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PEV Workplace Charging Costs and Employee Use Fees

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CONTENTS

FIGURES

TABLES

PEV Workplace Charging Costs and Employee Use Fees

1. INTRODUCTION

On December 4, 2015, President Obama signed H.R. 22, “Fixing America’s Surface Transportation Act (FAST Act).” Section 1413(c) authorizes the Administrator of the General Services Administration, or the head of a Federal agency, to install, construct, operate, and maintain on a reimbursable basis, plug-in electric vehicle (PEV) charging infrastructure. This can include the use, again on a reimbursable basis, of 120-volt electrical receptacles for charging of Federal employee-owned vehicles at Federal workplaces.

The U.S. Department of Energy requested that Idaho National Laboratory (INL) perform an analysis to estimate charging infrastructure and electricity costs that the Federal government would incur. Because some of the charging equipment does not include any electricity metering or data collection methods, reasonable reimbursement fees will need to be established. One such method is included in this document. The reimbursement method described may also be applicable to private businesses that wish to use a method to charge their employees an equitable reimbursement rate for charging personal PEVs at their workplaces.

This analysis uses five different PEV charging infrastructure scenarios to provide 10-year total costs, cost per charge event, and cost per kWh to install and operate PEV charging infrastructure. The costs are in current-year dollars, with no inflation. The five charging infrastructure scenarios provide alternating current (AC) 110-V, AC 220-V, or direct current (DC) 440-V power from the grid to PEVs. While some electric utilities may provide electricity at slightly different voltage levels, the economics would be similar. PEVs include battery electric vehicles, plug-in hybrid electric vehicles, and extended range electric vehicles. The estimated capital and annual costs, energy transfers per charge event, and frequencies of charge events for each scenario were based on data from the installation and use of 17,000 electric vehicle supply equipment (EVSE) and DC fast chargers (DCFCs) that Idaho National Laboratory (INL) and its research partners collected data from. While every EVSE installation is unique, the costs shown and discussed in the following sections, as well as the energy used and charge frequencies are based on the largest research sample of charging infrastructure use in the United States.

2. COST SUMMARY

Table 1 contains a summary of the potential workplace charging costs for five different scenarios. The kWh electricity use estimates come from past studies conducted by INL staff. Section 5 of this document contains another method for estimating fees for employee charging based on a different scenario for a specific PEV model and miles driven daily, which results in a different estimated daily fee.

Table 1. Summary 10-year total costs, cost per charge event, and cost per kWh for charging infrastructure Scenarios 1 through 5. The electricity cost per kWh used here is based on the national cost for electricity.

Scenario	10-year Total Cost	Cost per Charge	Cost per kWh
1. Existing AC Level 1 (110-V) Use	$870	$0.73	$0.11
2. AC Level 1 (110-V) Installation and Use	$2,875	$2.40	$0.36
3. AC Level 2 (220-V) Less Functional Wall-Mounted (Parking Garage, Restricted Access)	$4,763	$2.84	$0.25
4. AC Level 2 (220-V) Smart Pedestal-Mounted (Outside Parking Lot)	$12,997	$7.74	0.67
5. DCFC (440-V) Pedestal-Mounted	$123,071	$18.99	$2.09

3. SUMMARY DISCUSSION

3.1 Scenario 1 (Existing AC Level 1 EVSE) Summary

While using existing AC Level 1 (i.e., 110-V) outlets (Figures 1 through 3) is the lowest cost option, charging times can be very long. For a full 20-kWh charge, 15 hours is required. This also limits the number of vehicles that can charge per day to one per charge unit. Because of electric breaker sizing, only one PEV can charge per receptacle. This option relies on already installed 110-V wall outlets. Level 1 is best used overnight at home when charging plug-in hybrid electric vehicles, which have smaller battery packs than battery electric vehicles. This type of charging is also best for periods when a PEV is parked for a long period of time. An example would be parking at an airport during a multi-day trip. There is no way to electronically record which Federal employee's PEV is charging and the amount of energy received in order to require reimbursement on a per kWh or time basis. However, a voluntary method could be used, where the Federal fleet manager would have to rely on employees signing up or volunteering when they have charged their PEV, or a simple monthly or paycheck fee could be calculated.

This type of charging has the lowest cost, but it may prove inadequate for current PEVs with large-traction battery packs or for future PEVs that are anticipated to have larger-traction battery packs.

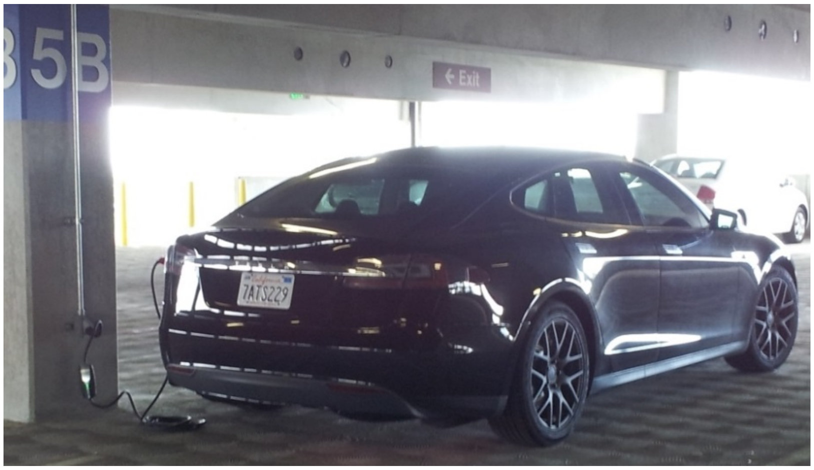

Figure 1. A single AC Level 1 EVSE in a parking garage.

