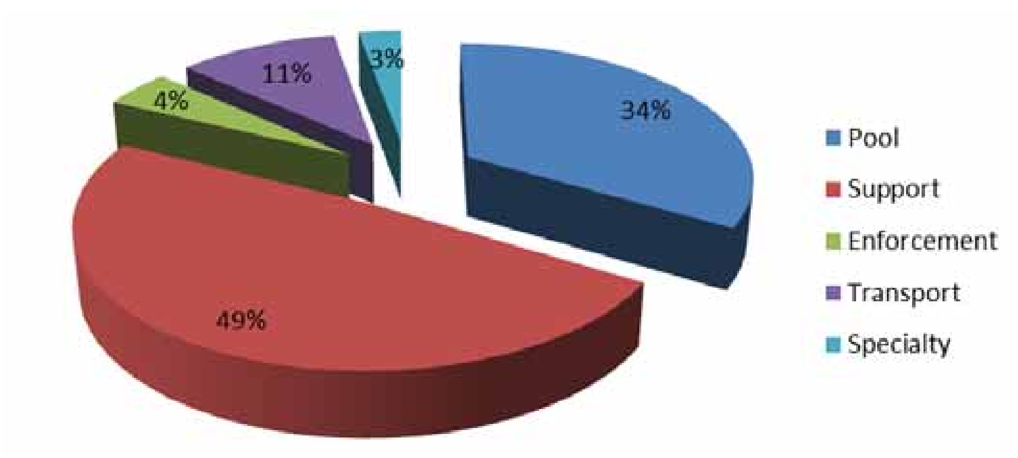


Figure 3. Full fleet mission classification.

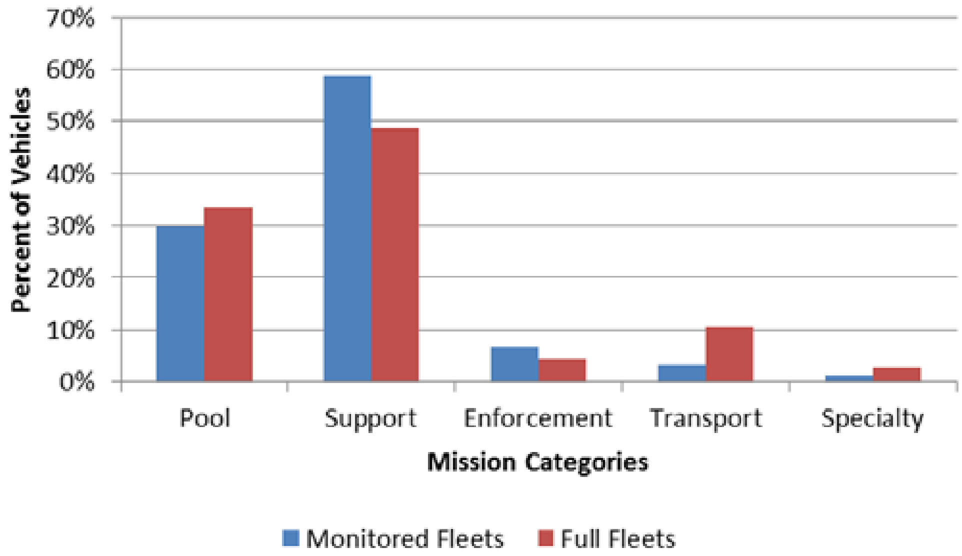


Figure 4. Monitored versus full fleet mission assignments.

3. PLUG-IN ELECTRIC VEHICLE ADOPTION

3.1 Plug-In Electric Vehicle Availability

The adoption of PHEVs and BEVs is a primary goal of GSA and supports many directives in this area. As GSA increases its certification of PHEVs and BEVs, agencies can plan for vehicle replacement through GSA for passenger vehicles and trucks. GSA provides a summary of light and medium-duty passenger vehicles available for lease or purchase through the GSA portal;[2] however, not all BEVs and PHEVs currently on the market are 'certified' to be GSA replacements. At this writing, only sedan-type vehicles are listed. Vehicles not on the GSA list of certified vehicles require an agency to self-certify a functional need or alternative measures for exemptions.

