


NECA
NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION

Managing Electric Vehicle Supply Equipment (EVSE) Installations

NECA

Introduction to Electric Vehicle EVSE

- Electric vehicles create a need to build an infrastructure that will supply the added load of charging.

- Contractors are equipped to manage the installation and commissioning of EVSE.

- The goal of NECA is to assist in the safe, sound and successful growth of the electric vehicle market.




Electric Vehicle Progression

- 1910 – Baker Model V Electric Victoria
- 1970s – Citicar Electric Vehicle
- 1990 – GM Impact
- 1996 – EV1 General Motors
- 2010 – Nissan Leaf
- 2010 – Toyota Tesla
- 2011 – Chevy Volt General Motors
- 2011 – Others in development

NECA

Objectives of the Workshop

- Review the EVSE market opportunities for electrical contractors.
- Review the process of coordinating and facilitating the installation of electric vehicle supply equipment (EVSE)
- Review types of EVSE equipment and charging stations
- Review equipment listing requirements and installation requirements
- Review the permit process and coordination of the inspection process

Opportunity and Challenge

- Historic Opportunity/Revolutionary Change
- Automakers' Perspectives
- Manufacturers' Concerns
- Unique Position in EV Market
- Residential and Commercial Applications
- Evolving Business Models
- The Consumer Experience
- Training and Certifying Installers
- Contractor and Inspector Awareness & Education




Electrical Contractor Responsibilities

- Communication with dealer, coordinator, owner, inspector, supplier, others
- Understand the types of EVSE and which type is to be installed
- Perform and accurate efficient site assessment of existing power service
- Provide accurate and clear estimate of necessary upgrades (if applicable)
- Coordinate with the applicable utility company and authority having jurisdiction
- Business as usual for electrical contractors, but…
- Use expertise to ensure a positive customer experience.

NECA

Basic Steps in the Process

- Electrical contractor site assessment for EVSE installation
- Obtain electrical wiring permit(s) and coordination of the inspection and approval processes.
- Coordinate with local utility company for time-of-use (TOU) meters, off-peak metering, etc.)
- Facilitate the installation of the EVES and branch circuit wiring
- Inspection, startup, and commissioning completed EVSE installation




Terminology

- Continuous Load. A load where the maximum current is expected to continue for 3 hours or more. [*NEC* Article 100]

- Non-Continuous Load. A load where the maximum current is expected to continue for less than 3 hours. [*NEC* Article 100]

- Section 625.14 indicates that electric vehicle charging loads are considered continuous loads.




Terminology (cont.)

- Electric Vehicle (EV) Connector. A device that, by insertion into an electric vehicle (EV) inlet, establishes an electrical connection to the EV for the purpose of energy transfer and information exchange. This device is part of the EV coupler. [*NEC* 625.2]

Courtesy of General Motors

Terminology (cont.)

- Electric Vehicle (EV) Cord. The off-board cable containing the conductors to connect the electric vehicle (EV) plug with the EV power controller to transfer energy between the electric vehicle supply equipment (EVSE) and the EV, and to provide for communications during energy transfer. [NECA 413]

Terminology (cont.)

- Electric Vehicle (EV) Inlet. The device on the electric vehicle (EV) into which the EV connector is inserted for energy transfer and information exchange. This device is part of the EV coupler. [*NEC* 625.2]

I-Stock Photo Courtesy of NECA




J1772 Architecture

- Power: 2 pins (AC Line 1 & AC Line 2/neutral)
- Ground: First to engage, last to disengage and break (for safety)
- Proximity Detection: Prevents the car from moving while charging (for safety)
- Control Pilot: Last to engage, first to disengage and break. Communicates charge rate available to determine amount of current (amperes) allowed for the vehicle being charged.

Courtesy of General Motors

J1772 Architecture

Courtesy of General Motors




SAE Charging Configurations

- AC L1: 120V AC single phase
  - Configuration current 12, 16 amp
  - Configuration power 1.44, 1.92kw
- AC L2: 240V AC single phase
  - Rated Current ≤ 80 amp
  - Rated Power ≤ 19.2kw
- AC L3:TBD
  - AC single or 3ϕ ?

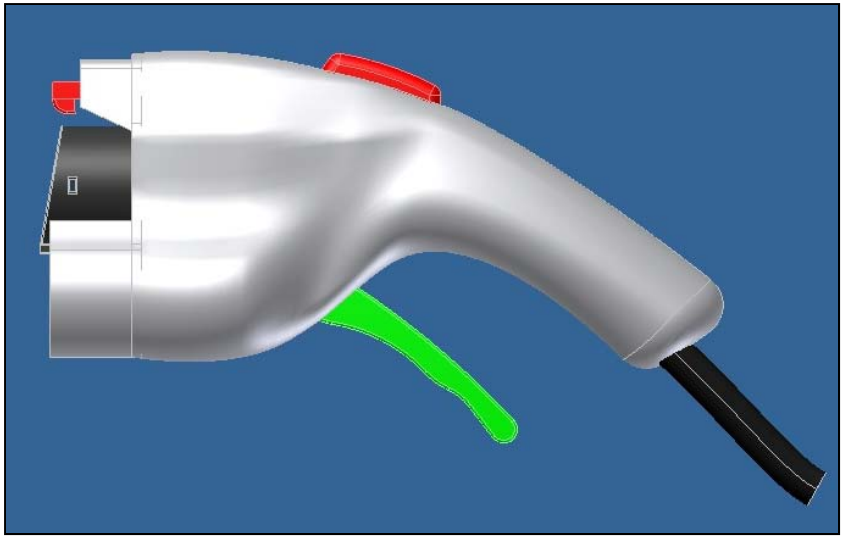
SAE Charging Configurations

- DC L1: 200 – 450V DC
  - Rated Current ≤ 80 amp
  - Rated Power ≤ 36kw
- DC L2: 200 – 450V DC
  - Rated Current ≤ 200 amp
  - Rated Power ≤ 90kw
- DC L3: TBD
  - 200 – 600V DC ?
  - Rated Current ≤ 400 amp?
  - Rated Power ≤ 240kw?

Supply Equipment Connectors

AC L1 & L2
DC L1

Courtesy of General Motors



DC L2

Terminology (cont.)

