# Electric Vehicle Infrastructure

Senator Heinrich's Renewable Energy Summit
Albuquerque, NM Convention Center
August 5th, 2019


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# Implementation Plan for EV Infrastructure

## Vehicles

Choose vehicles and technology.

LSEV
PHEV
BEV

## EVSE

Choose EVSE type and quantity.

SAE Level 1
SAE Level 2
CHAdeMO

## Analysis

Determine necessary upgrades.

Service Panel
Circuit Breakers

## Utility

Contact utility rep regarding new load.

Grid impacts
Service voltage
Transformer

## Construction

Install new infrastructure.

Breakers
Conduit/conductors
EVSE

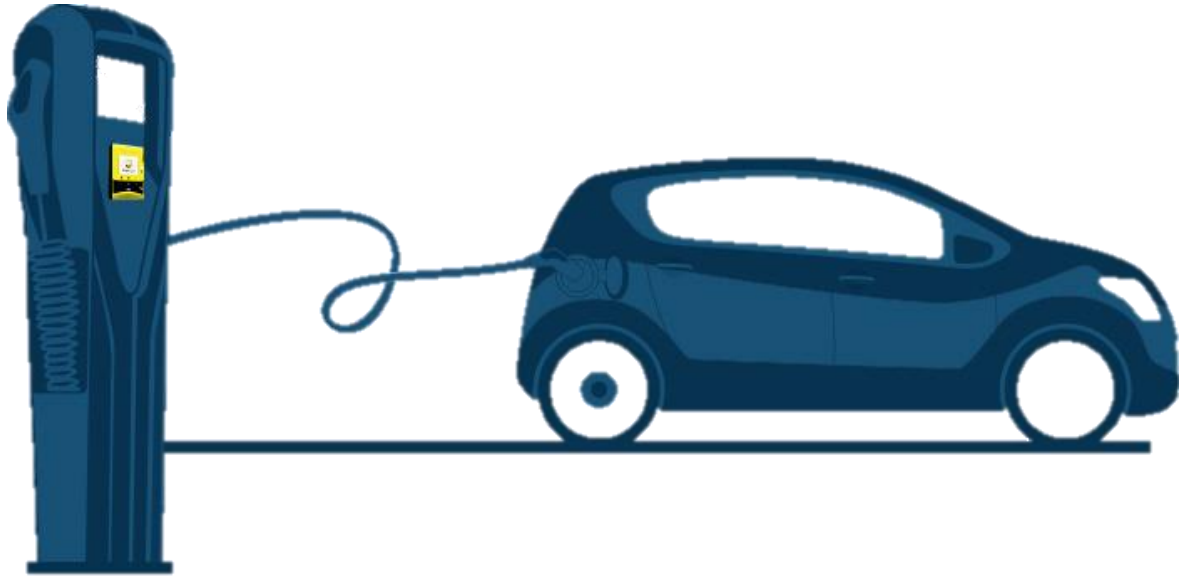
# Electric Vehicle Supply Equipment

Electric Vehicle Supply Equipment (EVSE) standards and performance metrics

- How do I select the best charger for my application?
  - Level 1, Level 2, DCFC
  - Compare recharge times

# Vehicles and EVSE

- Industry Standards
  - **SAE**
    - J1772
      - AC Level 1 and Level 2
      - DC Level 1 and Level 2
    - J2954
      - Wireless Charging
    - J3068
      - Three Phase Charging
    - J3105
      - Mechanized Coupler Charging
  - **CHAdeMO**
    - IEEE 2030.1.1
      - DCFC



# Vehicles and EVSE

## SAE J1772 and CHAdeMO

**SAE Provides various designs for both home and public charging**

**DCFC and CHAdeMO primarily for commercial use and long distance travel**

| Charging Level | Input Voltage (V) | Output Voltage (V) | Max Current (A) | Max Power (kW) |
|---|---|---|---|---|
| AC 1 | 120 | 120 | 16 | 1.9 |
| AC 2 | 208-240 | 208-240 | 80 | 19.2 |
| DC 1 | 208-600* | 50-1,000 | 80 | 80 |
| DC 2 | 208-600* | 50-1,000 | 400 | 400 |
| CHAdeMO | 120-600 | 50-500 | 400 | 200 |

*AC or DC input voltage

# EVSE Options


Level 2 Wall Mount, DCFC Pedestal, and Overhead Pantograph

# Electric Vehicle Supply Equipment

## Charging Comparison

- Chevrolet Volt
  - 18.4 kWh/8.9 gal
  - 53/420 mi
- Chevrolet Bolt
  - 60 kWh
  - 238 mi

| EVSE Type | Charging Power (kW) | Chevrolet Volt (PHEV) | | Chevrolet Bolt (BEV) | |
|---|---|---|---|---|---|
| | | Rate (mi/hr) | Recharge Time (hrs) | Rate (mi/hr) | Recharge Time (hrs) |
| **Level 1** | 1.8 | 5.2 | 10.2 | 7.1 | 33.3 |
| **Level 2** | 7.2* | 10.4 | 5.1 | 28.7 | 8.3 |
| **DCFC** | 50** | N/A | N/A | 198.3 | 1.2 |

* Volt: max 3.6 kW AC charging, Bolt: max 7.2 kW AC charging
**Volt: no DCFC, Bolt: max 50 kW DCFC (SAE only)

