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National Alternative Fuels Training Consortium

Electric Vehicle Charging Infrastructure

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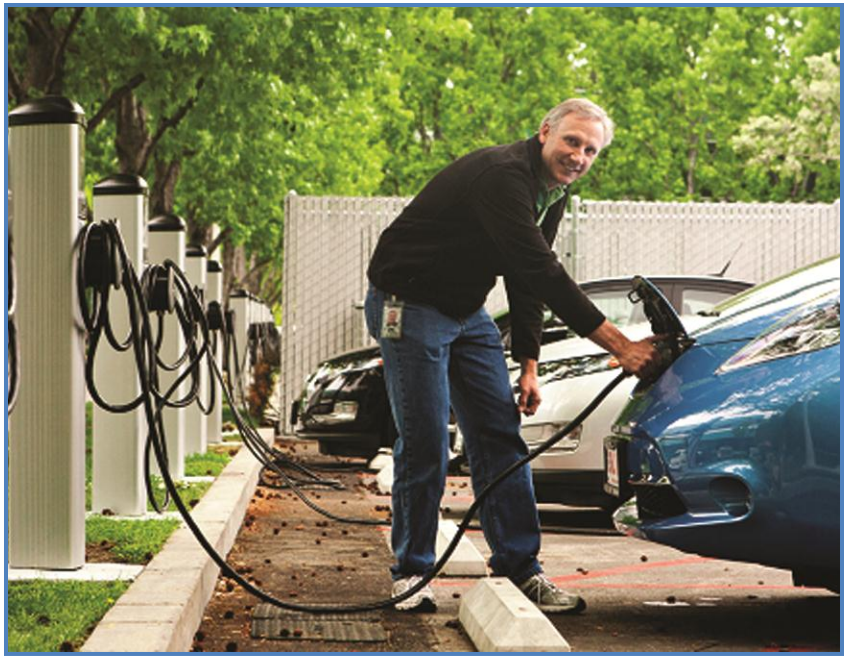
Challenges for Creating a Sustained Electric Drive Vehicle Market

- Educate new EV drivers
  - Responsibilities of owning, maintaining, and charging vehicles
- Promote interest through government policies
  - Tax incentives to reduce cost of vehicles
- Develop EV infrastructure supplied with grid electricity
  - Home
  - Work
  - Community
  - Interstates for traveling
- Collaborate with services for installation of EV infrastructure

Electric Vehicle Infrastructure

- Drivers need EV infrastructure to "refuel" vehicles
- Essential component for sustainability of electric vehicle market
- Allows EVs to "recharge" by transferring electricity to vehicle
- Relies on electric distribution system



Electric Vehicle Supply Equipment (EVSE)

Defined

- Equipment installed for the purpose of delivering energy from premise wiring to plug-in vehicles for charging

Purpose

- Transferring electric energy to a battery or other energy storage
  device in a plug-in electric vehicle
- Designed to connect safely to the BEV/PHEV
- Safety - EVSE interlock limits the amount of branch circuit electricity

Includes

- Conductors, underground conductors, grounded conductors, equipment grounded conductors
- Electric vehicle connectors
- Attachment plugs
- All other fittings, devices, power outlets, apparatuses

Three Different Levels of Charge

- EVSE classified into three different levels by rate at which the equipment charges the electric vehicle's battery.
  - Level 1 AC
  - Level 2 AC
  - DC Fast Charging or Quick Charging
- Rate – EVSE charging adds range/miles to electric vehicle among 3 levels depends on:
  - Electric vehicle
  - Battery type
  - EVSE level of charge

Levels of Charge; Level 1 AC Charging

Level 1 AC Electrical Requirements

- 120 volt, AC receptacle, 15 to 20 amperes
- Dedicated 20 to 25 amp circuit for overcurrent protection
  - EVSE requires 125% overcurrent protection (continuous electric charge/load 3 hours +)

PHEVs and BEVs will come with a Level 1 EVSE portable cord set

- kept with the vehicle at all times
- used when the driver is running low on charge

Rate of charge adds about 2 to 5 miles of range to the vehicle per hour of charging time.