- Electric Vehicle Supply Equipment (EVSE). The conductors, including the ungrounded, grounded, and equipment grounding conductors and the electric vehicle (EV) connectors, attachment plugs, and all other fittings, devices, power outlets, or apparatus installed specifically for the purpose of transferring energy between the premises wiring and the EV. [*NEC* 625.2]

Courtesy of Leviton

Electric Vehicle Supply Equipment (EVSE)

Courtesy of Schneider Electric




Terminology (cont.)

- Off-Board Charger. A charger with control and monitoring capabilities built into the electric vehicle supply equipment (EVSE), not on the electric vehicle (EV). [NECA 413] Typically Level 3 Fast Charging

- On-Board Charger. A charger with control and monitoring capabilities built into the electric vehicle (EV), not in the electric vehicle supply equipment (EVSE). [NECA 413] Typically Levels 1 and 2

Terminology (cont.)

- Personnel Protection System. A system of personnel protection devices and constructional features that, when used together, provides protection against electric shock of personnel. [*NEC* 625.2]

- Rechargeable Energy Storage System. Any power source that has the capability to be charged and discharged. [*NEC* 625.2]




Electrical Vehicle Supply Equipment

- There are currently three levels of EVSE, AC Levels 1, 2 and DC fast charging based on the operating voltage and the peak power drawn during energy transfer.
  - AC Level 1 operating on single-phase 120 V
  - AC Level 2 operating on single-phase 208 V or 240 V
  - DC Fast Charging (DC Level 2) operating on three-phase 208 V, 480 V or 600 V.




Typical Charging Times

- AC Level 1 charging typically takes between 12 and 16 hours to complete
- AC Level 2 charging typically takes between 4 and 6 hours to complete.
- Fast Charging (DC Level 2) charging typically takes less than one hour to complete (i.e. 20% –> 80 % charge).
- Higher power capacity is required for faster charging processes.

NECA

EVSE Levels

- Level 1 and 2 electric vehicle supply equipment relate to supply equipment connected to onboard chargers.
- Level 3 relates to charging equipment (off-board) also known as *Fast Charging* or *Quick Charging.*
- Level 1 is portable and connected to the wiring system by cord and plug connection.
- Pedestal (free-standing) EVSE units are also available (typically for commercial applications).

Courtesy of Leviton

EV Supply Equipment Wiring

- AC Level 1 cord-and-plug connected (portable)
- AC Level 2 can be cord and plug connection or directly wired to individual branch circuit.
- Fast Charging (DC Level 2) wired to individual branch circuit

Courtesy of General Motors

NECA

Typical Current for Level 1 and 2

- Maximum electrical current for level 1 and level 2 electric vehicle supply equipment (EVSE).
  - AC Level 1 – 120 V Single-phase, 16 A
  - AC Level 2 – 240 V Single-phase, 80 A
  - Products and standards development:
  - DC Fast Charging – 240, 480, 600V, 3-phase 30 to 50 Kw



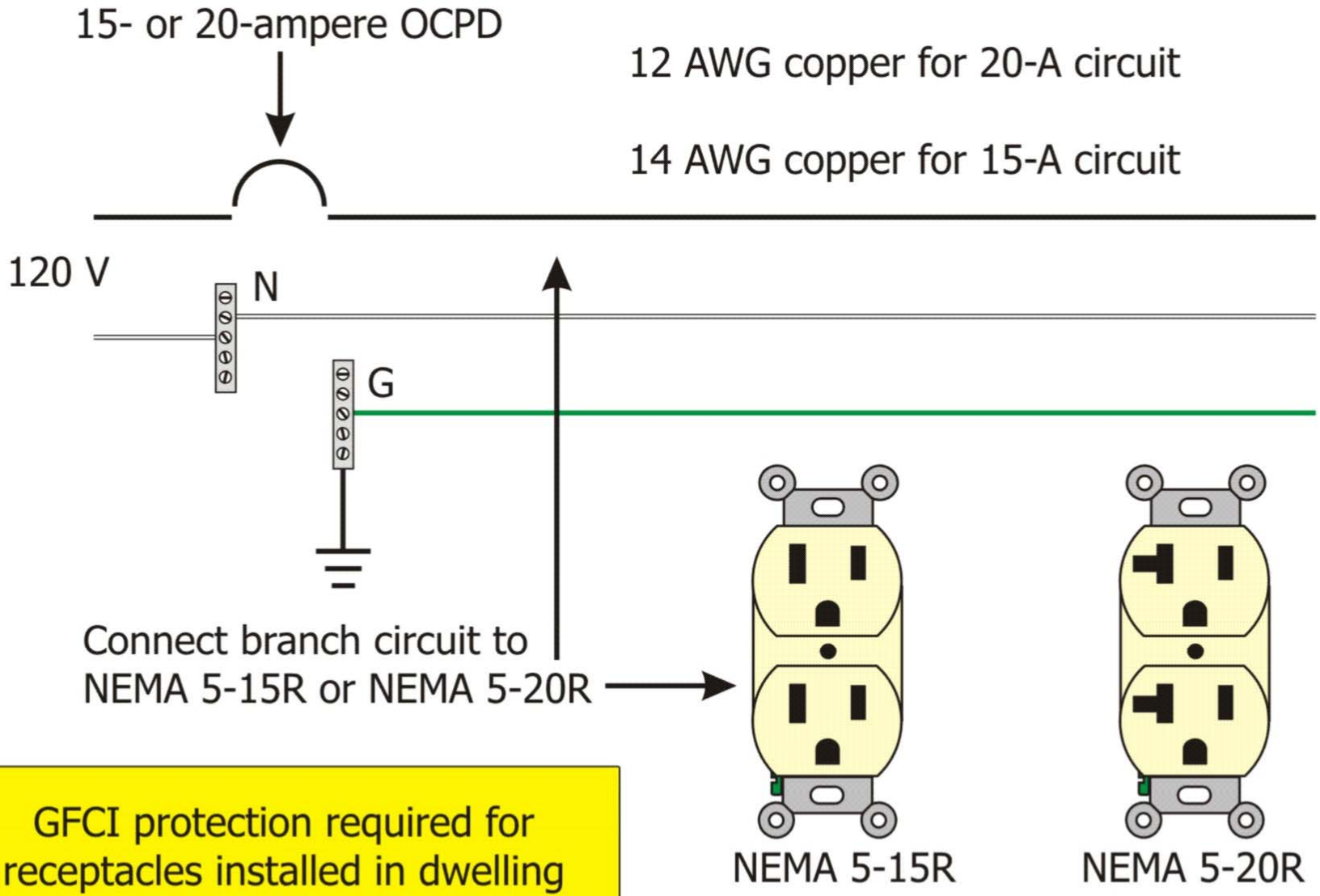

AC Level 1 EVSE Wiring

- Electric vehicle (EV) charging that employs cord-and-plug connected portable electric vehicle supply equipment (EVSE) that is transported with the EV and is used specifically for EV.
- AC Level 1 EVSE is rated single-phase, nominal 120 VAC, 16 A maximum, and is suitable for connection to NEMA 5-15R or 5-20R receptacles.
- NECA recommends an individual branch circuit for all EVSE, including AC level 1.

