

Module 1.10 — Power Flow: Utility to Charger

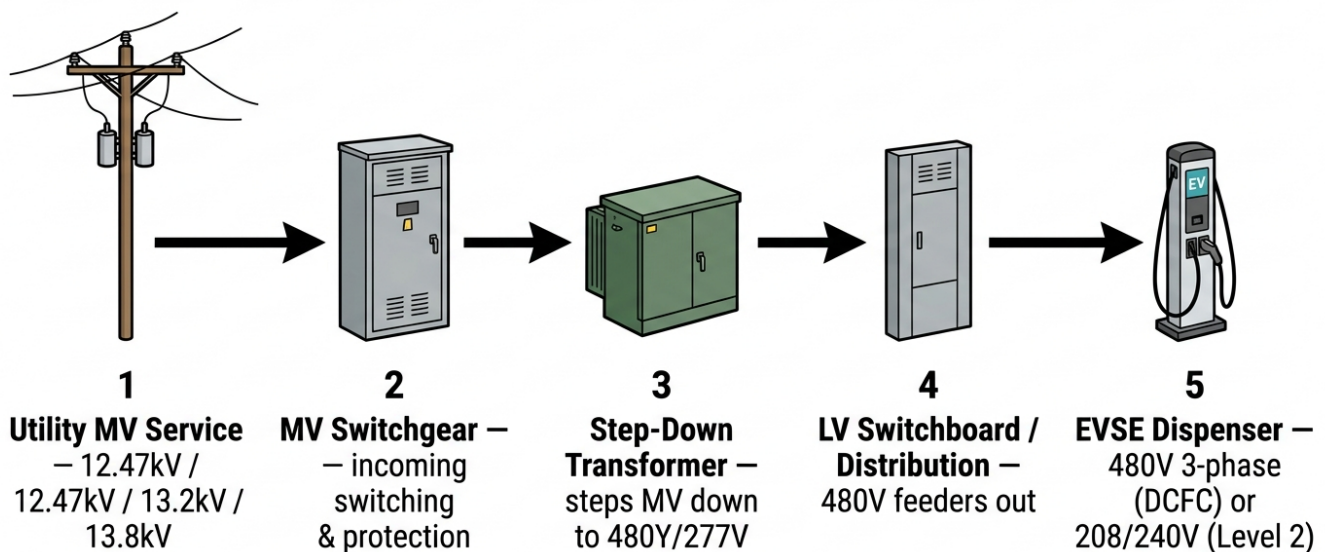
Where site power comes from, what it passes through, how EV circuits, panels, feeders and transformers are sized, and how chargers are installed and commissioned.

Why this module. Modules 1.8 and 1.9 covered the raceway and the box. This module follows the power from the utility to the charger cable: what equipment it passes through, what each piece looks like in the field, how the circuits are sized, and how chargers are installed and commissioned. EV charging is the example because it touches every stage, but the same chain feeds any large site load. It walks step by step through the utility service request, sizing a Level 2 circuit, a load-managed charger panel, a DC fast charger feeder and its transformer, voltage drop to the far stalls, setting a pedestal, and commissioning. It ends with the 2026 code changes for Article 625.

Part A — The Full Power Flow

On a full build-out there are five stages, in order, from the street to the charger cable:

THE POWER FLOW — UTILITY TO CHARGER



The confirmed order: MV switchgear sits BEFORE the transformer, not after.

- 1. Utility medium-voltage (MV) service.** Power arrives at the site at medium voltage, typically 12.47 kV, 13.2 kV, or 13.8 kV class.

2. **MV switchgear.** The incoming switching and protection point, ahead of the step-down.
3. **Step-down transformer.** Converts MV down to the site's working voltage, almost always **480Y/277 V** on commercial and industrial sites.
4. **Low-voltage (LV) switchboard and distribution.** Takes the 480 V secondary and splits it into feeders.
5. **EVSE** (electric vehicle supply equipment, the charger). DC fast chargers are fed at 480 V three-phase; Level 2 chargers at 208 or 240 V.