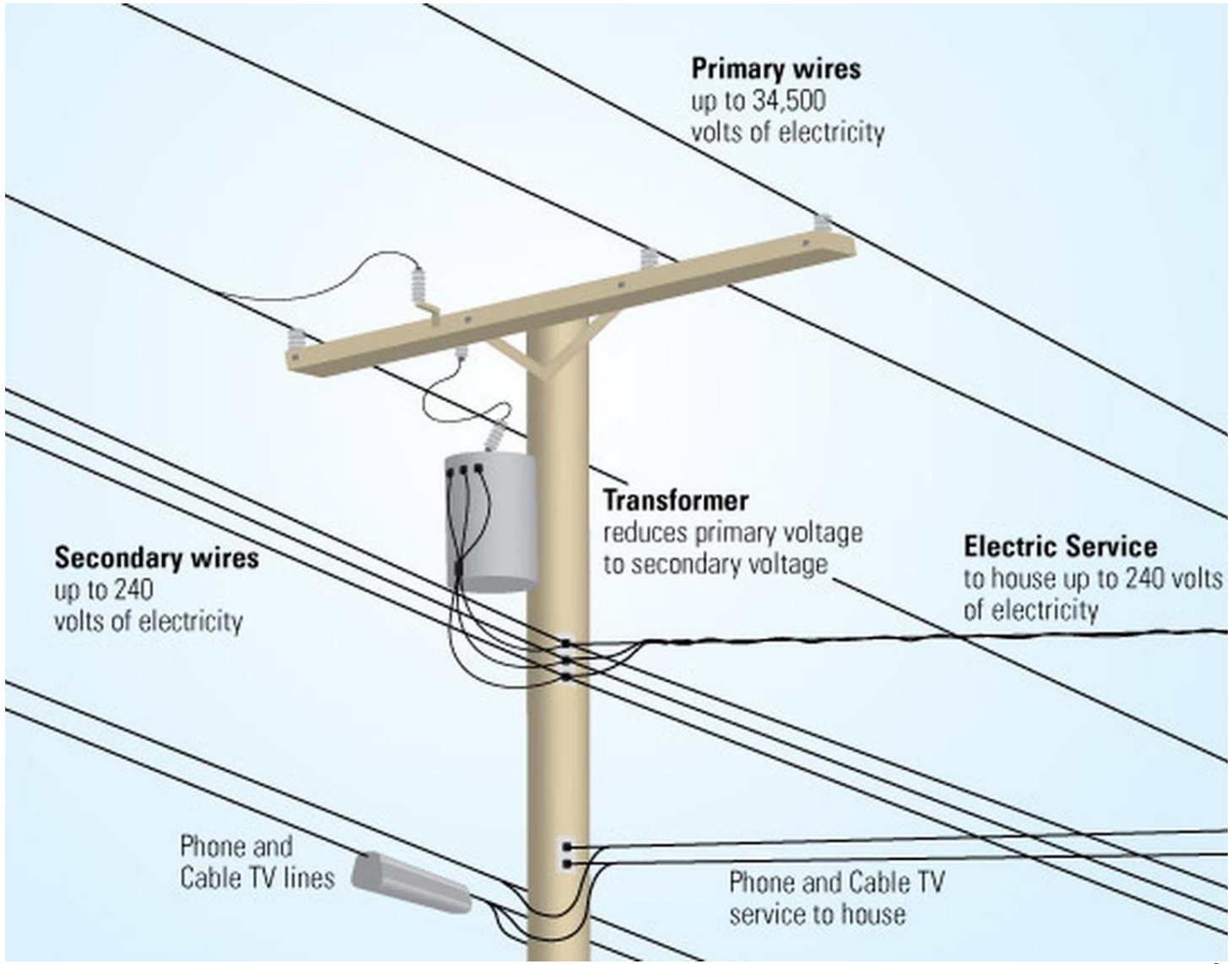
# Electric Service Equipment

Equipment and considerations necessary to power to EVSE

- What equipment/upgrades will I need?
  - Electric service impacts
    - Service panel, circuit breakers, conduit raceway, wiring

# Electric Service Equipment

- **Primary Lines:**
  - Conductor lines carrying energy throughout the distribution circuit at medium voltage
- **Transformer:**
  - Reduces primary line medium voltage down to low voltage service level
- **Secondary Bank:**
  - Conductor lines carrying electricity at low voltages to multiple service points
- **Service Lines:**
  - Conductor lines providing electric service to individual locations

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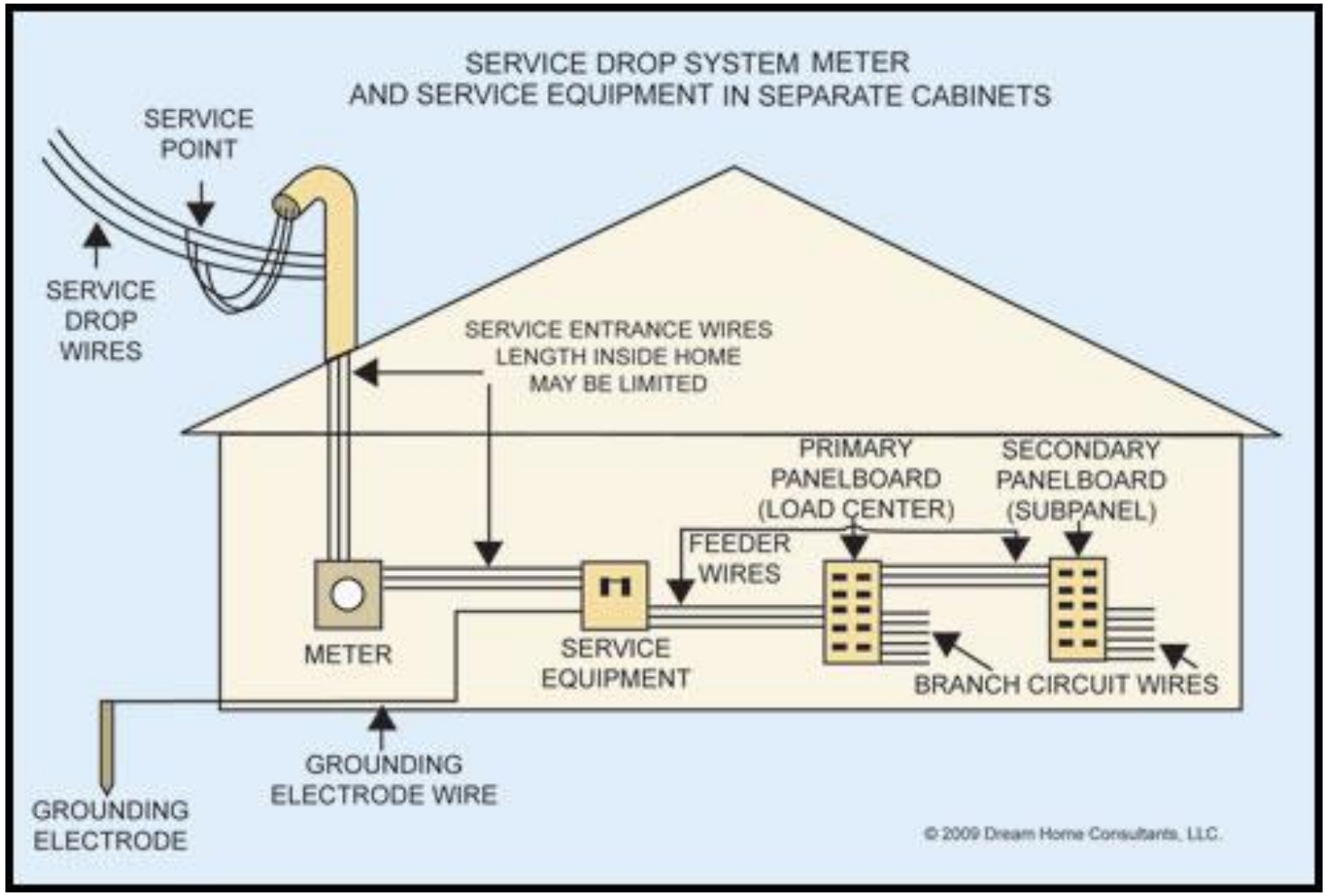
# Electric Service Equipment