Conductor sized by NEC 310.15(B)16

12 AWG copper for 20-A circuit

14 AWG copper for 15-A circuit



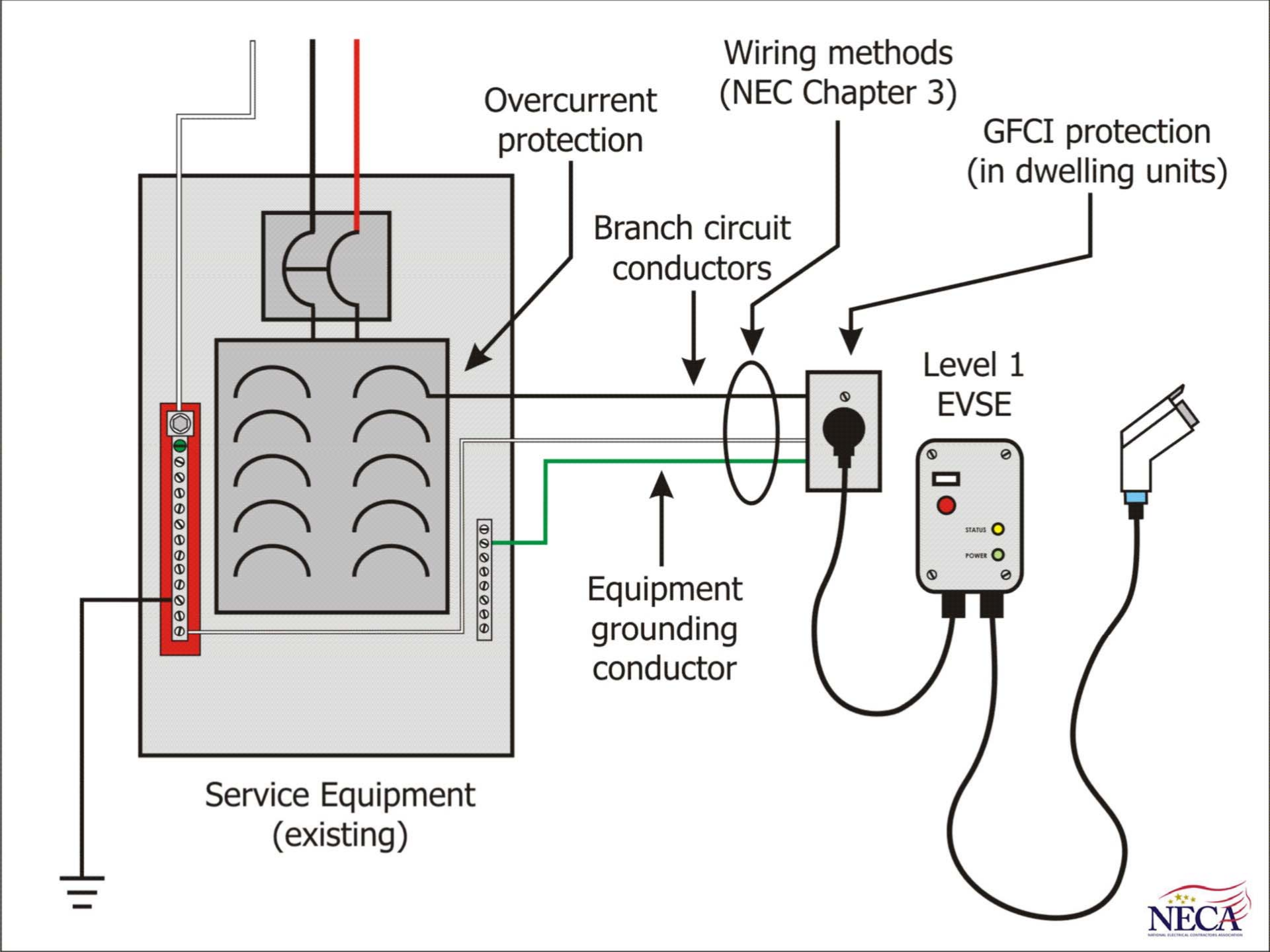
GFCI protection required for receptacles installed in dwelling garages or outdoor locations




Cord-and-Plug Connections

- Electric vehicle supply equipment rated at 125 volts, single phase, 15- or 20-amperes or part of a system identified and listed as suitable for the purpose and meeting the requirements of *NEC* 625.18, 625.19, and 625.29 shall be permitted to be cord-and-plug-connected.

- AC Level 1 and AC level 2 equipment is permitted to be cord-and-plug connected provided it meets the requirements in 625.18 and 625.19 and is listed and identified for such use.


Overcurrent protection
Wiring methods (NEC Chapter 3)
GFCI protection (in dwelling units)
Branch circuit conductors
Level 1 EVSE
STATUS
POWER
Equipment grounding conductor
Service Equipment (existing)
NECA

Courtesy of Pass and Seymour Legrand

Courtesy of Leviton

AC Level 2 Charging is Desired

- AC Level 2 power is approximately 3300 watts at 240-volts and the charge time should be about 42% of the 120-volt charge time.
- AC Level 2 EVSE requires higher voltage and ampacity to operate.
- Capacity of the existing power system must be verified through an accurate site assessment.