Figure 2. Several AC Level 1 EVSE in a parking garage.

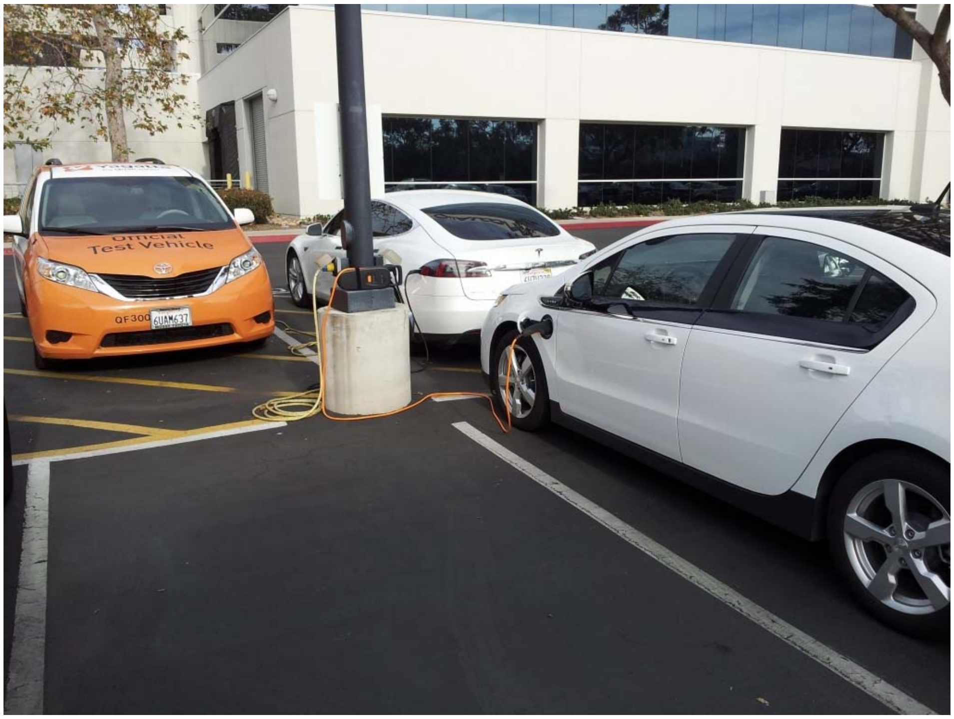

Figure 3. Multiple AC Level 1 in a parking lot at the base of a light pole.

3.2 Scenario 2 (Installing Level 1 EVSE) Summary

While installing AC Level 1 (i.e., 110V) outlets is the second lowest per charge cost option and the third least expansive option per kWh, charging times can be very long. For a full 20-kWh charge, 15 hours is required. This also limits the number of PEVs that can charge per day per 110-V outlet. Because of electrical breaker sizing, only one PEV can charge per receptacle. This scenario installs a charging source that is best used at home overnight when charging plug-in hybrid electric vehicles and their smaller battery packs. This type of charging is also best for periods when a PEV is parked for a long period of time. An example would be parking at an airport during a multi-day trip. There is no way to capture who is charging and the amount of energy received. However, a voluntary method could be used as discussed in Scenario 1.

3.3 Scenario 3 (Installing Least-Functional Level 2 EVSE) Summary

While installing a wall-mounted AC Level 2 (i.e., 220-V) EVSE (Figure 4) that does not have any functions (such as a meter, data storage, communication, or a driver interface) or the ability to be activated via a readable device (such as a radio frequency identification device), it is the third lowest cost option on a per charge basis and it is the second least expensive on a per kWh basis due to much higher charge rates than Level 1 and the ability to charge more than one PEV per day. Charging times are significantly faster than Level 1, with the ability to obtain a full 20-kWh charge in approximately 3 hours (i.e., assumes a 6.6-kW charge rate). This option allows for multiple vehicles to share a single EVSE, with often one PEV before lunch and a second PEV after. This would allow for one Level 2 to be more capital cost effective than a Level 1, because it can avoid installation of two Level 1 units and still serve as many, if not more, PEVs per day. However, with this least-functional Level 2 EVSE, there is no way to capture who is charging and the amount of energy received, therefore, the Federal fleet manager would have to rely on employees signing up or volunteering when they have charged their PEV, or a simple monthly fee could be calculated.

Figure 4. Wall-mounted AC Level 2 EVSE in a parking garage. These EVSE are fully functional and are a good example of a wall-mounted EVSE in a parking garage.