- Meter:
  - Measures energy flow in kWh
- Primary Panel:
  - Electric panel with circuit breakers protecting branch circuits and sub-panels
- Secondary Panel:
  - Second electric panel fed from primary panel
- Branch Circuit:
  - Individual circuits feeding various loads with overcurrent protection through a single circuit breaker




# Design and Construction

## Design Considerations and Construction Costs

- What should I be planning for?
  - EVSE Requirements, Possible trenching, Service upgrades
- How much will it cost to build?
  - EVSE Cost/Unit, Installation Cost/Port

# Design and Construction

- **EVES Requirements**
  - Level 1 (15 Amps)
    - Single 20 A Breaker
      - 1.8 kW (120 V)
  - Level 2 (32 Amps)
    - Double pole 40 A breaker
      - 7.7 kW (240 V)
      - 6.7 kW (208 V)

- **Site Equipment**
  - Transformer Capacity
    - Distribution transformer must be large enough to supply peak load demand
  - Main Breaker
    - Must be sized large enough to supply the peak coincident demand from all branch circuits
  - Panel Capacity
    - Spare breaker positions must be available
  - Circuit Breaker
    - NEC 625.41: overcurrent protection shall be rated for 125% of the maximum EVSE load

# Design and Construction

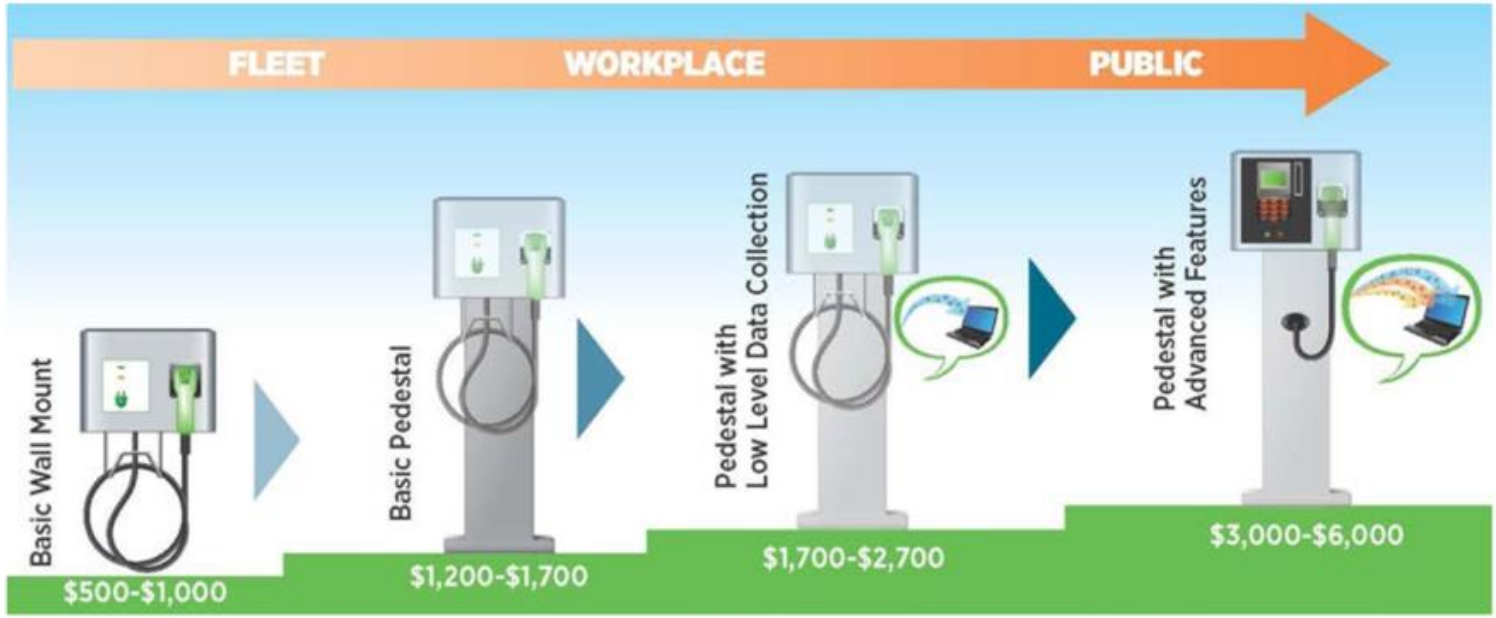
## EVSE Cost/Unit

- $400 - $6,500
  - Wall Mount/Pedestal
  - Data Collection/Transactions
  - Managed Charging