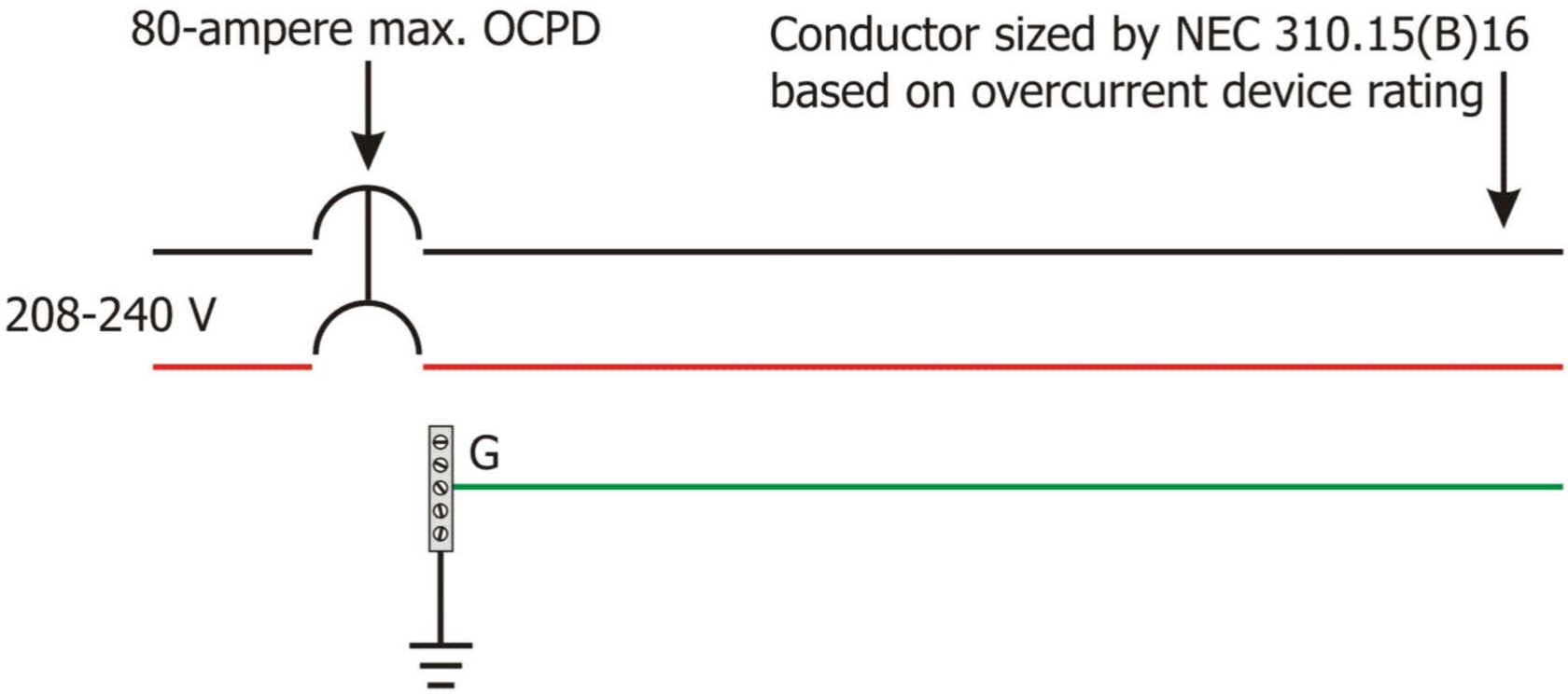



AC Level 2 EVSE Wiring

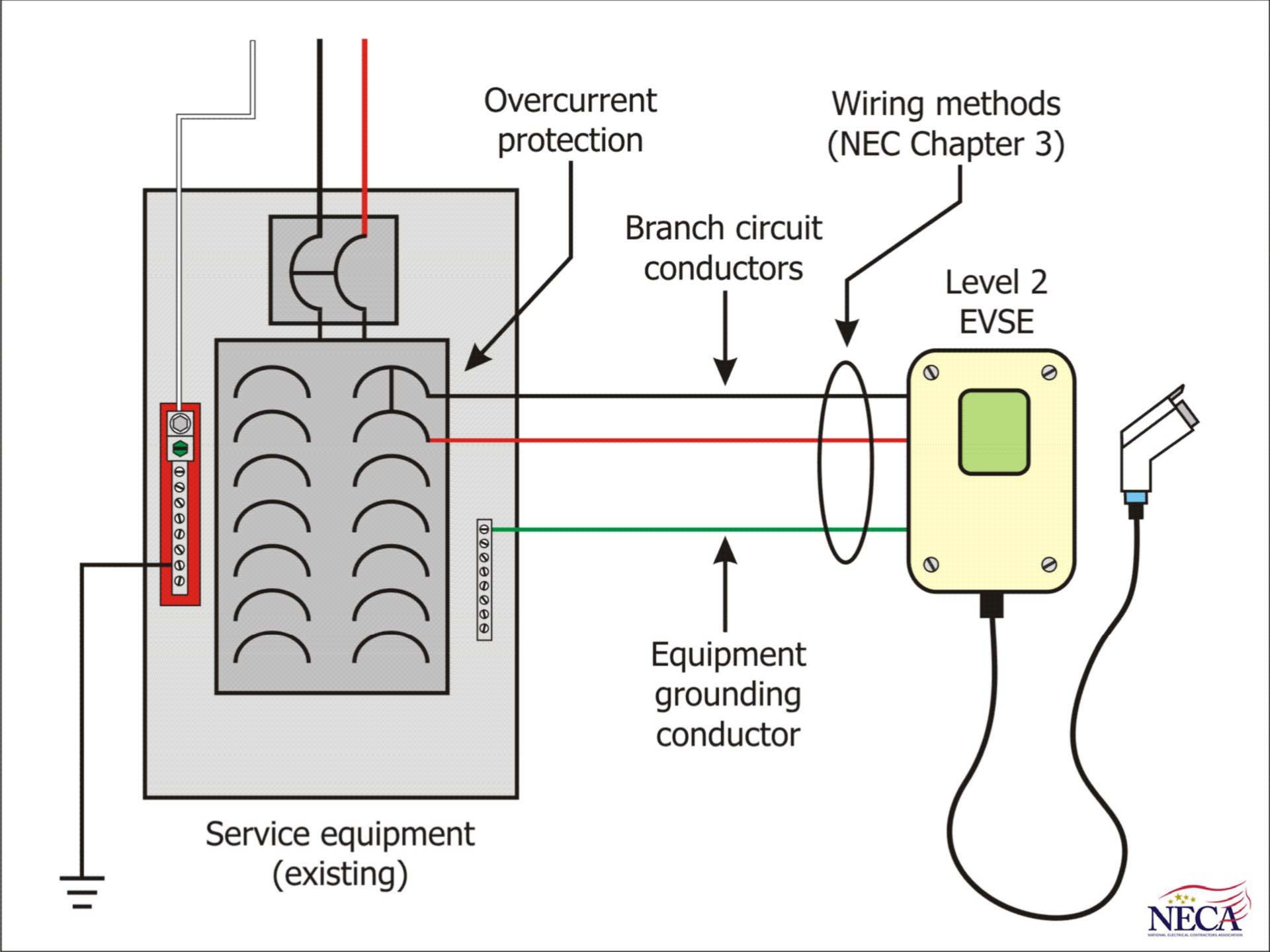
- Electric vehicle (EV) charging that employs EVSE that is typically operated at a fixed location and is used specifically for EV charging.
- AC Level 2 EVSE is rated single-phase, nominal 208 VAC or 240 VAC, 80 A maximum, with appropriate branch circuit overcurrent protection.
- AC Level 2 EVSE is typically wired directly to an individual branch circuit or cord- and plug-connected as specified in 625.13.