3.4 Scenario 4 (Installing Fully Functional Level 2 EVSE) Summary

Installing a fully functional, pedestal-mounted (Figures 5 and 6) AC Level 2 EVSE (i.e., 220-V), which includes a kWh meter, data storage, communications, a driver interface, or the ability to be activated via a readable device ((such as radio frequency identification device), is the second most expensive option on both a per charge and per kWh basis. (An AC Level 2 EVSE with these capabilities is sometimes referred to as a “Smart” AC Level 2). Charging times are significantly faster than Level 1, with the ability for a full 20-kWh charge in approximately 3 hours (i.e., assumes a 6.6-kW charge rate). This option allows for multiple vehicles to share a single EVSE, with often one PEV before lunch and a second PEV after. The features of the smart Level 2 EVSE allow the EVSE to capture who is charging and the amount of energy received; therefore, the Federal fleet manager would not have to track employee charging practices. Employees would have to sign up with and pay the EVSE provider and the Federal agency would have to pay the 10 years of fees to the manufacturer for back office costs or this cost could be added to the fees the employees pay the EVSE provider. It should be noted, that there are other various business models where the manufacturer shares revenue with the host, or possibly installs the EVSE for a much lower price, and the manufacturer keeps all revenue from electricity resale and possible monthly fees paid by the employees.

Figure 5. AC Level 2 EVSE mounted on precast concrete pedestals. These EVSE are intended to charge one PEV per parking spot. Note that the left most EVSE is of reduced height in order to comply with the American with Disabilities Act.

Figure 6. AC Level 2 EVSE mounted on a precast concrete pedestal. This EVSE is intended to charge vehicles in both parking slots.

3.5 Scenario 5 (Installing DCFC) Summary

Installing a DCFC (i.e., 50 kW) is the most expensive option both on a per charge and per kWh basis. However, charging times are significantly faster than Level 2, with the ability to obtain a full 20-kWh charge in approximately 1 hour or a half charge in approximately 30 minutes. Factors (such as the size of the traction battery pack and the temperature of the battery pack) can greatly influence charge times, with some PEVs able to recover full or half battery capacities faster. This option allows for multiple vehicles to share a single DCFC, but the vehicles must be moved often, which would possibly require employees to wait 30 minutes at a time or result in the need for a Federal fleet employee to switch out employees' PEVs and fleet vehicles multiple times per day (or night). Many PEV enthusiasts advocate for DCFC, but the capital and installation costs can be significant. The features of the DCFC (Figure 7) allow the unit to capture who is charging and the amount of energy received; therefore, the Federal fleet manager would not have to track employee charging practices. Employees would have to sign up with the EVSE manufacturer and the Federal agency would have to pay 10 years of fees to the manufacturer or the service fees can be collected on a per charge basis. It should be noted that there can be variations to the business model; however, capital and installation costs can be very high and charging providers may be reluctant to take on the capital and installation cost risk alone. It should be noted that there are several different DCFC connection technologies for plugging into PEVs and each is not compatible with all vehicles.

Figure 7. DCFC to the left and two AC Level 2 wall-mounted EVSE to the right.

4. RECOMMENDATION

Options 3 and 4 (i.e., Level 2 EVSE at 220 V) would deploy many more EVSE than the cost of one DCFC. Level 2 EVSE also present a more visible demonstration of charging infrastructure expansion at Federal facilities than additional Level 1 EVSE (i.e., 110-V receptacles). INL has studied use patterns at more than 17,000 Level 2 EVSE; it has been demonstrated that PEV drivers prefer Level 2 charging at their work places and, in general, at public access areas. INL testing has also demonstrated that Level 2 EVSE have very high efficiency rates. Therefore, considering costs and charge frequencies, smart Level 2 EVSE should be considered for installation in areas that do not have limited access, and either smart or least functional Level 2 EVSE should be considered for installation in areas with limited access. Having stated that Level 2 has many advantages, budgeting realities also have to be acknowledged. There is not any known charging infrastructure hardware or installation funding associated with the FAST Act. Therefore, using existing Level 1 EVSE may be the most realistic option in the near term.

The only decision remaining is if Federal employees will be billed for charge events via an arrangement with the Federal fleet manager on a per charge basis or on a per pay period basis. Reimbursement via the per pay period basis may not capture the exact amount of electricity used per pay period. However, on an annual basis, a reasonable estimate of kWh used annually will result in reasonable reimbursement to the Federal government.

5. CALCULATING PAYCHECK FEES FOR CHARGING

If Federal employees are going to be assessed a fee for workplace charging at a Level 1 or Level 2 EVSE with no kWh meter nor data collection capability, a method is required to estimate the amount of electricity that is used. The number of days the PEV is charged at work, the PEV model's efficiency, and miles driven before charging (this directly impacts kWh used) should all be used to determine the pay deduction amount for charging at work. This section contains one possible method for determining the amount for all Federal employees that charge at work. It is dependent on the PEV model, miles driven, real or regional electricity rates, work schedule, and days off for vacation, sick leave, and so forth.

In order to calculate the approximate electricity the employees' PEVs use, one can visit the Fuel Economy Guide, which for 2016 PEV models can be found at: https://www.fueleconomy.gov/feg/bymodel/2016MakeList.shtml. By selecting the PEV make and PEV model, the PEV's efficiency ratings can be obtained.