Three topologies you will see

Topology	Chain	Typical use
Retrofit Level 2	Existing 208Y/120 or 120/240 panel → branch circuit → EVSE	2-10 Level 2 ports at an office or retail lot
New secondary service	Utility-owned pad-mount transformer → CT cabinet and meter → service switchboard → EV distribution panels → EVSE	Most commercial DC fast and Level 2 lots
Primary (MV) service	MV switchgear → customer-owned transformer → LV switchboard → DC fast charger cabinets	Fleet depots and multi-megawatt sites

Worked example: an EV fleet charging depot (a past YES Electric project type). A large delivery-fleet depot is the full build-out in the third row: MV service, switchgear ahead of the transformer, a 480Y/277 V switchboard, and DC fast charging dispensers on a load-management system. Out in the lot, the circuits run in PVC under the parking area (24" of cover, Module 1.8), come up in Schedule 80 risers, and land in NEMA 3R enclosures (Module 1.9). The pull points are polymer-concrete handholes (Part E). A small Level 2 retrofit inside an existing building skips most of this and taps an existing 208/120 V panel.

Step by step: the utility service request

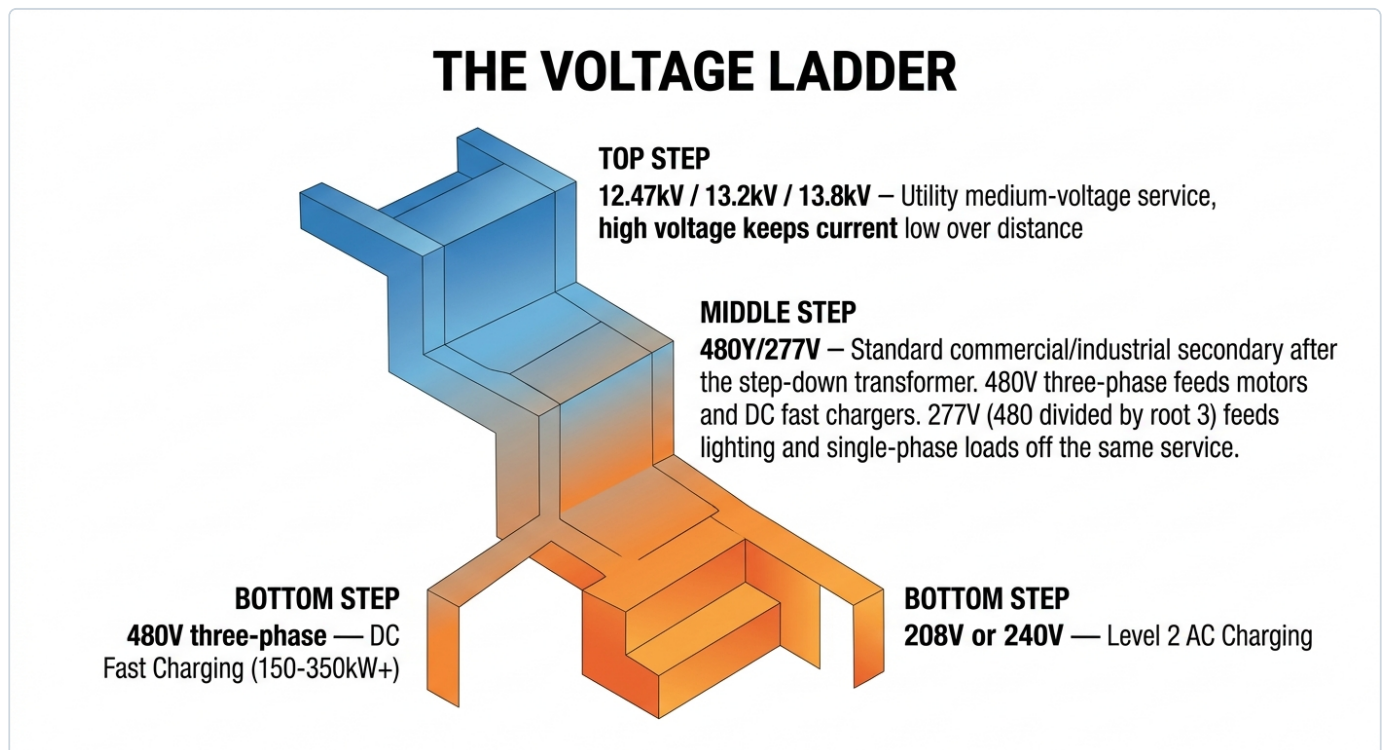
Utility rule text below is from Alabama Power's Rules and Regulations for Electric Service. Other utilities follow a similar path; the assigned utility engineer has the exact forms.