NECA

Level 2 Branch Circuit Requirements



Note: NEC provides general requirements for overcurrent protection. The equipment nameplate may specify maximum overcurrent device ratings and minimum conductor size.


Overcurrent protection
Wiring methods (NEC Chapter 3)
Branch circuit conductors
Level 2 EVSE
Equipment grounding conductor
Service equipment (existing)
NECA

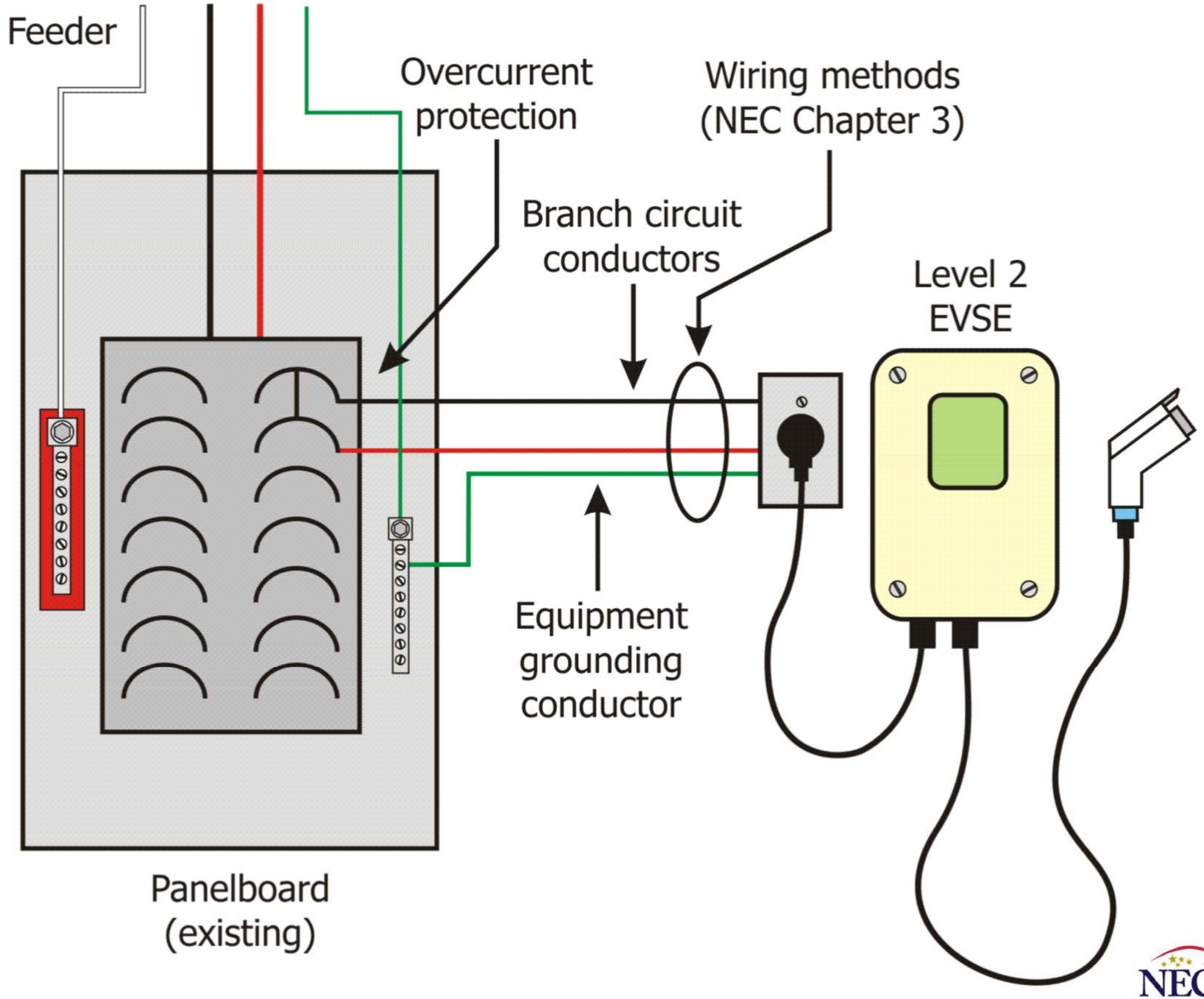
Courtesy of Leviton

Courtesy of Eaton Corporation

Courtesy of Pass and Seymour Legrand

NECA

Courtesy of Leviton


Feeder
Overcurrent protection
Wiring methods (NEC Chapter 3)
Branch circuit conductors
Level 2 EVSE
Equipment grounding conductor
Panelboard (existing)

Courtesy of Leviton




DC Fast Charging

- Electric vehicle (EV) charging that employs permanently wired electric vehicle supply equipment (EVSE) that is operated at a fixed location and is used specifically for EV charging.
- DC Fast Charging EVSE is rated 400 A maximum, and 600 VAC maximum, with branch circuit overcurrent protection as required.
- Products and standards are in development.

Courtesy of Eaton Corporation

Site Assessment

- Determine type of occupancy
- Contractor site evaluation for installation of EVSE and required individual branch circuit
- Coordinate and determine the EVSE installation location with customer
- Determine branch circuit requirements (based on L-1, L-2, L-3)

Branch Circuit Limitations

- The *NEC* limits branch circuit current to 80% of the overcurrent device rating. [*NEC* 210.19(A)(1)]

- Level 1 charging from a NEMA 5-15 conventional outlet is limited to 12 amps, the current of a 1440 watt unit supplied by 120 volts.

- This current level can result in tripped breakers in a typical residence as multiple outlets are installed on general purpose branch circuits.

Branch Circuit Sizing

- Branch-circuit conductors shall have an ampacity not less than the maximum load to be served.