Executive Order 13693, issued on March 25, 2015, directs "…that by December 31, 2020, zero emission vehicles or plug-in hybrid vehicles account for 20 percent of all new agency passenger vehicle acquisitions and by December 31, 2025, zero emission vehicles or plug-in hybrid vehicles account for 50 percent of all new agency passenger vehicles…"

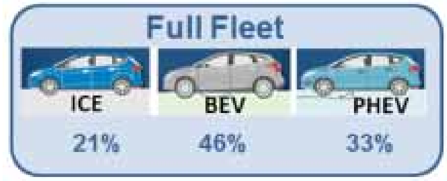
As seen in Figure , sedans comprise only 13% of all non-tactical fleet vehicles. Compliance with the Executive Order is not possible at this writing if only GSA-listed vehicles are adopted. Each base will need to develop their adoption approach based on specific conditions and requirements. If GSA continues to list sedans only, either the base will need to justify vehicles not listed by GSA or review vehicle requirements in order to replace other vehicle types with sedans. For example, pickup trucks are the most popular vehicle type; however, it may be possible that the mission for many of the pickups can be accomplished by a sedan. It is likely that GSA will list other PEV body types in the coming years to provide more options as more PEVs become available.

The detailed Task 4 reports for each base identified two strategies for PEV adoption: replacing sedans only and replacing all vehicle types with current or soon-to-be available PEVs. In addition, the projected approaches to PEV introduction were to replace selected ICE vehicles with PEVs as they would normally be replaced. The replacement approaches present a structured and gradual introduction of PEVs into each base's fleet. This approach was based on an increasing percentage of PEVs as replacements being considered over the next few years. This approach allows for growth in experience in management, support, and maintenance of a PEV fleet.

---

[2] http://www.gsa.gov/portal/content/104211 [accessed August 1, 2014].

The Task 3 report for each base identified potential PEV replacements for the monitored vehicles using the second strategy identified above. At the time of the evaluation for JBLM, PEV replacement of passenger and cargo vans were not generally available and were not considered. Overall, the Task 3 reports show that of the 180 vehicles monitored, 166 of the 180 vehicles could be replaced by PEVs. Extrapolating this to the full fleets of each base suggest that 1,852 of the 2,341 vehicles could likely be replaced by PEVs. These suggestions form the bases for estimating the fuel cost reductions and greenhouse gas emissions (GHG) reductions found in Section 4.



3.2 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 for BEVs. The Task 3 infrastructure report for each base provides detailed information on recharging PEVs.

Most PEV manufacturers supply an alternating current (AC) Level 1 (120 Volts) cordset with the vehicle, which provides sufficient capabilities for some drivers, but more typically provides an emergency backup capability because of the long recharge times. AC recharging capabilities found in the public arena more typically are AC Level 2 (220 Volts).

Because the battery of a BEV is typically much larger than that of a PHEV, recharge times are longer. BEVs that see daily mileage near the limits of the advertised range do better when recharged using AC Level 2 electric vehicle supply equipment (EVSE) or direct current (DC) fast charging, 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. DC fast charging provides the fastest recharge capability for those vehicles equipped with DC fast charge inlets; however, currently, no PHEVs with DC fast charging capability are available and there are no announced plans for one to be introduced. It is important to note that the Task 3 reports show that the PEVs studied do not need to rely on DC fast charging to complete their missions.