For example, the 2016 Ford Focus Electric is rated at 32 kWh per 100 miles. (https://www.fueleconomy.gov/feg/bymodel/2016_Ford_Focus.shtml). Simply taking the average distance the PEV is driven to work each day or since the last time it was near fully charged, one can generate the average kWh used. For this scenario, we assume the vehicle is only charged at work, the employee lives 15 miles from work, works in the District of Columbia, and runs about 5 miles of errands each day. The result would be an average of 35 miles of driving per charge event at work. The calculation would be:

Distance in miles * vehicle efficiency/100.

For the employee in this example, the calculation would be

35 * 32/100 = 11.2 kWh used per day of average charging.

The 11.2 kWh used would next be multiplied by the electricity rate the Federal agency was paying for that location. While it does lag by a couple of months, the Energy Information Administration publishes national, regional, and state electricity prices by market segment; this can be used if the actual Federal price of electricity is difficult to obtain. The information can be found at: https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a. For November 2015, the commercial rate for electricity in the District of Columbia was 12.03 cents per kWh. Therefore, the calculation formula at this point would be as follows:

Distance in miles * vehicle efficiency from the Environmental Protection Agency/100 * electricity price/100.

For our imaginary Federal employee, the calculation formula at this point would be as follows:

35 * 32/100 * 12.03/100 = $1.35 day.

Therefore, our imaginary Federal employee that travels 35 miles on average before he or she charges their personal Ford Focus Electric at work should have to pay $1.35 per day they charge.

Taking this analysis one step further, the average paycheck reduction to charge at work can be calculated using the days at work on an annual basis.

((pay periods per year * workdays per pay period) – holidays – vacation days – sick days – government shutdowns – travel days away from home office).

Using 26 pay periods in a year, an every other Friday off schedule that results in one non-adjusted 9 workdays per pay period, 10 Federal holidays in 2016, and assuming 3 weeks of vacation, 1 week of sick leave annually, 3 non-scheduled government shutdowns per year, and 10 travel days away from the work office annually, this employ's calculations of days at the workplace would be as follows:

((26 * 9) – 10 – 15 – 5 – 3 - 10)/26 = 7.35 days per pay period.

The employee would come to their workplace and charge their vehicle an average of 191 days per year or 7.35 days per 2-week pay period. Using the $1.35 per day for days the vehicle is charged, the every 2-week paycheck deduction would be $9.92 (7.35 * $1.35). However, this step-by-step explanation introduces rounding errors that results in the $9.92 figure, which is to the detriment of Federal employees. In order to eliminate rounding errors, the complete formula to determine paycheck deductions would be as follows:

Distance in miles * vehicle efficiency/100 * electricity price * ((pay periods per year * workdays per pay period) – holidays – vacation days – sick days – government shutdowns – travel days away from home office)/pay periods/100.

For our fictional Federal employee driving the Ford Focus Electric, the formula is as follows:

35 * 32/100 *12.02 * ((26 * 9) – 10 – 15 – 5 – 3 - 10)/26/100 = $9.89 per pay period.

Using this method accounts for regional differences in electricity prices, days not at work, different work schedules, and the different distances employees will drive to work. The only shortcoming is the lack of data about how far the vehicles are actually being driven before each charge and the actual state of charge of the vehicle battery pack. However, given that these data does not exist, this method may best approximate the kWh of electricity being used to charge personal Federal employee methods.

It should be noted that if charging is occurring via an AC Level 1 EVSE, the electricity transfer rate is fairly low. Therefore, on a circuit with 15 amps, the maximum energy that can be charged in 9 hours is 11.88 kWh (15 amp * 80% * 110 Volts * 9 hours = 11.88 kWh). If the receptacle is on a 20-amp breaker, the maximum energy that can be charged in 9 hours is 15.84 kWh (20 amp * 80% * 110 Volts * 9 hours = 15.84 kWh). This assumes that each Level 1 receptacle has a dedicated circuit breaker.

6. GENERAL ASSUMPTIONS

The assumptions in this section support Scenarios 1 through 5, which were part of an infrastructure focused analysis. These assumptions are not the assumptions used in Section 5.

- Almost the entire charging infrastructure in use today has been installed since 2010. Therefore, the full operating and economic life of the recently installed charging infrastructure is difficult to quantify with complete certainty. Life is highly dependent on the following:
  - Use rates: how many times the plug is connected and unconnected to a vehicle for charging
  - Features: EVSE with screens for interacting with PEVs will likely need maintenance or replacement sooner
  - Vandalism (Figure 8)
  - Being run over by snow plows and PEVs (Figure 9)
  - Quality of the EVSE
- Protection from the elements (in a covered parking location). Charging infrastructure hardware, installation, maintenance, annual fees (if applicable), and electricity costs were identified for a 10-year period for five scenarios:

- Scenario 1, Existing AC Level 1 (i.e., 110-V), referred to as Level 1
- Scenario 2, AC Level 1 (i.e., 110-V) requiring installation, referred to as Level 1
- Scenario 3, AC Level 2 (i.e., 220-V) least functional (i.e., dumb), wall-mounted EVSE in parking garages and restricted access locations, referred to as Level 2
- Scenario 4, AC Level 2 (i.e., 220-V) smart (has revenue, data collection, and other features) pedestal-mounted in a non-access-controlled location like a parking lot, referred to as Level 2
- Scenario 5, DCFC (i.e., 50 kW) free-standing mounted, in a non-access controlled area like a parking lot.