- Where a branch circuit supplies continuous loads or any combination of continuous and non-continuous loads, the conductor size must have an allowable ampacity not less than the non-continuous load plus 125 percent of the continuous load. [*NEC* 210.19(A)(1)]

  - 15 ampere breaker limited to 12 amperes
  - 20 ampere breaker limited to 16 amperes

Branch Circuit Requirements

- In addition to level 1, level 2 and 3 typically require new individual branch circuits.
- The EVSE load is continuous (maximum load is for 3 hours or more).
- Determine minimum wires size and rating of overcurrent device for branch circuit (based on manufacturer nameplate rating and requirements).

- Note: NECA recommends installing an individual branch circuit (20-ampere) for all level 1 applications (draws between 10 and 16 amperes).

Establishing EVSE Location

- Determine the type occupancy where the EVSE will be installed.
- Determine the overnight parking location for the vehicle.
- Locate the EVSE outlet (minimum 18 in. and maximum 48 in. above finished floor)
- Verify from manufacturer what type of connection is required (receptacle or hard-wired)
- Determine circuit routing and wiring methods necessary for the circuit (fished or surface installation).

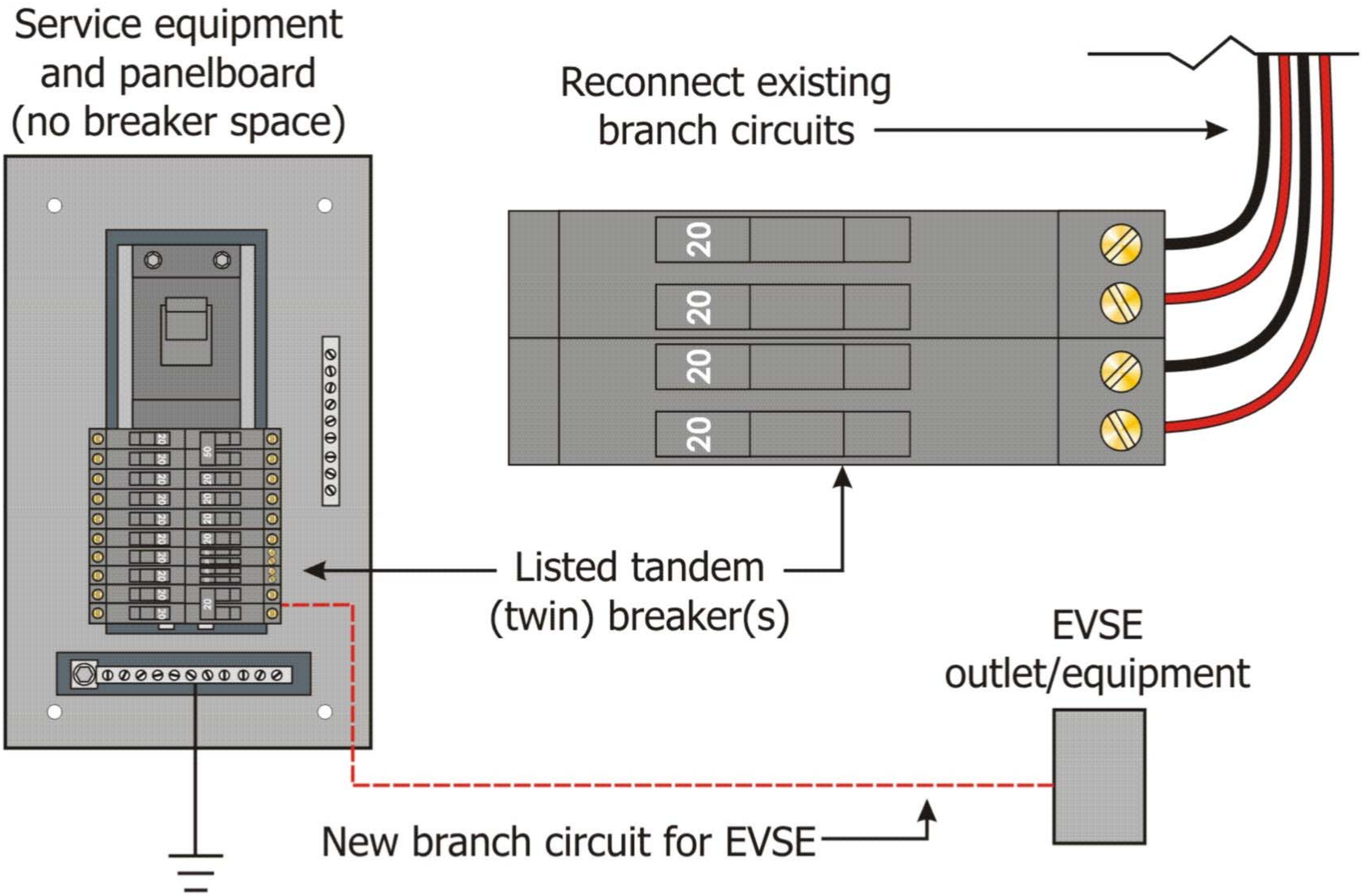
Power Source Capacity

- Which level EVSE is being installed?
- Verify existing service or source capacity.
- Will space for a 1-pole device or 2-pole device be needed?
- Is there breaker space available in the existing equipment?
  - Use of listed tandem/half-size breakers to create space
  - Installation of subpanel to create space