4. FUEL COSTS AND GREENHOUSE GAS EMISSIONS REDUCTIONS

PEV substitution for an existing conventional vehicle reduces GHG emissions and 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 these reports 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. It should be noted that transmission losses in electricity transport have been neglected. Cost reduction also occurs because the cost of electricity is comparable to the cost of gasoline on a unit of energy basis; however, electric motors are more efficient than ICEs. The U.S. Department of Defense bases provided information related to the current average annual mileage per vehicle. This information was compared to the mileages measured during the study to identify the source of fuel consumption estimates for the study vehicles and to use the PEV replacement scenario to estimate a reduction in GHG emissions and fuel costs.

Each base’s Task 3 report details the methodology and calculations involved in estimating fuel cost reduction and reduction in GHG emissions; therefore, it is not repeated here. For each of the bases, the fuel cost reduction and GHG emissions considered both the local cost of fuel and the national average cost for fuel. In addition, GHG emissions rely on the local energy generation mix and emissions reductions were provided for both the local generation mix plus the national average. The national average values are presented in this section.

As noted above, PHEVs have, in general, two modes: (1) CD mode, where the battery provides all or most (depending on the PHEV design) of the motive power and the battery is being depleted, and (2) charge-sustaining mode, where the non-battery power source provides the majority of the motive power while being supplemented by the battery power while the battery state of charge is maintained within a designed range.

Original equipment manufacturers provide information related to a vehicle's range in CD mode and the U.S. Environmental Protection Agency provides test results. However, actual results may vary, depending on several factors other than travel that may also deplete a vehicle's battery. These factors include changes in the battery's capacity over time, area topography, weather conditions (e.g., cabin cooling/heating), and payload. These reports identified a BEV's "safe range" as 70 miles because this is typically less than the advertised range of most BEV's original equipment manufacturers. PHEV's advertised ranges vary from 6 to 72 miles. The JBLM and NASWI reports identified the PHEV safe range in CD mode as 40 miles, whereas MCBCL updated the safe range to 30 miles because the average range of PHEVs available at that writing was about 33 miles.

A BEV can be considered to operate solely in CD mode. Miles in CD mode are the base identified annual miles times the percent of daily travel less than the PHEV safe range for the PHEV replacement and full base reported miles for the BEV replacement. The base Task 3 reports identify the economy and emissions of the existing vehicle and of a suggested PEV replacement. Table 3 shows the resulting fuel cost savings, assuming the bases replace the existing monitored vehicles with the suggested 166 PEVs. Table 4 identifies the resulting savings in GHG emissions.

Table 3. Monitored vehicle fuel cost savings (national fuel and generation mix values).

Total Miles CD Mode	Annual Petroleum Fuel Cost	Annual Electric Fuel Cost	Annual Fuel Savings	Annual Fuel Cost Reduction
838,025	$138,512	$40,029	$98,483	71%

Table 4. Monitored vehicle GHG emissions reductions (national fuel and generation mix values).

Annual ICE GHG Emissions (lb-CO_2e)	Annual PEV Emissions (lb-CO_2e)	Annual Emissions Reduction (lb-CO_2e)	Annual Emissions Reduction
913,419	510,057	433,551	47%

On average, the PEV travels just over 5,000 miles per year and saves nearly $600 in fuel costs and 2,600 lb-CO_2e in GHG emissions annually.

Extrapolating the results to the entire base fleets, Table 5 identifies the fuel cost savings, assuming 1,852 PEVs replace the ICE vehicles. Table 6 identifies the resulting savings in GHG emissions.

Table 5. Full fleet fuel cost savings (nation fuel and generation mix values.)

Total Miles CD Mode	Annual Petroleum Fuel Cost	Annual Electric Fuel Cost	Annual Fuel Savings	Annual Fuel Cost Reduction
9,682,004	$1,854,021	$465,481	$1,388,534	75%

Table 6. Full fleet GHG emissions reductions (national fuel and generation mix values).