## Installation Cost/Port

- $600 - $12,700
  - Interconnection
  - Service Upgrades
  - Labor
  - Trenching (~$100/ft)

## Non-Residential EVSE Costs




| Average Level 2 Installation Costs per Port | | | | |
|---|---|---|---|---|
| Source | All Non-residential | Fleet | Workplace | Public |
| EV Project (2011-2013) | $2,979 | N/A | $2,223 | $3,108 |
| 2013 EPRI Report | $3,005 | $2,018 | $2,704 | $3,343 |

# Site Assessment

## Site Assessment Overview

- Vehicle and EVSE Selection
  - PHEV vs BEV, Range, Level 2 vs DCFC…
- Install Location
  - Parking Availability, Install Considerations
- Equipment Upgrades
  - Service Panel, Circuit Breakers, Distribution Transformer

## Site Assessment Example 1 – Vehicle Selection

- Requirements
  - 5 LD Vehicles
  - Operated: 5 days/week 9-5
  - Average daily travel: 50 miles
    - Occasional longer trips
    - unpredictable schedule
    - AWD preferred
- EV Selection
  - Mitsubishi Outlander PHEV
    - Range 22/310 miles
    - AWD SUV

**Design Note**

The Outlander's 12 kWh battery can be fully recharged in 3.5 hours with a Level 2 EVSE. This is limited by the 3.6 kW on-board charger.

# Site Assessment 1

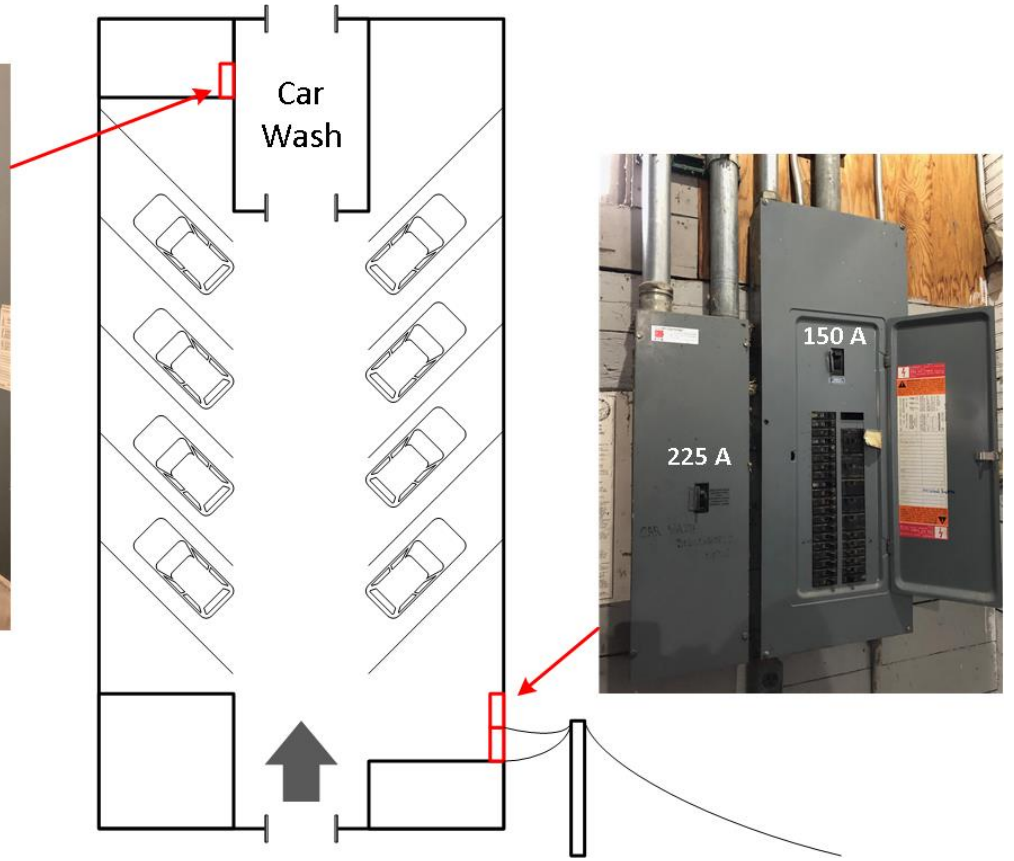
## Site Assessment Example 1 – Electric Service and EVSE Requirements

- Electric Service
  - Two 1-phase 3-wire services
    - Each from a 37.5 kVA transformer

# Site Assessment 1

## Site Assessment Example 1 – Electric Service and EVSE Requirements

- Electric Service
  - Two 1-phase 3-wire services
    - Each from a 37.5 kVA transformer
  - Lighting Circuit
    - 120/240 V, 150 A
  - Car Wash Circuit
    - 120/240 V, 225 A





**Design Note**

Service Panels have an enclosure rating, which is separate from and should be greater than or equal to the main breaker rating.