Figure 8. Vandal attaching an AC Level 2 EVSE.

Figure 9. Fully functional AC Level 2 EVSE damaged by a snow plow.

- Level 1 is assumed to be a simple commercial-grade, 110-V outlet, with no ability to monitor connect time, number of charge events, which driver charged which PEV, or energy delivered.
- Level 2 can be of two basic designs:
    - One Level 2 EVSE design simply transfers AC energy from the grid to the PEV via a Society of Automotive Engineers-approved cord and plug set. There is no ability to monitor connect time, number of charge events, which vehicle and driver charged the vehicle, or energy delivered. This is the simplest and least expensive Level 2 hardware and it does not require any communication with a business's back-office computer system for billing by a third party. This design is often referred to as a "dumb EVSE" or a "least-functional EVSE."
    - The second Level 2 EVSE design, often called a "smart charger" or a "smart EVSE," will have a suite of features that may include the following:
        - Multiple ways to communicate with a back office for the purpose of billing and monitoring use (such as WiFi, ethernet, and cellular)
        - A revenue grade meter
        - Two-way communication with a back office, allowing downloads to the smart Level 2 EVSE of firmware and subscriber lists
        - An interactive screen for communicating with the PEV driver
        - A method to "swipe" an identification card and the ability to take information either via a mobile app (I.E., application) or verbally via a cell phone regarding a credit card
        - There may be a credit card fee that must be paid for each transaction when the Smart EVSE is used; the fee can be based on the amount of electricity sold, hours connected, number of transactions, and the kWh cost of electricity (which nationally averages 11 cents per kWh in commercial applications).
- DCFC will often have a demand charge for any change over 20 kW. This charge can be as high as $1,500 per month, even if only one DCFC charge occurs per month. The economics of DCFC can be difficult when demand charges are considered.
- Demand charges can also be incurred when several Level 2 EVSE are collocated, they are all on the same meter service, and they are all used at the same time. Under this scenario, if four Level 2 EVSE were in use and charging at the 6.6-kW level, the total demand would be 26.4 kW, which exceeds the demand fee that starts at 20 kW. Demand fees in the Phoenix, Arizona area can be as high as $500 per month [1] and almost $1,500 per month in California [2].
- If a smart EVSE is used, a technical support center would include both call center support and the computer technical support center. A monthly cellular fee would also be needed so revenue and use can be reported to the network owner.
- An EVSE design life of 10 years is sometimes used by EVSE providers. Factors impacting EVSE life can include the following:
    - In areas of the southwestern United States, extreme sunlight can discolor the hardware and any type of screen installed, making EVSE displeasing to see and use, even if it is still functional
    - Instances of EVSE units being run over by snow plows and cords cut by snow plows has been documented in snowy areas
    - Simple vandalism
    - Technical obsolescence, where some members of industry are talking about new connector designs for higher-energy levels.

7. SCENARIO-SPECIFIC ASSUMPTIONS AND ANLYSIS

7.1 Scenario 1, Existing AC Level 1 Use Costs for 10 Years

Table 2. 10-year total costs, cost per charge event, and cost per kWh for Scenario 1, which involves the use of existing Level 1 (i.e., 110-V) receptacles.

	Scenario 1, Use Existing AC Level 1 Annual/Monthly Cost	10 Years
Hardware		NA
Installation		NA
Maintenance	NA	NA
Back office systems support	NA	NA
Demand charge	NA	NA
Electricity cost	$0.11/kWh	$870
Total 10-year cost		$870
Number of charge events	120	1,200
Cost per charge event		$0.73
kWh used	792	7,920
Cost per kWh		$0.11

- Requires the use of an existing, commercial-grade, National Electrical Manufacturers Association receptacle. It is assumed that a commercial-grade receptacle is used in existing parking structures.
- Allows use of the plug and extension cord that comes with the PEV; therefore, there is not any additional hardware or fee costs for using an existing Level 1.
- No maintenance is assumed for the 10 years of use.
- A study at a Facebook facility found vehicles were connected about 9 hours per day when connected to a Level 1 EVSE, transferring power about 5 hours per day. For this analysis, we will use 8 hours per day, 5 hours of charging, and the Level 1 EVSE being used about 50% of the days. This equates to 15 amps x 110 V x 80% power rating x 0.5 uses per day x 5 hours of use per day x 5 days per week x 48 weeks = 792 kWh per year. Note: because the Level 1 EVSE have no way of capturing the energy data, kWh use must be estimated.
- The most recent (i.e., September 2015) available data for the average price of electricity for commercial use in the United States is 11 cents per kWh. Thus, 792 x 11 cents would require recapturing $87 per year.
- The total 10-year cost would be $870 ($87 x 10 years).
- Using 0.5 charges per day x 5 days/week x 48 weeks x 10 years = 1,200 charge events in 10 years.
- The employee cost per charge would be $875/1,200 events = $0.73 per charge.
- Or $0.11 per kWh ($0.73/6.6 kWh per charge) (15 amps x 110 V x 80% x 5 hours = 6.6 kWh).