1. **Apply for service.** Alabama Power Rule 1.1: "Such application may be written, oral or electronic," and "where the construction of additional facilities is required to provide service, the Company may require that the Customer enter into a separate written agreement."
2. **Send the load information.** Industry practice is a load letter listing charger count, each charger's nameplate kVA and input amps, the service voltage requested (480Y/277 for DC fast), the single-line diagram, a site plan with the pad and meter location, and the date power is needed. Get the utility's own commercial checklist from its engineer.
3. **Receive the utility design and cost letter.** Costs over the utility's allowance are billed to the customer (Alabama Power Rule 4.2.1, "Customer payment for excess construction charges"). Added load on an existing account falls under Rule 4.2.7(b).

4. **Install the customer scope:** transformer pad and conduits per the utility drawing (Module 1.8 Part F), CT cabinet or meter base, service equipment, grounding.
 5. **Pass the AHJ inspection.** The inspector releases the service to the utility, which sets the transformer and meter and energizes.
 6. **Commission the chargers** (Part H).
- **Meter base or CT cabinet.** Alabama Power's approved self-contained meter sockets top out at the 320/400 A class ("All 320/400A Meter sockets must have an anti-inversion clip in the right line side meter jaw"). A DC fast charging service of hundreds or thousands of amps is CT-metered: current transformers sit in a utility-approved CT cabinet or a switchboard CT compartment, wired to a remote meter socket. Ask the utility which CT cabinet to buy before ordering gear.
 - **Fault-current label.** 110.24(A): "Service equipment at other than dwelling units shall be legibly marked in the field with the available fault current," including the date.
 - **625.47:** one EVSE may be fed by more than one feeder or branch circuit "where equipment is identified for the application."

Part B — The Voltage Ladder: Why These Numbers

Every voltage change in the chain has a reason.



High voltage moves power efficiently over distance. Low voltage is what equipment can actually use.

- **Medium voltage for the utility feed (12-13.8 kV):** power is voltage times current. At a higher voltage the same power needs less current, and less current means smaller conductors

and less energy lost to resistance over distance. That is why the utility does not run 480 V for miles.

- **480Y/277 V on the secondary:** the standard US commercial and industrial voltage. 480 V three-phase feeds motors and DC fast chargers. 277 V ($480 \div 1.732$) feeds lighting off the same service with no second transformer.
- **At the charger:** DC fast chargers (150–350 kW and up) take 480 V three-phase input directly. Level 2 runs on 208 V (typical commercial) or 240 V (typical residential), per the Department of Energy's Alternative Fuels Data Center.

The math you will use in every Part below

Formula	Use
Single-phase: $I = VA \div V$	A Level 2 charger on 208 or 240 V
Three-phase: $I = VA \div (1.732 \times V)$	A DC fast charger on 480 V; panel feeders
Three-phase: $kVA = 1.732 \times V \times I \div 1000$	Checking a nameplate
$277 = 480 \div 1.732$; $120 = 208 \div 1.732$	Why two voltages come off one wye

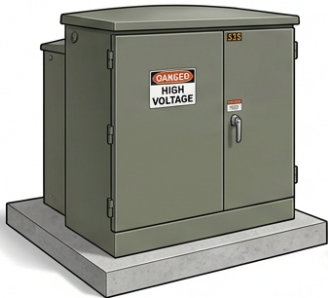
Worked example 1 (check a nameplate). The ABB Terra 184 DC fast charger lists "480Y / 277 VAC +/- 10 % (60 Hz)" and "230 A, 192 kVA." Check: $192,000 \div (1.732 \times 480) = \mathbf{230.9\ A}$, which matches.