Annual ICE GHG Emissions (lb-CO_2e)	Annual PEV Emission (lb-CO_2e)	Annual Emissions Reduction (lb-CO_2e)	Annual Emissions Reduction
11,519,940	6,027,884	5,530,133	48%

5. BASE REPLACEMENT APPROACH

The base Task 4 reports detail an approach for introduction of PEVs into the respective fleets. In general, the strategy outlined four approaches for each base:

- Monitored vehicles
  - GSA-listed PEVs only
  - All potential PEV types
- Full fleet
  - GSA-listed PEVs only
  - All potential PEV types.

First, the normal replacement cycle for the existing inventory of vehicles was estimated using GSA guidelines. PEVs were substituted into the replacement cycle using the strategy outlined above. The selection of a BEV or PHEV was based on the details from the Task 3 reports. The replacement approach presented a structured and gradual introduction of PEVs into the base fleets. This approach was based on an increasing percentage of PEVs as replacements are considered over the next several years. This approach allows for growth in experience in management, support, and maintenance of the PEV fleet.

While the details of the approach, including the specific vehicle to be replaced and the make and model of the PEV to be its replacement, are identified in the base Task 4 reports, the overall effects of these replacements are summarized in the following subsection.

5.1 Replacement Approach for Sedans

Assuming the total fleet inventory at JBLM remains the same; the suggested replacement approach resulted in the fleet composition shown in Figure 5 for the years 2015 through 2022.

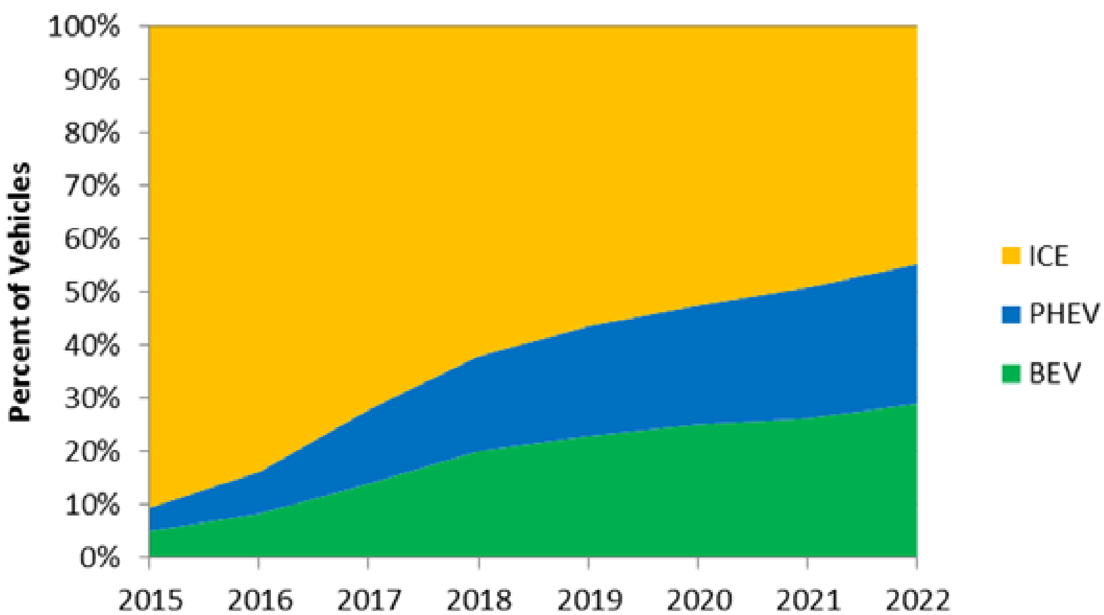


Figure 5. PEV introduction of JBLM fleet sedan types 2015 through 2022.

Assuming the total fleet inventory at NASWI remains the same, this replacement approach results in the fleet composition shown in Figure 6 for the years 2015 through 2030.