7.2 Scenario 2, AC Level 1 Installation and Use Costs for 10 years

Table 3. 10-year total costs, cost per charge event, and cost per kWh for Scenario 2, which involves installation of Level 1 (i.e., 110-V) receptacles.

	Scenario 2, AC Level 1 Installation Annual/Monthly Cost	10 Years
Hardware		$5
Installation		$2,000
Maintenance	NA	NA
Back office systems support	NA	NA
Demand charge	NA	NA
Electricity cost	$0.11/kWh	$870
Total 10-year cost		$2,875
Number of charge events	168	1,680
Cost per charge event		$2.40
kWh used	792	7,920
Cost per kWh		$0.36

- Requires installation of a commercial-grade National Electrical Manufacturers Association receptacle (the 110-V receptacle in our homes is only tested to 250 cycles). It is assumed that a commercial-grade receptacle is used in existing parking structures.
- Allows use of the plug and extension cord that comes with the PEV.
- Because an additional Level 1 must be installed, the average cost of installation is assumed to be the same as installing a Level 2 wall-mount EVSE, given the similar need to run conduit and add a breaker, with that cost being $2,000 per EVSE [3].
- Several commercial-grade 15 or 20-amp, 120-V receptacles are listed for about $5 on the Home Depot website [4].
- Total installation + hardware cost is $2,005 [5].
- No maintenance is assumed for the 10 years of use.
- A study at a Facebook facility found that vehicles were connected about 9 hours per day when connected to Level 1 EVSE, transferring power about 5 hours per day. For this analysis we will use 8 hours per day, 5 hours of charging, and the Level 2 units being used about 50% of the days. This equates to 15 amps x 110 V x 80% rating x 0.5 uses per day x 5 hours of use per day x 5 days per week x 48 weeks = 792 kWh per year.
- The most recent (i.e., September 2015) available data for the average price of electricity for commercial use in the United States was 11 cents per kWh. Thus, 792 x 11 cents would require recapturing $87 per year.
- The total 10-year cost would be $2,005 + $870 ($87 x 10 years) = $2,875.
- Using 0.5 charges per day x 5 days/week x 48 weeks x 10 years = 1,200 charge events in 10 years.
- The employee cost per charge would be $2,875/1,200 events = $2.40 per charge or $2.40/6.6 kWh per charge (15 amps x 110 V x 80% x 5 hours = 6.6 kWh) = $0.36 cent per kWh.

7.3 Scenario 3, AC Level 2 Least-Functional Wall-Mounted (Parking Garage, Restricted Access) EVSE Installation and Use Costs for 10 Years

Table 4. 10-year total costs, cost per charge event, and cost per kWh for Scenario 3, which involves the installation of wall-mounted dumb Level 2 EVSE (i.e., no features beyond safe transfers of 220-V energy between the grid and the PEV).

Scenario 3, Non-Smart, Wall-Mounted AC Level 2 EVSE		
	Annual/Monthly Cost	10 Years
Hardware		$500
Installation		$2,000
Maintenance	$12.50	$125
Back office systems support	NA	NA
Demand charge	NA	NA
Electricity cost	$0.11/kWh	$2,138
Total 10-year cost		$4,763
Number of charge events	168	1,680
Cost per charge event		$2.84
kWh used	1,944	19,440
Cost per kWh		$0.25

- Requires use of an EVSE installed to the wall, which most likely can occur in a parking garage. It is assumed the garage has limited access and access to the least-functional Level 2 EVSE would be limited by the limited access placed on entering the garage.
- The documented average installation cost of wall-mounted Level 2 EVSE at workplaces is $2,000 per EVSE [6].
- Several least-functional Level 2 EVSE list for $400 to $600 each on the Home Depot site [7] and an average price of $500 will be assumed.
- It will be assumed that approximately 25% of Level 2 least-functional EVSE will need maintenance over the 10-year life; therefore, a maintenance cost of $125 will be added once.
- A study at a Facebook facility found vehicles were connected about 8.7 hours per day to Level 2 EVSE, transferring power about 4.4 hours per day, and 12 kWh per charge event was used each workday [8]. For this analysis, we will use 12 kWh per day, with the Level 2 EVSE being used 100% of the workdays. Facebook has an employee demographic that is highly receptive to electric vehicles; therefore, for this analysis, Facebook charge frequency will be decreased to 0.8 charges per day. The energy use would be 12 kWh x 0.80 of the days x 5 days x 48 weeks = 2,304 kWh per year.
- During the third quarter of 2013, The EV Project Level 2 EVSE averaged 0.6 charge events per day and 11 kWh was used during the 3.3 hours power was drawn on weekdays [9]. For The EV Project analysis, we will use 11 kWh per day, with the Level 2 EVSE being used 60% of the days. Therefore, the energy use would be 11 kWh x 0.60 of the days x 5 days x 48 weeks = 1,584 kWh per year.
- For this analysis, the average of the two studies will be used or 1,944 kWh per year ((2,304 + 1,584)/2), or 19,440 kWh for 10 years.
- The most recent (i.e., September 2015) available data for the average price of electricity for commercial use in the United States was 11 cents per kWh. Thus, 19,440 x 11 cents would require recapturing $2,138 for the 10 years.