# Site Assessment 1

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- Electric Service
  - Two 1-phase 3-wire services
    - Each from a 37.5 kVA transformer
  - Lighting Circuit
    - 120/240 V, 150 A
  - Car Wash Circuit
    - 120/240 V, 225 A

$$240\ V \times 32\ A = 7.6\ kW$$

- EVSE requirements

$$7.6\ kW \times 6\ port = 46.2\ kW$$

  - Three level 2 dual port units
    - Six 240 V, 32 A (7.6 kW) ports
    - 46.2 kW additional load

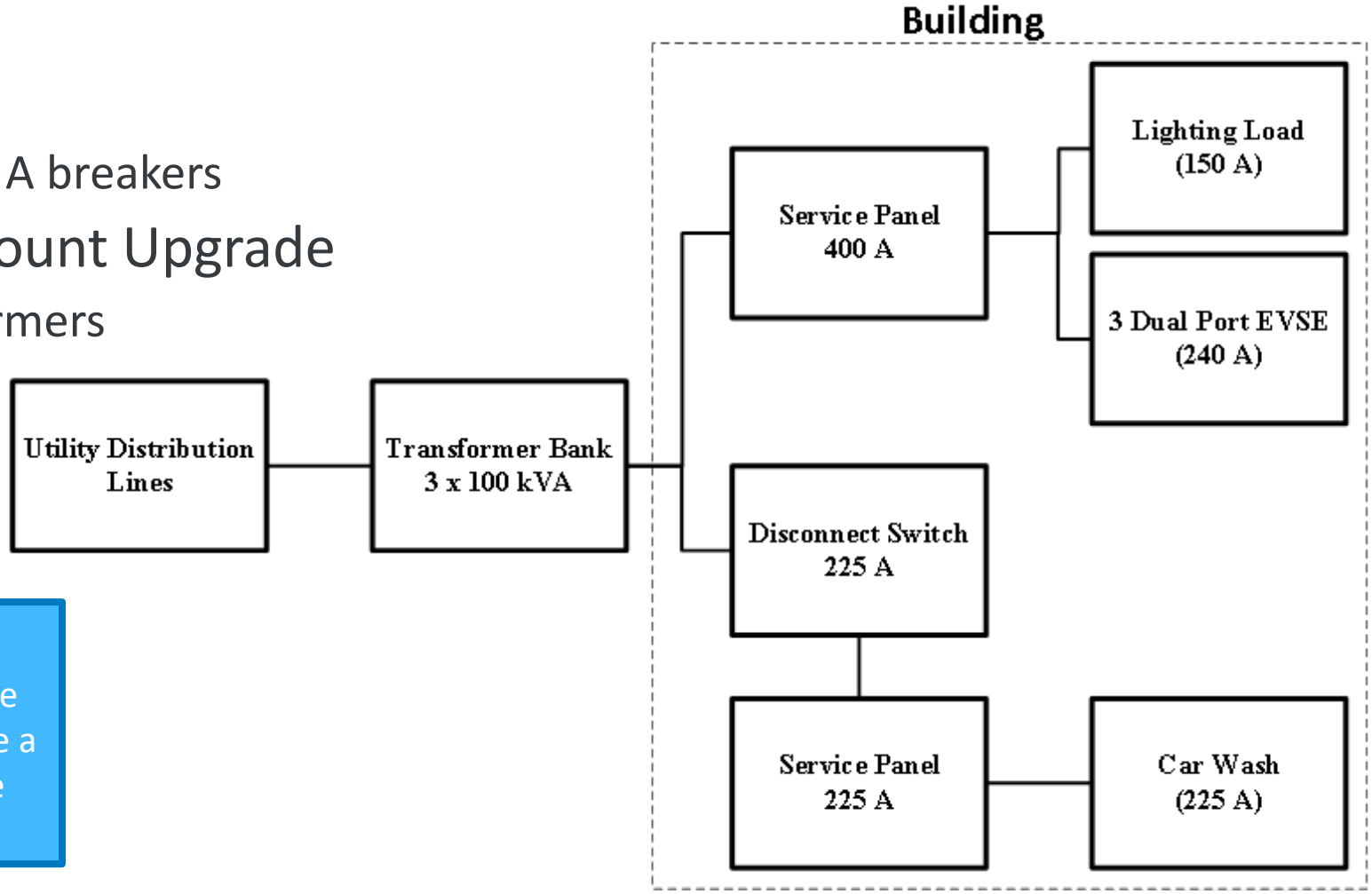
**Design Note**

Wall mount units and dual port units offer the most affordable unit prices per port.

# Site Assessment 1

## Site Assessment Example 1 – Equipment Upgrades and Installation

- Lighting Circuit
  - 400 A service panel
    - Twelve double-pole 40 A breakers
  - Transformer Cluster-mount Upgrade
    - Three 100 kVA Transformers




**Design Note**

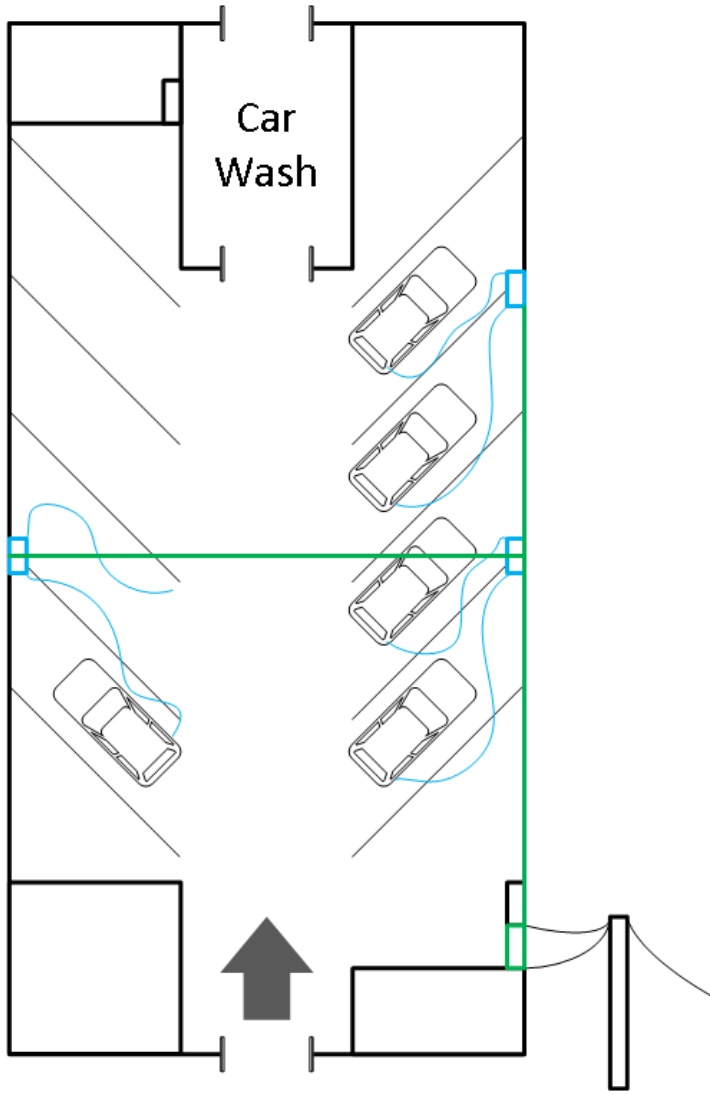
The sum of all branch circuits may exceed the main breaker rating. However, if all loads have a high coincident peak, it may cause nuisance tripping of the main breaker.