Worked example 2 (208 vs 240 V). A 48 A Level 2 charger delivers $48 \times 208 = \mathbf{9.98\ kW}$ at 208 V but $48 \times 240 = \mathbf{11.5\ kW}$ at 240 V. The same car charges about 13% slower on a commercial 208 V system.

Part C — Reading the Equipment: Switchgear vs. Switchboard vs. Panelboard

WHAT AM I LOOKING AT? — EQUIPMENT ON SITE

1 PAD-MOUNTED TRANSFORMER



Steps MV down to 480V.
The classic green box.

2 MV SWITCHGEAR / UNIT SUBSTATION



Incoming switching & protection, upstream of the transformer.

3 LV SWITCHBOARD



Distributes 480V power to feeders after the transformer.

4 PANELBOARD



The familiar breaker panel — branch circuits out to equipment.

Four pieces of equipment, four different jobs — and four different looks.

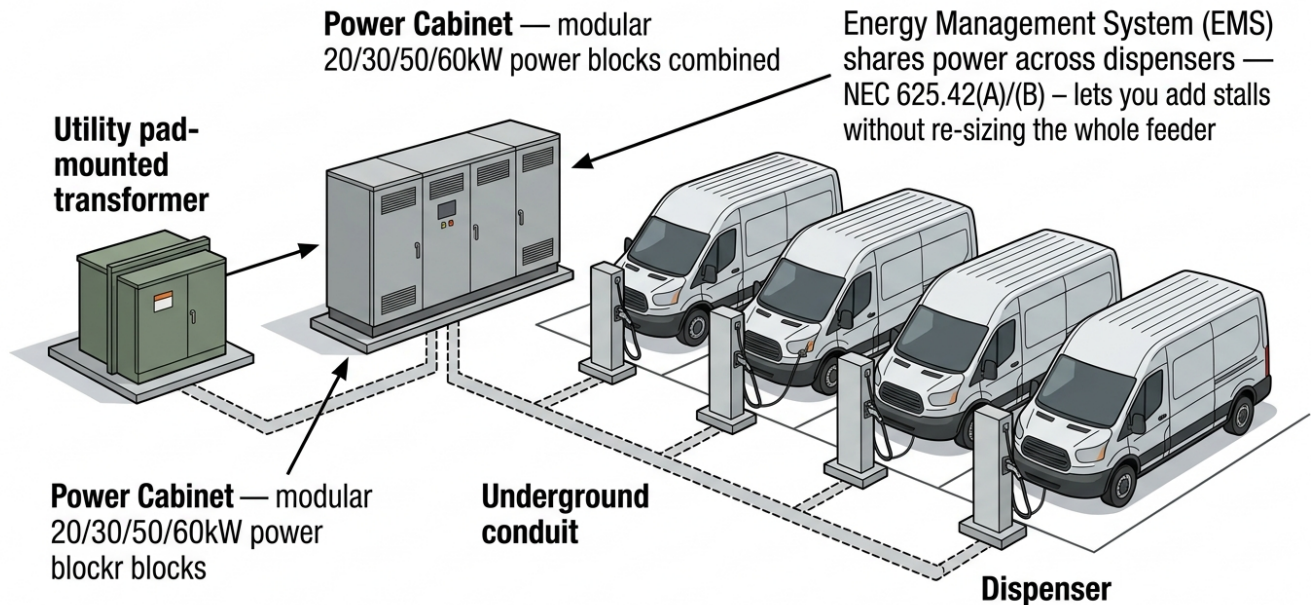
- **Switchgear:** individually compartmented switching, protection, and control equipment. It is the incoming equipment, upstream of everything else, generally built to a higher protection standard than what is downstream.
- **Switchboard:** downstream of the transformer. Takes the stepped-down secondary and distributes it to feeders.
- **Panelboard:** the familiar breaker panel. Takes a feeder in and breaks it into branch circuits.
- **MCC (motor control center):** a lineup built for motor starters and controls (Module 1.6).