- The total 10-year cost would be $2,000 + $500 + $125 + $2,138 = $4,763.
- Using 0.7 (i.e., the average of the two above studies) charges per day x 5 days/week x 48 weeks x 10 years = 1,680 charge events in 10 years.
- The employee cost per charge would be $4,763/1,680 events = $2.84 per charge.
- The cost per kWh would be $0.25 ($2.84 / ((11 + 12)/2)).

7.4 Scenario 4, AC Level 2 Smart Pedestal-Mounted (Outside Parking Lot) EVSE Installation and Use Costs for 10 Years

Table 5. 10-year total costs, cost per charge event, and cost per kWh for Scenario 4, which involves installation of pedestal-mounted smart Level 2 EVSE (features include revenue grade meter, communication with the PEV and the manufacturers software back office operations, ability to be re-flashed remotely, and safe transfers of 220-V energy between the grid and the PEV).

Scenario 4, Smart Pedestal-Mounted AC Level 2 EVSE		
	Annual/Monthly Cost	10 Years
Hardware		$3,000
Installation		$3,209
Maintenance	$105	$1,050
Back office systems support	$30 (monthly)	$3,600
Demand charge	NA	NA
Electricity cost	$0.11/kWh	$2,138
Total 10-year cost		$12,997
Number of charge events	168	1,680
Cost per charge event		$7.74
kWh used	1,944	19,440
Cost per kWh		$0.67

- This type of installation is common in parking lots at workplaces without a parking garage or the side of a building that would allow a wall-mounted Level 2 EVSE installation. Therefore, a pedestal is used; this normally requires more costly trenching in order to run the conduit and wires underground. Because this type of installation may not have physical limitations on access by the public, it is assumed that smart Level 2 EVSE must require some sort of payment plan and access limit by the smart Level 2 EVSE in order to stop random use by PEV drivers that are not reimbursing Federal agencies for charging.
- The EV Project documented the average installation cost of pedestal-mounted Level 2 at workplaces as $2,305 per EVSE [10]. However, the overall cost of installing a non-residential pedestal-mounted Level 2 EVSE is $3,209 [11]. This includes a fully publically accessible pedestal Level 2 EVSE cost of $3,308 and the workplace cost of $2,305. Note there are more publicly accessible Level 2 EVSE than workplace pedestal-mounted Level 2; therefore, $3,209 is the weighted average. The cost of $3,209 will be used for this scenario.
- Several pedestal hardware options (from single charge ports to multiple charge ports) exist and the level of sophistication of the control and billing systems varies. Hardware costs can run from $2,000 to $7,000. However, several options in the $3,000 range are available; this value is used for the hardware cost for a single charge port smart Level 2 EVSE.
- It will be assumed that approximately 35% of Level 2 smart EVSE will need maintenance over the 10-year life; therefore, a maintenance cost of $1,050 will be added once. The higher percentage of smart Level 2 EVSE needing maintenance is due to the higher amount of technology in the units compared to least-functional Level 2 EVSE.

- When smart Level 2 EVSE is used, there is a monthly or yearly fee for accessing the information collected by the system and handling the billing. This fee level is not readily advertised and it is dependent on the number of EVSE owned, the EVSE location, and the customer. Quotes have been received that range from $30 per month to $1,000 per year, which also covers maintenance. The $30-per-month fee will be used. This fee does not provide access to charging privileges; it is the fee that the EVSE manufacturer charges in order to host the software required to operate the smart Level 2 EVSE. The 10-year service fee would be $3,600 ($30 x 120 months).
- Total 10-year installation + hardware + maintenance cost + monthly fee is $10,859 ($3,209 + $3,000 + $1,050 + $3,600).
- A study at a Facebook facility found vehicles were connected about 8.7 hours per day to Level 2 EVSE, transferring power about 4.4 hours per day, and 12 kWh per charge event was used, every workday [12]. Facebook has an employee demographic that is highly receptive to electric vehicles; therefore, use for this analysis will be decreased to 0.8 charges per day. Therefore, the energy use would be 12 kWh x 0.80 of the days x 5 days x 48 weeks = 2,304 kWh per year.
- During the third quarter of 2013, The EV Project Level 2 EVSE averaged 0.6 charge events per day and 11 kWh was used on weekdays. For this analysis, we will use 11-kWh per day and the Level 2 EVSE being used 60% of the days. Therefore, energy use would be 11 kWh x 0.60 of the days x 5 days x 48 weeks = 1,584 kWh per year.
- For this analysis, the average of the two studies will be used: or 1,944 kWh per year ((2,304 + 1,584)/2) or 19,440 kWh for 10 years.
- The most recent (i.e., September 2015) available data for the average price of electricity for commercial use in the United States was 11 cents per kWh. Thus, 19,440 x 11 cents would require recapturing $2,138 for 10 years.
- The total 10-year cost would be $10,859 + $2,138 = $12,997.
- Using 0.7 (i.e., average of the two above studies) charges per day x 5 days/week x 48 weeks x 10 years = 1,680 charge events in 10 years.
- The employee cost per charge would be $12,997/1,680 events = $7.74 per charge.
- The cost per kWh would be $0.67 ($7.74/((11 + 12)/2)).