# Site Assessment 1

## Site Assessment Example 1 – Equipment Upgrades and Installation

- Lighting Circuit
  - 400 A service panel
    - Twelve double-pole 40 A breakers
  - Transformer Clustermount Upgrade
    - Three 100 kVA Transformers
- Three level 2 dual port units
  - Wall mount installation
    - Lower cost units
    - Avoids trenching
  - Conduit Raceway
    - 150 feet of conduit
    - Installed along garage walls and ceiling

**Design Note**
Avoid trenching when possible.
~$100/ft



## Site Assessment Example 2 – Vehicle Selection

- Requirements
  - 6 LD Vehicles
  - Operated: 6 days/week 9-5
  - Average daily travel: 100 miles
    - Occasional longer trips
    - Consistent parking location
- EV Selection
  - Chevrolet Bolt BEV
    - Range 310 miles
    - LD subcompact sedan

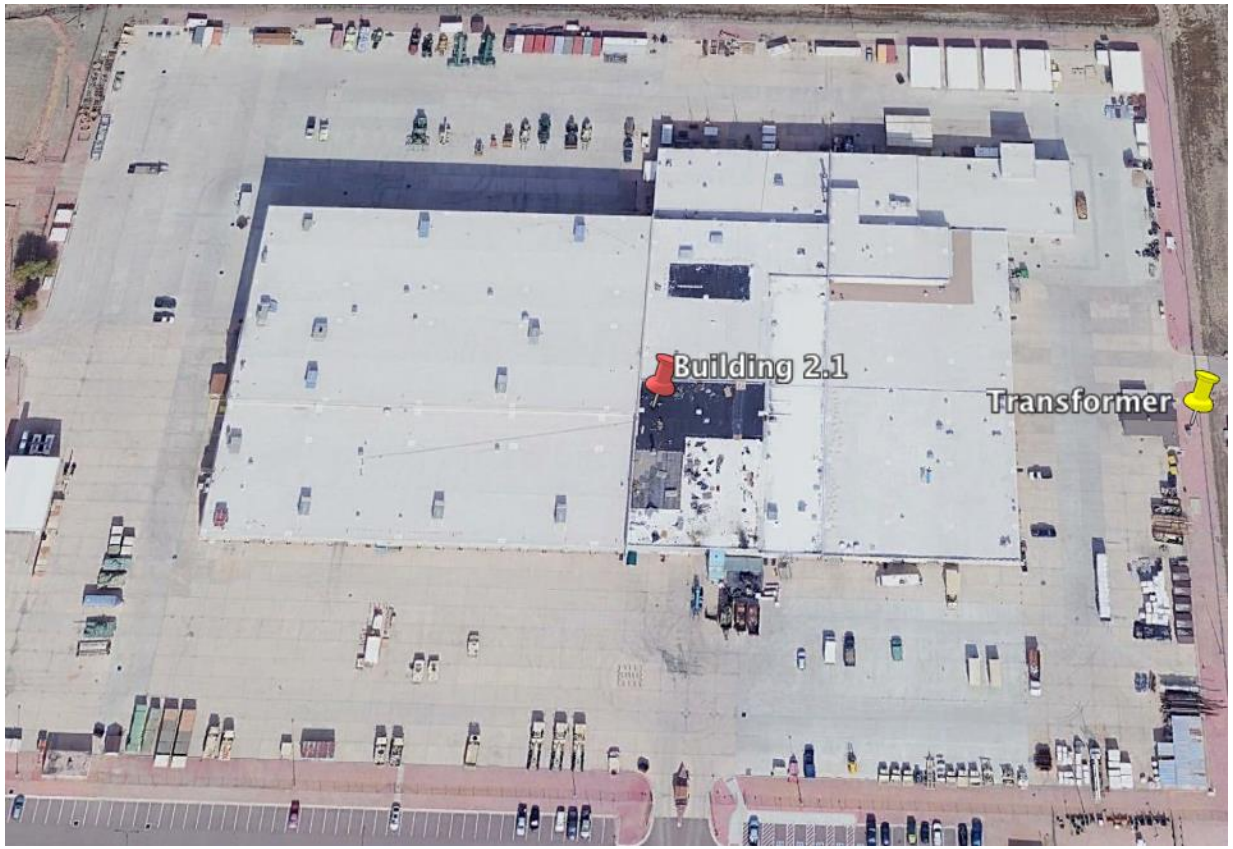
**Design Note**

The Bolt's 60 kWh battery can be fully recharged in 8.3 hours with a Level 2 EVSE. This is limited by the 7.2 kW on-board charger.