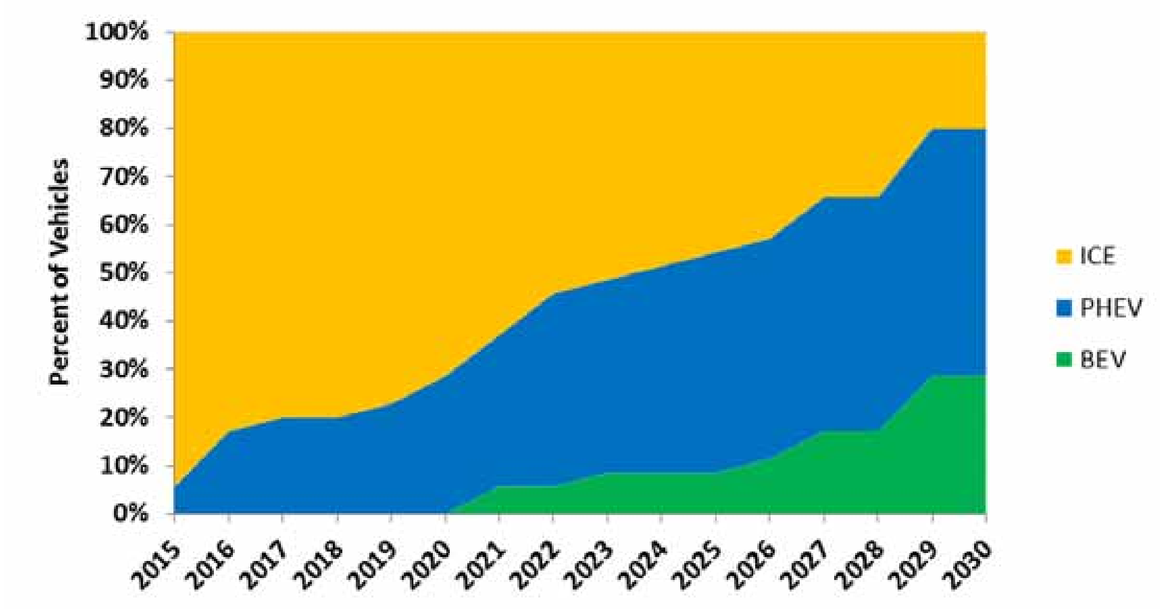


Figure 6. PEV introduction of NASWI fleet sedan types 2015 through 2030.

Assuming the total fleet inventory remains the same at MCBCL, this replacement approach results in the fleet composition shown in Figure 7 for the years 2015 through 2026.