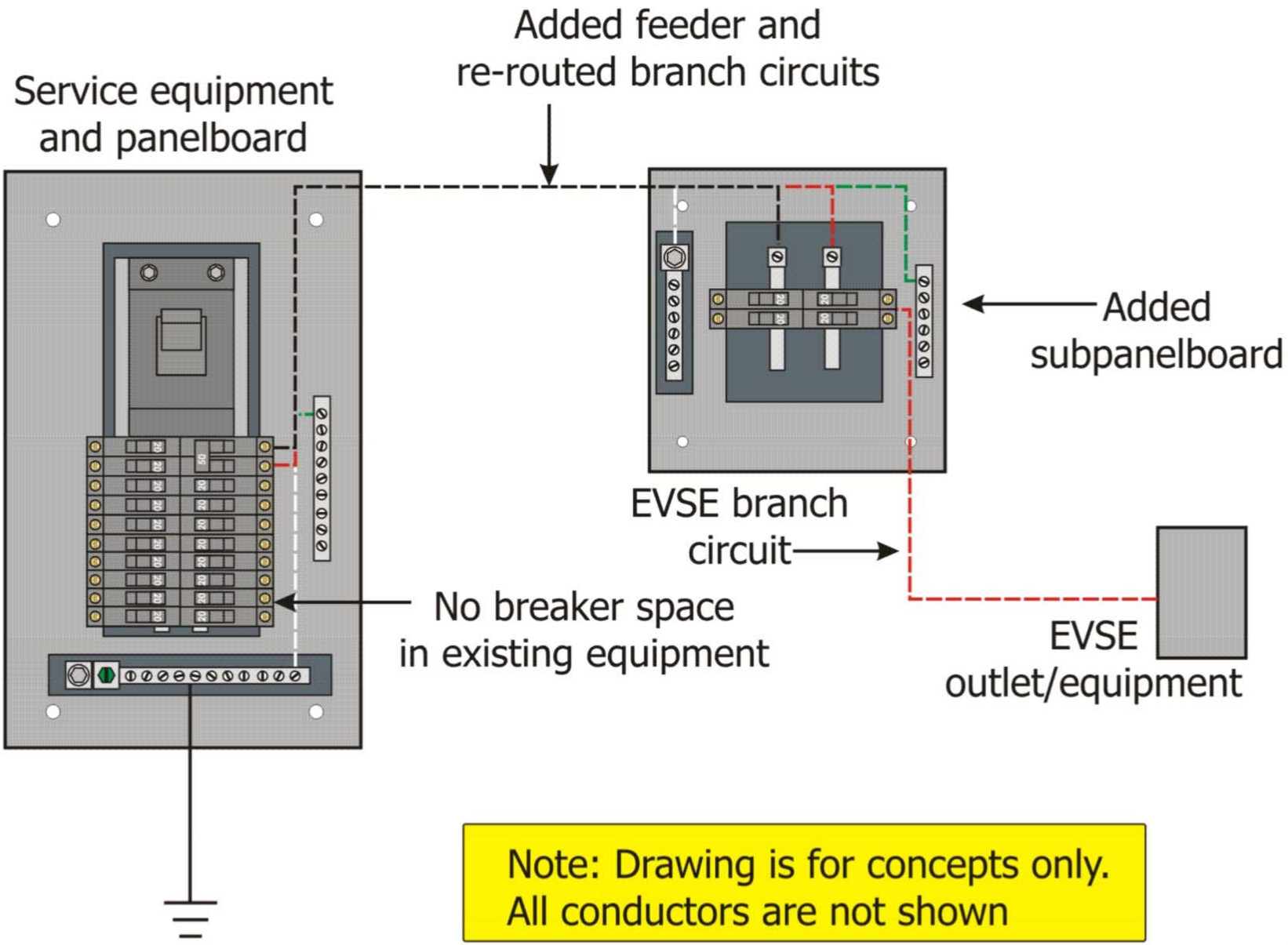

Adding Circuits to Existing Equipment

- Ensure that installers follow all applicable safety-related work practices and contractor safety policies
- Requires use of listed breakers in equipment with space, or listed tandem breakers or half-size breakers to create space in a full panelboard.
- Do not exceed the maximum number of half-size or tandem breakers in the equipment as specified by the manufacturer.
- A subpanel may be necessary in some cases to create space for the additional branch circuit.



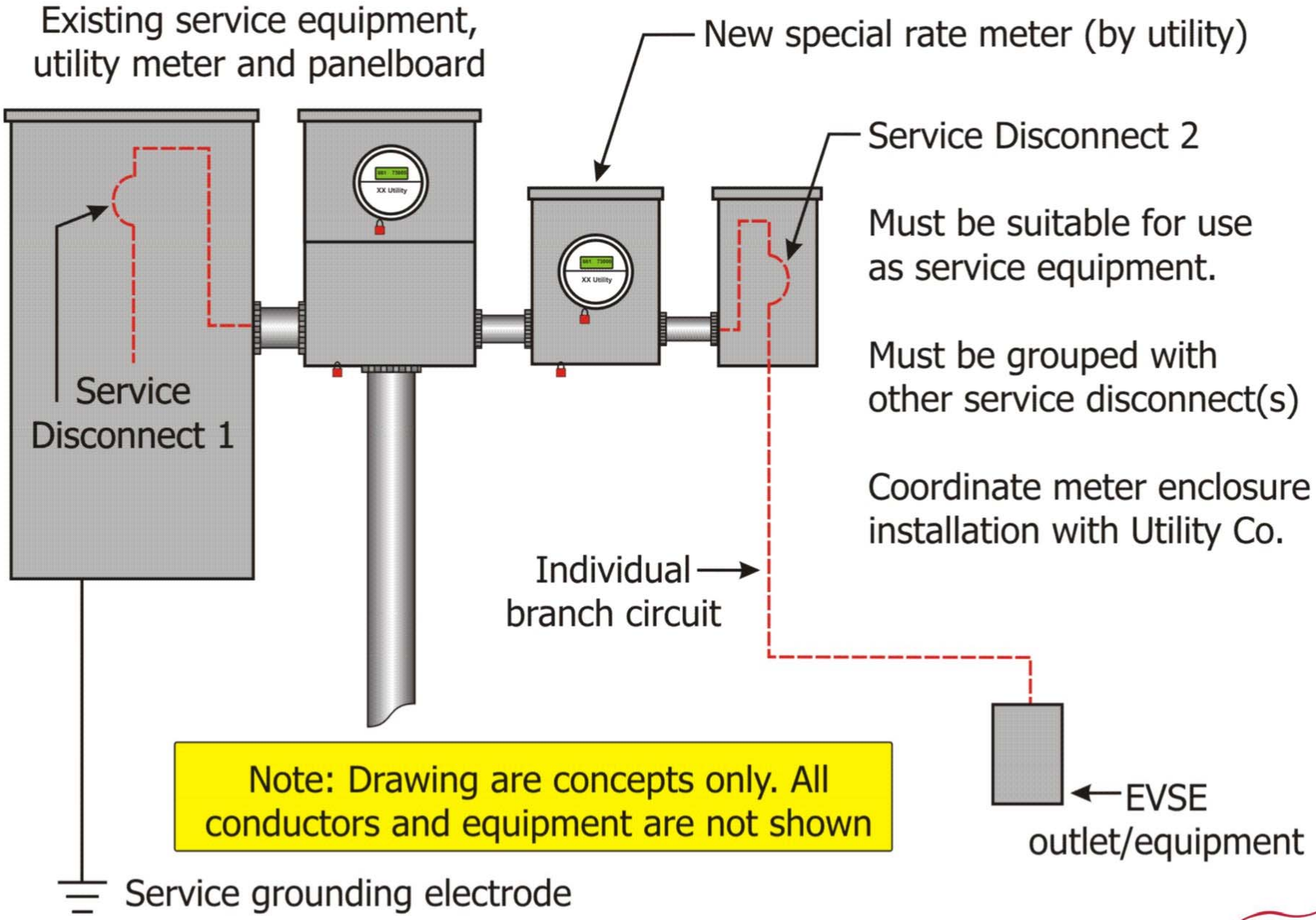
Important: Do not exceed the maximum permitted tandem breakers within listed equipment. Comply with manufacturer's installation instructions in accordance with NEC 110.3(B).