Levels of Charge; Level 2 AC Charging

Level 2 AC Electrical Requirements

- 240 volts of AC, 30amps to 80amps
- Dedicated circuit and separate manual service disconnect
- Enclosure – (EVSE unit may be hardwired or plugged into a dedicated circuit)
  NEMA Type 3R

How to Use the Level 2 AC EVSE

- Charging unit may be either plugged into 240V receptacle or hardwired to dedicated circuit
- Level 2 AC typically used for charging at home and public locations

Rate of charge adds 10-20 miles of range to vehicle per hour of charging time (depends on vehicle; PHEV or BEV)

Levels of Charge; DC Fast Charging

DC Fast Charging Electrical Requirements

- 240 to 600 volts of direct current (DC) from off-board charger, 150 to 400amps
- Dedicated circuit (require separate manual service disconnect)
- Enclosure – EVSE unit will be hardwired

Electric Vehicle's Equivalence to Commercial Gas Station

- Primarily commercial charging

How to Use the DC Fast Charging EVSE

- Uses CHAdeMO or SAE J1772 Combo connector and plug into electric vehicle inlet

Provide nearly (80%) 60 to 80 miles of range to the vehicle in 20 to 30 minutes of time

Charge Method Electrical Rating

Overview and comparison of the different levels of charge.

Level	Voltage	Amperage	Type of Current	Estimated Charge Time
Level 1	120V AC	16 to 20 amps	Common alternating current residential grounded receptacle from electrical source to vehicle's onboard charger.	8-16 hours
Level 2	240V AC	30 to 80 amps	Dedicated circuit from electrical source to vehicle's onboard charger.	3-8 hours
DC Fast Charging	Anything over 240V DC	100 amps +	Direct Current from off-board charger.	20 to 30 minutes

EVSE Mounting Styles

Floor Mount or Pedestal Mount

- Securely mounted onto ground
- Common for Level 1, 2, & DC fast charging
- Parking lots
- Parking garages
- Street
- Protective bollards & wheel stops used to prevent vehicle impact

EVSE Mounting Styles

Wall Mount or Pole Mount

- Mounted onto a wall or securely attached to a pole
- Flexible placement options

Services Involved in the Installation of Electric Vehicle Infrastructure

Professional Service	Roles and Responsibilities
Automotive Manufacturers	Produce and place EVs on the market.
Automotive Dealers	Informs customers about EVs for sale.
Electric Vehicle Supply Equipment Manufacturers	Manufacture and supply charging station equipment.
Consumers & Fleet Owners	Adopt new methods of refueling EVs.
Electricians	Provide expertise to install charging equipment in different locations.
Utility Companies	Provide electricity and power to the charging stations.
Municipalities	Provide authority for infrastructure design and placement.
Government	Provide policies focused on economic, environmental improvement.

EV Charging Costs

- Various utility rate options for charging EVs may be available
- EV customers will add vehicle usage to existing rate schedule
  - Same as any other additional appliance to home
- Rate pricing
  - Dependent upon utility
- Information utility company and customer need to discuss
  - Discounted rates for EV charging
  - Demand-Response programs
  - Meter Options
  - Electricity cost assessment for added EV charging load

On Peak Charging versus Off Peak Charging

On Peak Charging / 14-26 kWh	Off Peak Charging / 4-11 kWh
• Charging that occurs during the day	• Charging that occurs during the night

• Greater strain on electric grid
  • People, businesses, factories, schools, stores all using electricity
	• Less strain on electric grid
	  • Preferred by utility companies

• Electric rates more expensive during day	• Common time for EV charging • People return home from work & plug in EV to recharge for morning
***Rates for charging EV during day will be more expensive also*	***Rates for charging EV are cheaper*
On Peak cost range - 14-26 kWh	Off Peak cost range - 4-11 kWh

Drivers Can Make Informed EV Charging Decisions

- Location and access to charging station (home, work, public)
- Time of day availability to charge (day or night)
- Level of charge at charging station (Level 1, 2 or DC fast charging)
- Length of time needed to recharge the battery

Costs of EVSE

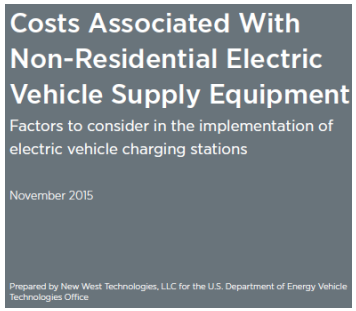
Ballpark EVSE Unit and Installation Costs

EVSE Type	EVSE Unit* Cost Range (single port)	Average Installation Cost (per unit)	Installation Cost Range (per unit)
Level 1	$300-$1,500	not available	$0-$3,000** *Source: Industry Interviews*
Level 2	$400-$6,500	~$3,000 *EV Project (INL 2015b)*	$600-$12,700 *EV Project (INL 2015b)*
DCFC	$10,000-$40,000	~$21,000 *EV Project (INL 2015d)*	$4,000-$51,000 *EV Project (INL 2015d) and (OUC 2014)*

Table 4. Ballpark costs for EVSE units and installation.