The names describe function and construction more reliably than voltage. "Switchgear = medium voltage, switchboard = low voltage" is a rule of thumb with exceptions. On DC fast charging sites, vendors now sell cabinet-style packages that put the disconnect, meter and CT cabinet, distribution panels, and even the transformer in one enclosure built for charging sites.

- **Directory (408.4(A)):** every circuit needs a description "located at each switch or circuit breaker in a switchboard or switchgear" that is "clear, evident, and specific." On an EV panel write the stall, for example "EV-07 stall 7 north row."
- **Working space (110.26):** pedestals and charger cabinets crowd panels on small pads. Check clearances (Module 1.9 Part E) before you set anything.
- **Transformer protection (450.5(B); 450.3(B) in 2023):** "Overcurrent protection shall be provided in accordance with Table 450.5(B)." Worked example 7 in Part G uses it.

Part D — DC Fast Charging at Depot Scale

DC FAST CHARGING AT DEPOT SCALE



A fleet depot is built from modular power blocks feeding multiple dispensers off a shared, code-legal load-management system.

	Level 2 (AC)	DC fast
Supply	208 or 240 V single-phase, 16–80 A	480Y/277 V three-phase, about 60–300 A per cabinet
Where AC becomes DC	The charger inside the car	The rectifier inside the charger cabinet
Connectors	SAE J1772; SAE J3400 (NACS)	CCS1 (J1772 combo), J3400, CHAdeMO (older)
Ground-fault protection	Built-in charge circuit interrupting device (CCID), e.g. ChargePoint CT4000 "20mA CCID with auto retry"	Listed internal protection

The Alternative Fuels Data Center lists DC fast outputs "up to 500 kW" with "CCS," "CHAdeMO," and "J3400" connectors, and notes "SAE International is standardizing the J3400 connector based on Tesla's design for the NACS connector, which works for all charging levels."

- **Modular power blocks.** Depot-scale DC fast equipment is built from smaller power modules (commonly 20, 30, 50, or 60 kW) combined to reach anywhere from 50 kW to over 1 MW.
- **Dedicated transformers are standard.** DC fast charging normally gets its own step-down transformer.
- **Load sharing is allowed by code.** 625.42(A) lets a listed Power Control System (PCS) limit the load so several chargers share capacity, and the feeder and service are sized to the PCS

limit instead of every charger at full output. This lets a depot add stalls over time without pulling a bigger feeder each time. Part G works the numbers.

- **Big depots become utility projects.** Above roughly 3 MW of charging load, a site can trigger utility substation work as well as a bigger transformer. Con Edison has committed about \$1.2 billion for two new substations to support MTA bus fleet electrification in Queens, and \$60 million for a school-bus depot at Zerega Avenue (New York Department of Public Service filing).

Federally funded sites (NEVI, 23 CFR 680). 680.106 requires "at least four network-connected" ports; each DC fast port needs "at least one permanently attached CCS Type 1 connector" and "at least 150 kilowatt (kW)" per port at the same time; Level 2 ports need "a permanently attached J1772 connector" and "at least 6 kW." Electricians must hold "Certification from the EVITP" or registered-apprenticeship EVSE training. 680.108 requires "OCPP 1.6j or higher," moving to "OCPP 2.0.1." Check current FHWA guidance on J3400 connectors before a NEVI job.