NECA


Added feeder and
re-routed branch circuits
Service equipment
and panelboard
Added
subpanelboard
EVSE branch
circuit
No breaker space
in existing equipment
EVSE
outlet/equipment
Note: Drawing is for concepts only.
All conductors are not shown

Utility Metering (off-peak)

- Some utilities offer an off-peak or time-of-use (TOU) metering option(s).
- This may require installing additional meter socket enclosures and associated wiring.
- Each utility company has specific regulations regarding meter installation.
- The electrical contractor coordinates special meter installations with serving utility.


Existing service equipment, utility meter and panelboard
New special rate meter (by utility)
Service Disconnect 2
Must be suitable for use as service equipment.
Must be grouped with other service disconnect(s)
Coordinate meter enclosure installation with Utility Co.
Service Disconnect 1
Individual branch circuit
Note: Drawing are concepts only. All conductors and equipment are not shown
EVSE outlet/equipment
Service grounding electrode

Installation Instructions

- Ensure conformance to all specific EVSE installation instructions. [*NEC* 110.3(B)]
- Section 625.5 requires all materials devices, fittings, and other equipment for EVSE to be listed.
- EVSE nameplates must be used to determine the load being added to the service or system.
- Location of EVSE will determine any specific installation mounting requirements other than ordinary.

Codes and Standards

- *NEC* rules (Chapters 1 through 4, Article 625, 230, others)
- Applicable IBC (Building Codes)
- Equipment Product Listing and Certification
- NECA 1, NECA 413 National Electrical Installation Standards
- Requirements in EVSE product standards
  - ADA requirements (other than dwellings)
  - OSHA Regulations
  - NFPA 70E- Standard for Electrical Safety in the Workplace

2011 National Electrical Code®

- Chapters 1 through 4, Article 625, 220, 230, and others
  - Article 110 – Requirements for Electrical Installations
  - Article 210 – Branch Circuits
  - Article 220 – Branch-Circuit, Feeder and Service Calculations
  - Article 230 – Services
  - Article 240 – Overcurrent Protection
  - Article 250 – Grounding and Bonding

2011 National Electrical Code®

- Chapter 3 Wiring Methods and Materials
  - Article 300 – Wiring Methods
  - Article 310 – Conductors for General Wiring
  - Applicable Chapter 3 Wiring Methods




2011 National Electrical Code®

- Article 625 – Electric Vehicle Charging Systems
  - Part I General
  - Part II Wiring Methods
  - Equipment Construction
  - Control and Protection
  - Electric Vehicle Supply Equipment Locations




2014 National Electrical Code®

- CMP-12 Task Group formed to address gaps and revisions to Article 625.

- Specific areas of concern:
  - Current organization of Article 625
  - Clarify branch circuit requirements
  - Clarify cord and plug connections for Level 2 EVSE
  - Load management alternatives in the NEC
  - Tentative Interim Amendments 1037 and 1038




NECA Installation Standard

- NECA 413 is the *Standard for Installing and Maintaining Electric Vehicle Supply Equipment (EVSE)*
- Currently in the ANSI-approval process.
- Describes procedures for installing and maintaining Level 1, Level 2, and DC Fast Charge electric vehicle supply equipment (EVSE).
- Addresses performing site assessment, installation management services, quality and performance issues, above the minimum safety rules.




Arrangement of NECA 413

- Standard for Installing and Maintaining Electric Vehicle Supply Equipment (EVSE)
  - Scope
  - Definitions
  - Overview
  - Product Regulation, Codes and Standards
  - Safety programs, safe workers
  - Pre-Installation Considerations
  - Installation
  - Maintenance and Commissioning




Role of the Inspector

- Issuing of construction/installation permits
- Enforcement of the *NEC* and other applicable standards
- Verify compliance with the *NEC* and other codes adopted within their jurisdiction
- Review of plans and specifications for code compliance
- Conduct field inspections
- Issuing of non-compliance reports/inspectors notices
- Notifying utility for connection or meter clearances
- Issue approvals upon completion of project

NECA

The Electrical Permit Process

- Determine and contact the applicable Authority Having Jurisdiction (AHJ)
- Determine the applicable *NEC* edition and other codes adopted and enforced by the AHJ
- Verify if there are specific local amendments to the *NEC* rules.
- Verify the specific inspection procedures/processes
- Verify utility company requirements (separately metered or off-peak metering and any applicable permits or applications)

Electrical Inspection Process - Approvals

- Once the wiring is installed, coordinate and schedule rough and final inspections simultaneously (if possible).
- Expediting inspection process (meeting with inspector on site)
- NECA recommends setting up an onsite inspection meeting to assist the inspector and address any issues or concerns they may have.
- Address any deficiencies that are identified by the inspector.
- Recordkeeping process and approval

Additional Resources

- National Codes and Standards
- American National Standards Institute (ANSI)
- National Fire Protection Association (NFPA)
- Underwriters Laboratories, Inc. (UL)
- International Association of Electrical Inspectors (IAEI)
- International Code Council (ICC)

- NECA-NEIS Standards
- NECA and NFPA Webinars
- Electric Vehicle Infrastructure Training Program (EVITP) Installer Training Course/Certification

EVITP

- Training program for installers
- Crowd-sourced development led by NECA and IBEW
- EVITP Partner Advisory Board
- Over 100 Master Trainers
- Available through JATCs and community colleges
- Gaining industry recognition




Summary

- EVSE market presents opportunities for electrical contractors.
- Business models in EVSE are evolving dynamically, be prepared for change.
- The goal of NECA is to assist in the safe, sound and successful growth of the electric vehicle market.
- NECA member involvement is encouraged in residential and commercial installations.
- National involvement continues.




NECA
NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION

Managing Electric Vehicle Supply Equipment (EVSE) Installations

NECA