**EVSE unit costs are based on units commercially available in 2015.*

***The $0 installation cost assumes the site host is offering an outlet for PEV users to plug in their Level 1 EVSE cordsets and that the outlet already has a dedicated circuit.*



Appendix C: Electricity Consumption Examples

The scenarios below are based on specified assumptions and provide an example of annual electricity cost for Level 1, Level 2, and DCFC EVSE.

Level 1, Single Port Scenarios	Annual Electricity Consumption & Cost	Installation Cost Amortized Over 10yrs/kWh & cost/yr.*	Assumptions
Workplace charging • 1 light-duty vehicle • Charging 6hrs/day • 5 days/week	• 2,184 kWh/yr • $218/yr	$0.000-$0.023/kWh $0-$50/yr	• EVSE Type: Level 1 120 VAC • Power Level: 1.4kW (12A) • 4 miles added range/hr. of charging • Electricity Cost: $0.10/kWh • Installation Cost $0-$500
Fleet charging • 1 light-duty vehicle • Charging 14hrs/night • 5 days/week	• 5,096 kWh/yr • $510/yr	$0.000-$0.010/kWh $0-$50/yr	

Level 2, Single Port Scenarios	Annual Electricity Consumption & Cost	Installation Cost Amortized Over 10yrs/kWh & cost/yr.*	Assumptions
Workplace charging • 2 light-duty vehicles • Each charging 3hrs/ day • 5 days/week	• 10,296 kWh/yr • $1,030/yr	$0.006-$0.123/kWh $60-$1,270/yr	• EVSE Type: Level 2 240 VAC • EVSE Amperage: (30A) • Vehicle Power Acceptance Rate: 6.6kW • 20 miles added range/hr. of charging • Electricity Cost: $0.10/kWh • Installation Cost: $600-$12,700
Public charging • 1 light-duty vehicles • Each charging 5hrs/ day • 4 days/week	• 6,864 kWh/yr • $686/yr	$0.009-$0.185/kWh $60-$1,270/yr	
Fleet charging • 2 medium-duty vehicles • Each charging 5hrs/ night • 5 days/week	• 17,160 kWh/yr • $1,716/yr	$0.003-$0.074/kWh $60-$1,270/yr	

DCFC, Single Port Scenario	Annual Electricity Consumption & Cost	Installation Cost Amortized Over 10yrs/kWh & cost/yr.*	Assumptions
<u>Public charging</u> • 2 light-duty vehicles • Each charging 20 min/ day • 7 days/week	• 11,278 kWh/yr • $1,128/yr	$0.035-$0.452/kWh $400-$5,100/yr	• EVSE Type: DCFC 480 VDC • Power Level: 48kW (100A) • 50 miles added range/20 min of charging • Electricity Cost: $0.10/kWh • Installation Cost: $4,000-$51,000

**The installation cost amortized over 10yrs/kWh provides the cost per kWh that would need to be added to the electricity consumption rate in order to recoup the installation costs. This calculation assumes a 10 year lifespan for the EVSE and does not account for potential borrowing costs.*

SAFETY

- Electricity common source of energy essential to everyday life
- Electricity is used without much thought to electrical work hazards
- Electrical injury more likely to be fatal than other types of injury
  - *Estimated that one worker is electrocuted every day on the job*
- Qualified electrician is needed for installing, maintaining, and repairing different types of electrical systems

17 Steps for EVSE Installation Process

1. Overview
2. Identify Location
3. Communication
4. EVSE Site Area Analysis
5. EVSE Placement Area Analysis
6. EVSE Mounting Style
7. Desired Level of Charge
8. Electrical Load Analysis
9. EVSE Load Analysis

17 Steps for EVSE Installation Process

10. Rate Plan Decisions
11. Installation Cost Estimate
12. Permit
13. Electrical Service Upgrade
14. Electrical Panel Upgrade
15. Installation Process
16. Test the EV Charging Station
17. Charge the Electric Vehicle

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