7.5 Scenario 5, DCFC Free-Standing Mounted (Outside Parking Lot) Installation and Use Costs for 10 Years

Table 6. 10-year total costs, cost per charge event, and cost per kWh for Scenario 5, which involves the installation of pedestal-mounted smart DCFC (features include revenue grade meter, communication with the PEV and the manufacturers software back office operations, ability to be re-flashed remotely, and safe transfers of 440-V energy between the grid and the PEV).

	Scenario 5, DCFC Annual/Monthly Cost	10 Years
Hardware		$40,000
Installation		$23,600
Maintenance	$800	$8,000
Back office systems support	$1,500	$15,000
Demand charge	$250 (monthly)	$30,000
Electricity cost	$0.11/kWh	$6,480
Total 10-year cost		$123,071
Number of charge events	648	6,480
Cost per charge event		$18.99

	Scenario 5, DCFC Annual/Monthly Cost	10 Years
kWh used	5,883	58,830
Cost per kWh		$2.09

- DCFCs are normally sited in one of three types of locations:
  - Near a highway to facilitate commuting type of use
  - In a parking lot associated with a business or shopping venue
  - Or a combination of both.
- DCFCs have more change events per day then Level 1 or Level 2 EVSE, with each event for a short period of time, and with less energy transferred per charge event.
- A disadvantage of installing a DCFC at a Federal agency location is that not all of today’s PEVs can be fast charged; there are two competing connector and DCFC designs (Society of Automotive Engineers Combo and CHAdeMO) that are not interchangeable. However, there are some DCFC that contain both technologies in one unit with one charge port per technology.
- A third design by Tesla also exists. It is not likely that the Tesla design would be selected given that it is not likely Federal PEVs would include a vehicle model as expensive as the Tesla, and it is not anticipated that the Tesla will be a General Services Administration-listed PEV in the near term.
- Many different DCFC options exist and the suggested costs have been highly varied. INL has recently obtained a DCFC with both fast charge technologies, meaning dual cord/connector sets, and the cost was approximately $40,000. This cost will be used for the hardware costs.
- The costs to install a DCFC have ranged significantly, with an organization in Florida reporting an installation as low as $4,400 [13]. However, there has been an informal communication of installation costs over $100,000 per DCFC in Canada. During The EV Project, the 111 DCFC installation costs varied from $8,500 to $51,000, and the average cost was $23,600 [14]. This will be the assumed installation cost.
- Early DCFC units required significant amounts of maintenance, at the rate of 25% of all units per year. Given that newer technology is available today and it is more rigorous, an assumption is made that today’s rate would be closer to 10% per year or once every 10 years. Given the higher power ratings, the higher number of charge events per year, the higher internal heat levels, the greater sophistication of DCFCs, and the more expensive components, a total of $8,000 will be used for a 10-year maintenance cost.
- When a DCFC is used, there is often a monthly or yearly fee for accessing the information collected by the system and handling the billing. This fee level is not readily advertised and it is dependent on the number of DCFCs owned, the DCFC location, and the customer. Quotes have been received by INL for as high as $3,000 per year. Other earlier DCFC did not charge for this function. For lack of a better method, this will be split in half and an annual rate of $1,500 will be assumed or $15,000 for 10 years.
- Most electric utilities charge a demand charge for loads over 20 kW and DCFC normally charge up to 50 kW. If a separate electric meter is used for the DCFC, which is the norm, the demand charge can be significant (i.e., as high as $1,500 per month). A conservative monthly fee of $250 for the demand charge is assumed. The 10-year total demand charge would be $30,000 ($250 x 12 months x 10 years).
- Total 10-year hardware + installation + maintenance cost + monthly fee is $116,600 ($40,000 + $23,600 + $8,000 + $15,000 + $30,000).

- A workplace charging study at a Facebook facility found vehicles were connected to the DCFC about 4.5 times per workday day, transferring power about 22 minutes per charge event, with 9.3 kWh per charge event being used [15,16]. Facebook has an employee demographic that is highly receptive to electric vehicles; therefore, the use rate for this analysis will be decreased to three charges per workday. Therefore, energy use would be 9.3 kWh x 3 charge events per day x 5 days x 48 weeks = 6,696 kWh per year.
- During the third quarter of 2013, The EV Project's 100 DCFC averaged 2.4 charge events per workday and 8.8 kWh was used. Therefore, energy use would be 8.8 kWh x 2.4 of the days x 5 days x 48 weeks = 5,069 kWh per year.
- For this analysis, the average of the two studies will be used or 5,883 kWh per year ((6,696 + 5,069)/2) or 58,830 kWh for 10 years.
- The most recent (i.e., September 2015) available data for the average price of electricity for commercial use in the United States was 11 cents per kWh. Thus, 58,830 x 11 cents would require recapturing $6,471 for the 10 years.
- The total 10-year cost would be $116,600 + $6,471 = $123,071.
- Using 2.7 (average of the two above studies) charges per day x 5 days/week x 48 weeks x 10 years = 6,480 charge events in 10 years.
- The employee cost per charge would be $18.99 per DCFC charge event ($123,071/6,480 events).
- The cost per kWh would be $2.09 ($123,071/58,830).

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