# Site Assessment 2

## Site Assessment Example 2 – Electric Service and EVSE Requirements

- Electric Service
  - Building 2.1
    - 1500 kVA transformer
    - 208Y/120 V three-phase service




**Design Note**

Installing a new electric service may be cheaper than using existing infrastructure, particularly when the service panel is located far from the potential EVSE site.

# Site Assessment 2

## Site Assessment Example 2 – Electric Service and EVSE Requirements

- Electric Service
  - Building 2.1
    - 1500 kVA transformer
    - 208Y/120 V three-phase service
  - Building 2.2
    - 300 kVA transformer
    - 208Y/120 V three-phase service


**Design Note**

Some three-phase services are provided 480 V. In these circumstances a "step-down" transformer is required to supply the standard 208Y/120 V service.

# Site Assessment 2

## Site Assessment Example 2 – Electric Service and EVSE Requirements

- Electric Service
  - Building 2.1
    - 1500 kVA transformer
    - 208Y/120 V three-phase service
  - Building 2.2
    - 300 kVA transformer
    - 208Y/120 V three-phase service
- EVSE Requirements
  - Three level 2 dual port units
    - Six 240 V, 32 A (7.7 kW) ports
    - 46.2 kW additional load

**Design Note**

When installing pedestal units, trenching and a concrete surface are required. Concrete pad installations may also be necessary.

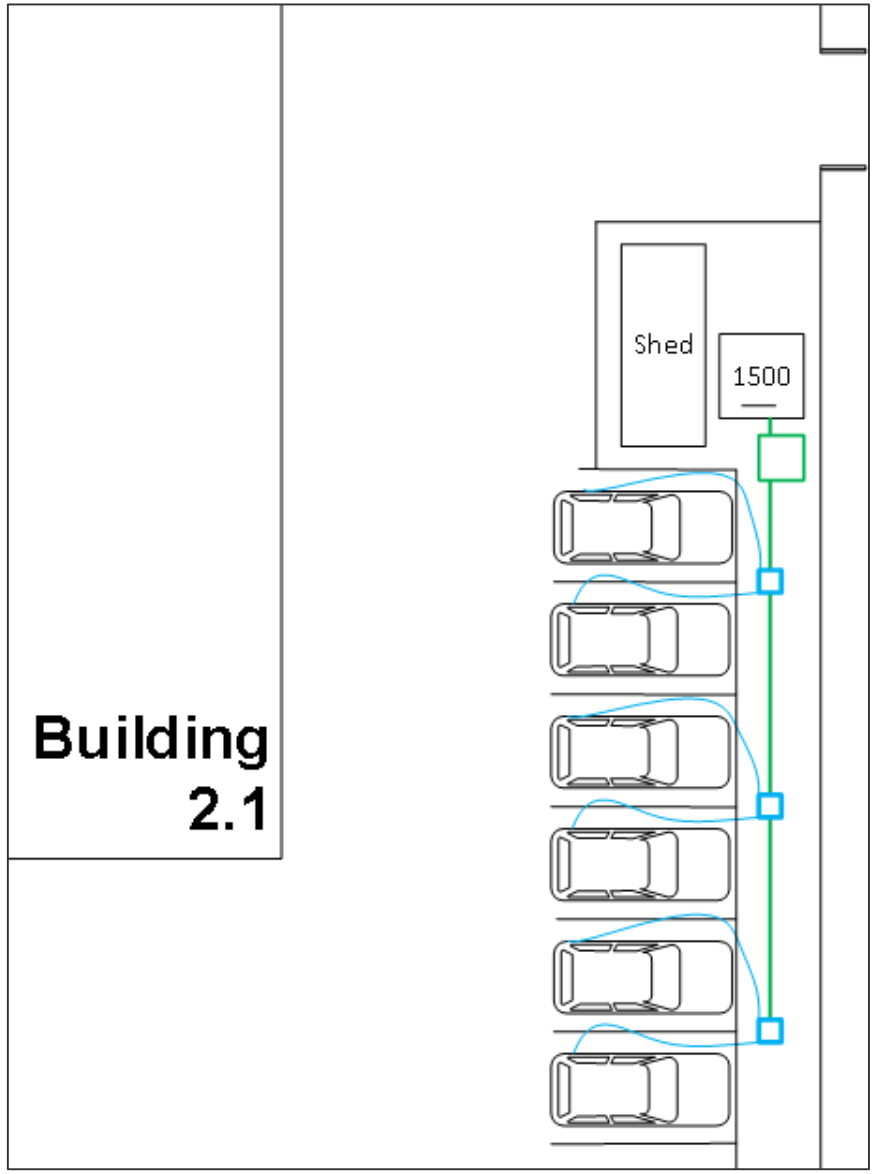
# Site Assessment 2

## Site Assessment Example 2 – Site Selection

- Building 2.1
  - Large transformer capacity
  - Minimal trenching required

**Design Note**

Locating EVSE close to the utility "point of interconnection" not only saves on trenching, but also limits the length of conduit and wire needed