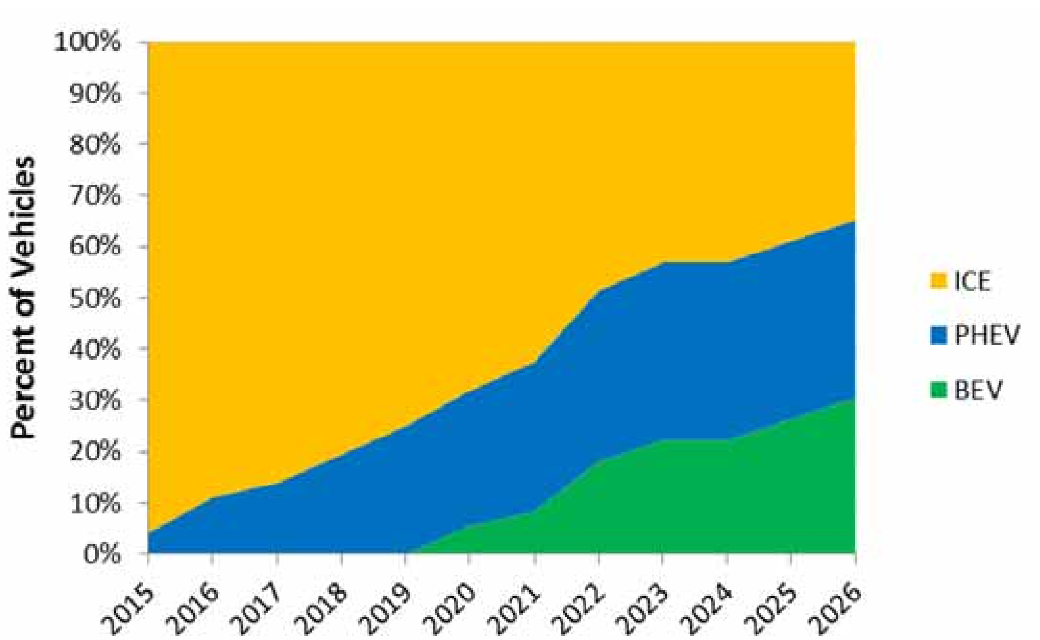


Figure 1. PEV introduction of MCBCL fleet sedan types 2015 through 2026.

5.2 Replacement Approach for All Fleet Vehicles

Again, assuming the size of the total fleet remains the same at JBLM, the adoption approach identified resulted in **30% of the fleet as PEVs** in 2022 (Figure 8). For NASWI, the adoption approach resulted in **51% of the fleet as PEVs** by 2030 (Figure 9). The vehicles introduced by this approach for MCBCL provide for **50% of the fleet as PEVs** by 2026 (Figure 10).

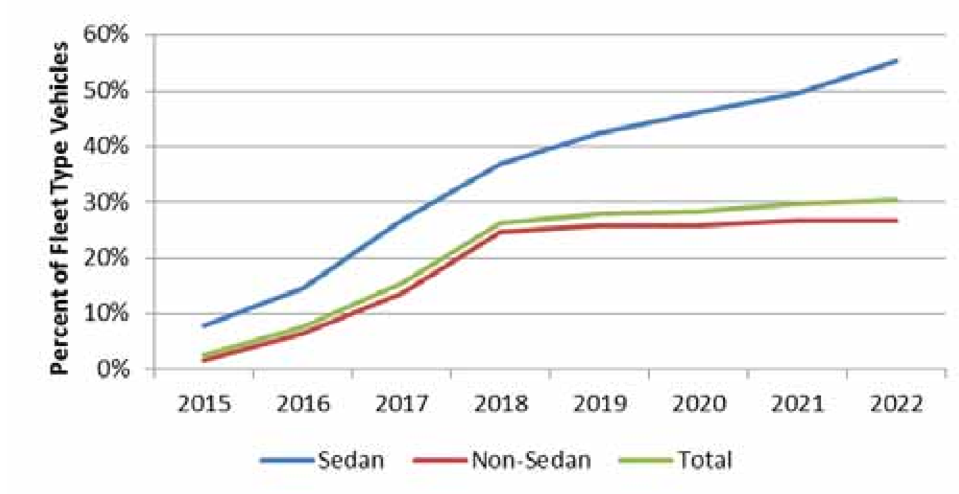


Figure 8. Projected PEVs in JBLM fleet.

