National Alternative Fuels Training Consortium

Electric Vehicle Charging Infrastructure

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Presenter:
Bill Davis, Director
because clean air and energy independence matter...

ELECTRIC DRIVE VEHICLE INFRASTRUCTURE TRAINING

LEVEL 2 CHARGER

GAIN EXTENSIVE “HANDS-ON” EXPERIENCE FROM LABORATORIES AND SHOP ACTIVITIES

National Alternative Fuels Training Consortium

A Program of

West Virginia University
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
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 400 amps
- 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
Overview and comparison of the different levels of charge.

<table>
<thead>
<tr>
<th>Level</th>
<th>Voltage</th>
<th>Amperage</th>
<th>Type of Current</th>
<th>Estimated Charge Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>120V AC</td>
<td>16 to 20 amps</td>
<td>Common alternating current residential grounded receptacle from electrical source to vehicle’s onboard charger.</td>
<td>8-16 hours</td>
</tr>
<tr>
<td>Level 2</td>
<td>240V AC</td>
<td>30 to 80 amps</td>
<td>Dedicated circuit from electrical source to vehicle’s onboard charger.</td>
<td>3-8 hours</td>
</tr>
<tr>
<td>DC Fast Charging</td>
<td>Anything over 240V DC</td>
<td>100 amps +</td>
<td>Direct Current from off-board charger.</td>
<td>20 to 30 minutes</td>
</tr>
</tbody>
</table>
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
## Professional Service Roles and Responsibilities

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

<table>
<thead>
<tr>
<th>On Peak Charging / 14-26₵ kWh</th>
<th>Off Peak Charging / 4-11₵ kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Charging that occurs during the day</td>
<td>• Charging that occurs during the night</td>
</tr>
</tbody>
</table>
| • 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

<table>
<thead>
<tr>
<th>EVSE Type</th>
<th>EVSE Unit* Cost Range (single port)</th>
<th>Average Installation Cost (per unit)</th>
<th>Installation Cost Range (per unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>$300-$1,500</td>
<td>not available</td>
<td>$0-$3,000**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>[Source: Industry Interviews]</em></td>
</tr>
<tr>
<td>Level 2</td>
<td>$400-$6,500</td>
<td>-$3,000</td>
<td>$600-$12,700</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>EV Project (INL 2015b)</em></td>
<td><em>EV Project (INL 2015b)</em></td>
</tr>
<tr>
<td>DCFC</td>
<td>$10,000-$40,000</td>
<td>-$21,000</td>
<td>$4,000-$51,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>EV Project (INL 2015d)</em></td>
<td><em>EV Project (INL 2015d)</em> and (OUC 2014)*</td>
</tr>
</tbody>
</table>

### 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.

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**Costs Associated With Non-Residential Electric Vehicle Supply Equipment**

Factors to consider in the implementation of electric vehicle charging stations

November 2016

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.

<table>
<thead>
<tr>
<th>Level 1, Single Port Scenarios</th>
<th>Annual Electricity Consumption &amp; Cost</th>
<th>Installation Cost Amortized Over 10yrs/kWh &amp; cost/yr.*</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workplace charging</td>
<td>• 2.184 kWh/yr</td>
<td>$0.000-$0.023/kWh</td>
<td>• EVSE Type: Level 1 120 VAC</td>
</tr>
<tr>
<td></td>
<td>• $218/yr</td>
<td>$0-$50/yr</td>
<td>• Power Level: 1.4kW (12A)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 4 miles added range/hr. of charging</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Electricity Cost: $0.10/kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Installation Cost $0-$500</td>
</tr>
<tr>
<td>Fleet charging</td>
<td>• 5,096 kWh/yr</td>
<td>$0.000-$0.010/kWh</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• $510/yr</td>
<td>$0-$50/yr</td>
<td></td>
</tr>
</tbody>
</table>

A Program of West Virginia University
<table>
<thead>
<tr>
<th>Level 2, Single Port Scenarios</th>
<th>Annual Electricity Consumption &amp; Cost</th>
<th>Installation Cost Amortized Over 10yrs/kWh &amp; cost/yr.*</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Workplace charging</strong></td>
<td>• 2 light-duty vehicles</td>
<td>• 10,296 kWh/yr</td>
<td>• EVSE Type: Level 2 240 VAC</td>
</tr>
<tr>
<td></td>
<td>• Each charging 3hrs/day</td>
<td>• $1,030/yr</td>
<td>• EVSE Amperage: (30A)</td>
</tr>
<tr>
<td></td>
<td>• 5 days/week</td>
<td>• 1,030/yr</td>
<td>• Vehicle Power Acceptance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rate: 6.6kW</td>
</tr>
<tr>
<td><strong>Public charging</strong></td>
<td>• 1 light-duty vehicles</td>
<td>• 6,864 kWh/yr</td>
<td>• 20 miles added range/hr. of</td>
</tr>
<tr>
<td></td>
<td>• Each charging 5hrs/day</td>
<td>• $686/yr</td>
<td>charging</td>
</tr>
<tr>
<td></td>
<td>• 4 days/week</td>
<td></td>
<td>• Electricity Cost: $0.10/kWh</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>• Installation Cost: $600-</td>
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<td></td>
<td></td>
<td></td>
<td>$12,700</td>
</tr>
<tr>
<td><strong>Fleet charging</strong></td>
<td>• 2 medium-duty vehicles</td>
<td>• 17,160 kWh/yr</td>
<td>• EVSE Amperage: (30A)</td>
</tr>
<tr>
<td></td>
<td>• Each charging 5hrs/night</td>
<td>• $1,716/yr</td>
<td>• Vehicle Power Acceptance</td>
</tr>
<tr>
<td></td>
<td>• 5 days/week</td>
<td></td>
<td>Rate: 6.6kW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 20 miles added range/hr. of</td>
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<td></td>
<td>charging</td>
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<td></td>
<td></td>
<td></td>
<td>• Electricity Cost: $0.10/kWh</td>
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<td>• Installation Cost: $600-</td>
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<td></td>
<td></td>
<td>$12,700</td>
</tr>
<tr>
<td>DCFC, Single Port Scenario</td>
<td>Annual Electricity Consumption &amp; Cost</td>
<td>Installation Cost Amortized Over 10yrs/kWh &amp; cost/yr.*</td>
<td>Assumptions</td>
</tr>
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<td>---------------------------</td>
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<td>-------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>Public charging</strong></td>
<td>• 2 light-duty vehicles&lt;br&gt;• Each charging 20 min/day&lt;br&gt;• 7 days/week</td>
<td>• 11,278 kWh/yr&lt;br&gt;• $1,128/yr</td>
<td><strong>$0.035-$0.452/kWh&lt;br&gt;$400-$5,100/yr</strong></td>
</tr>
</tbody>
</table>

*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
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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