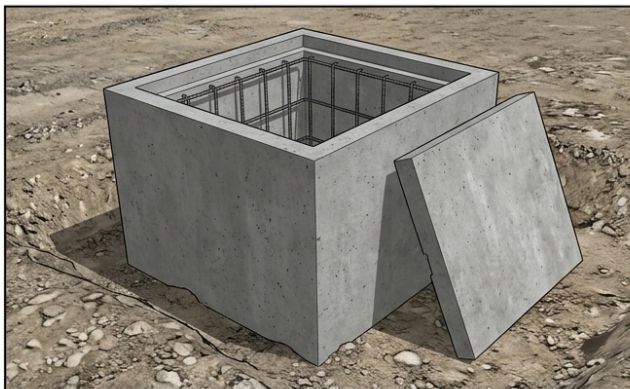
Part E — What Are You Actually Looking At? (Field ID)

Two things on site jobs that are easy to misidentify if nobody has shown you.

The concrete-looking boxes

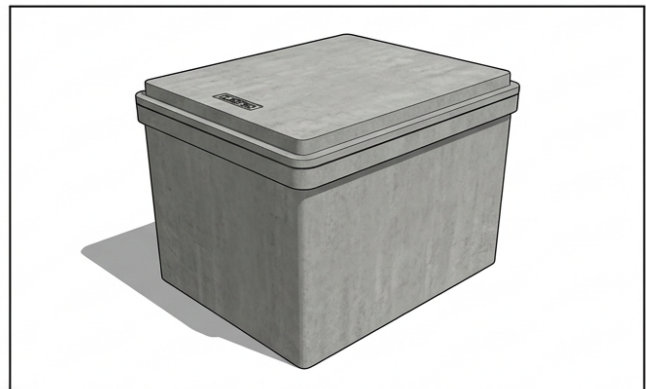
CONCRETE-LOOKING BOXES ON SITE

PANEL 1 'PRECAST CONCRETE VAULT'

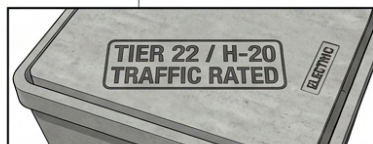


Steel-reinforced concrete — heavy, used for deep or very heavy-duty vaults.

PANEL 2 'POLYMER-CONCRETE VAULT (e.g. Quazite-style)'



Looks like concrete, isn't pure concrete — non-conductive, corrosion-proof, common on modern sites.



Read the lid stamp — tells you the traffic rating and what's inside.

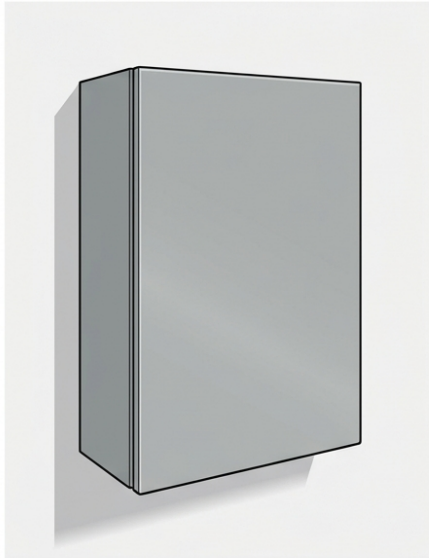
Two different products that both look like "a concrete box" — read the lid, not just the material.

These are precast **handholes and pull-box vaults**, the hardware behind the pull-box sizing in Module 1.8 Part E. Steel-reinforced concrete is heavy and used for deep or heavy-duty vaults.