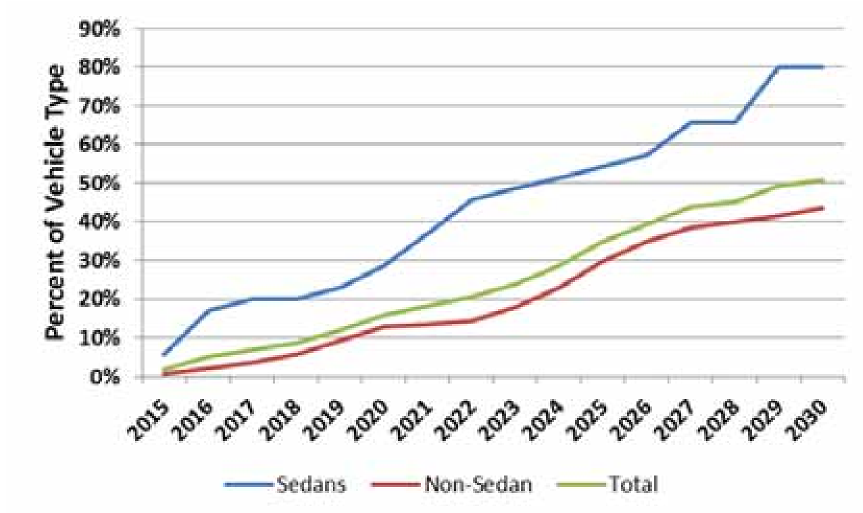


Figure 9. Projected PEVs in NASWI fleet.

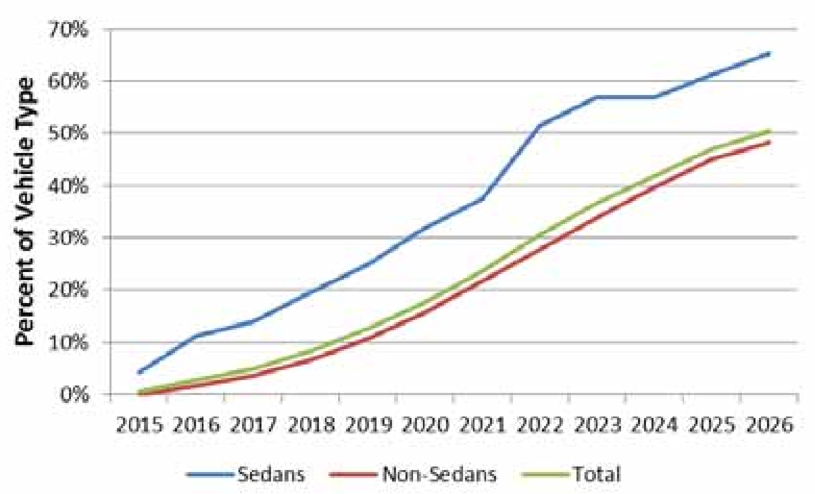


Figure 10. Projected PEVs in MCBCL fleet.

Differences in the analysis of percentages of vehicles and target years are a result of the differences in fleet size and composition.

Along with introduction of PEVs into the respective fleets, the Task 4 reports suggest the necessary EVSE required to support this introduction. The Task 3 infrastructure reports for each base provided recommendations related to location for these EVSE. EVSE capable of collecting and reporting data are recommended for selection.

6. OBSERVATIONS

As a result of this intensive study, Intertek suggests that each U.S. Department of Defense base is poised for successful introduction of PEVs into daily operation and that BEVs can provide support for most of the vehicle missions, while providing savings in fuel costs and greenhouse gas emissions. In meeting the directives and mandates, the adoption approach outlined for each base should provide input to the overall strategy and present an opportunity for gaining experience in the operation, support, and maintenance of PEVs. Each base may wish to move forward in the near future with replacement of vehicles with PEVs as current budget considerations allow. Certainly, the vehicle types studied in the respective reports may be candidates for immediate replacement.

Challenges to the adoption of PEVs include the following:

1. Costs associated with vehicle procurement that generally are higher for PEVs than a comparable ICE vehicle
2. Costs associated with procurement and installation of EVSE supporting PEVs
3. Limited availability of PEV vehicle types other than sedans; while many new vehicle types have been announced or projected in the next few years, at this writing, PEV replacement for pickup trucks, heavy-duty trucks, and specialty vehicles are primarily after-market PHEV conversions
4. Limited vehicle types on the GSA certified list
5. General unfamiliarity with PEV characteristics among those who may be using these vehicles, especially related to the range limitations of a BEV.

The impact of the first four items in the above list is expected to be lessened as adoption of PEVs by the public continues. The remaining item is resolved through education of personnel and experience in the operation of the vehicle.

Intertek and INL appreciate participation in this study and working with personnel from the U.S. Department of Defense bases at each of the sites.