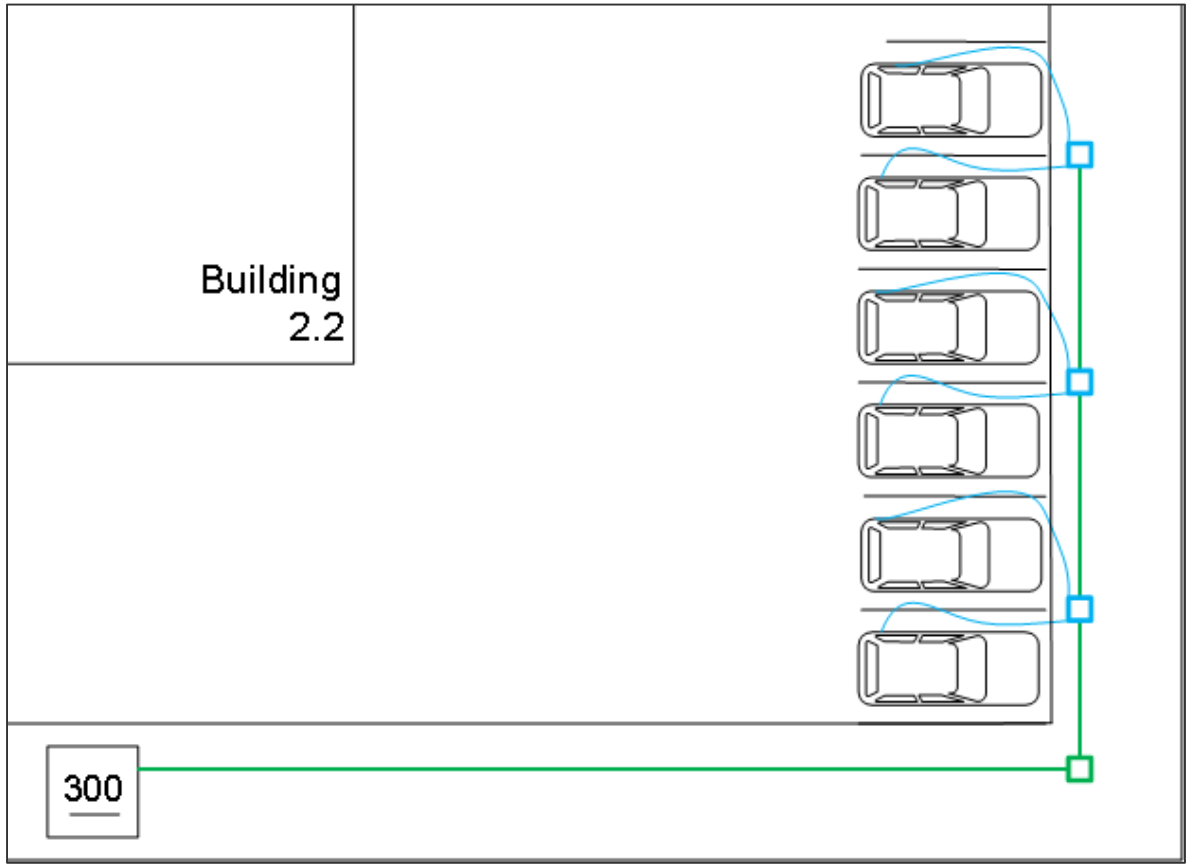
# Site Assessment 2

## Site Assessment Example 2 – Site Selection

- Building 2.1
  - Large transformer capacity
  - Minimal trenching required
- Building 2.2
  - Small transformer capacity
  - Extra 100’ trenching required

**Design Note**

Trenching costs are typically estimated at $100/ft. However, industrial strength concrete parking lots could create higher costs.



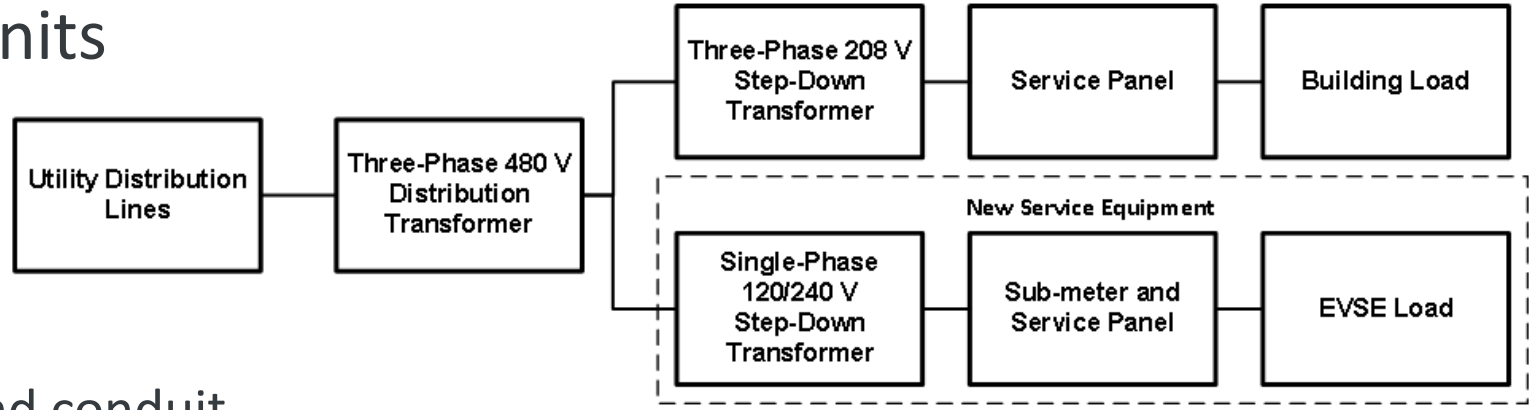
# Site Assessment 2

## Site Assessment Example 2 – Equipment Upgrades and Installation

- New electric service
  - Distribution transformer load analysis
  - New Step-Down Transformer
    - 120/240 V, 100 kVA
  - New 400 A service panel
    - Twelve double-pole 40 A breakers
- Three level 2 dual port units
  - Pedestal installation
    - Concrete pad
  - Conduit Raceway
    - 50 feet of trenching and conduit

**Design Note**

When trenching and installing conduit, if space permits, additional capacity may be planned for with additional conduit and wiring "stub outs".



# Implementation Plan for EV Infrastructure

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Choose vehicles and technology.

LSEV
PHEV
BEV

## EVSE

Choose EVSE type and quantity.

SAE Level 1
SAE Level 2
CHAdeMO

## Analysis

Determine necessary upgrades.

Service Panel
Circuit Breakers

## Utility

Contact utility rep regarding new load.

Grid impacts
Service voltage
Transformer

## Construction

Install new infrastructure.

Breakers
Conduit/conductors
EVSE

# Thank You

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