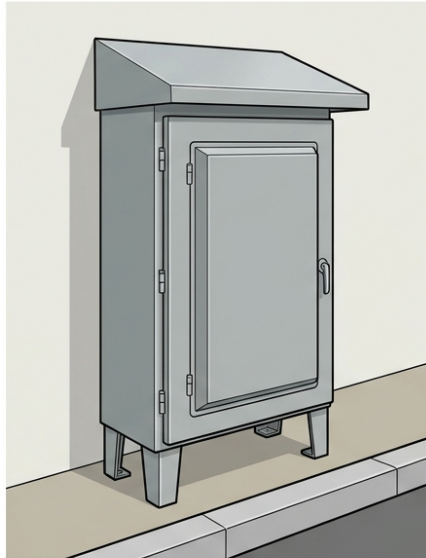
Polymer concrete (a fiberglass-reinforced composite; brands include Quazite and Oldcastle) looks like concrete but is lighter, does not conduct, and does not corrode, so it is common on modern sites. Read the lid: it is stamped with a load rating (from light duty up through H-20 for full parking-lot and roadway traffic) and often with what is inside. NEC 314.30 requires handholes to be "identified for use in underground systems" and covers to be marked to show their use, such as "ELECTRIC."

Spotting a NEMA rating without a spec sheet

SPOT THE NEMA RATING — IN THE FIELD



NEMA 1 — indoor only, smooth flat door, no rain hood



NEMA 3R — outdoor, the slanted rain hood is the giveaway



NEMA 4X — smooth non-metallic finish, stays rust-free outdoors for years

The quick visual tells: a rain hood means 3R; a smooth, rust-free non-metallic finish after years outside means 4X.

No rain hood and mounted indoors: probably Type 1. A slanted rain hood and a door-within-a-door outdoors: 3R. A smooth, nonmetallic-looking finish with no rust streaks after years outside: 4X. The rating is always marked on the enclosure (110.28), so confirm on the nameplate.

Part F — Code Snapshot: What's Actually Current (2023-2026)

The NEC edition in force is the one your AHJ (the local inspection authority) has adopted. Many jurisdictions inspect under the 2023 NEC or earlier for some time after a new edition is published. Ask the inspector which edition applies before you rely on a 2026-only rule.

NEC 2026 Article 625 rules you will use

- **625.2:** EV power transfer equipment "shall be listed."
- **625.4 (new in 2026):** permanently installed EVSE "shall be installed by qualified persons." It uses the existing Article 100 definition of Qualified Person: someone with "skills and knowledge related to the construction, operation, and installation of electrical equipment" who "has received safety training to recognize and avoid the hazards involved." The Informational Note points to NECA 413-2024.
- **625.5 (new in 2026):** permanent markings on the outside of the equipment: "(1) Supply voltage, number of phases, frequency, and full-load current for each incoming supply circuit (2) Short-circuit current rating."
- **625.40:** each outlet for EVSE "greater than 16 amperes or 120 volts shall be supplied by an individual branch circuit," except where 625.42(A) or (B) allows several EVSE on one circuit.
- **625.41:** EVSE and WPTE (wireless power transfer equipment), "including bidirectional," "shall be considered continuous loads." Conductors and breakers are sized at 125%.
- **625.42:** the service, feeder, and branch circuit "shall have sufficient rating to supply the load served, unless the overall rating of the installation can be limited through controls as permitted by 625.42(A) or 625.42(B)."
- **625.42(A) Power Control Systems (PCS):** a PCS used for load management "shall comply with Article 130 Part II and the maximum equipment load on a service, feeder, and branch circuit shall be the maximum load permitted by the PCS."
- **625.42(B) Adjustable settings:** an EVSE turned down to a lower current is allowed if access to the setting is restricted (130.70(B)), and the adjusted setting goes on a field label per 110.21. The Informational Note example: an EVSE that can be "set to a maximum of 80A but is adjusted to a 40A maximum output to match the 50A branch circuit."
- **625.44(C):** "All other EVSE and WPTE shall be permanently wired and securely fastened in place." Cord-and-plug EVSE uses an attachment plug rated at least 125% of the equipment (625.44).
- **625.46 and 625.48:** no backfeed through the vehicle when utility power is lost, unless the EVSE is listed and marked for power export (bidirectional). Standby use then follows Article 702 and a production source Article 705.
- **625.50:** the connector is stored at least 18" above the floor indoors and 24" above grade outdoors.
- **625.54:** "All receptacles installed for the connection of electric vehicle charging shall have ground-fault circuit-interrupter protection for personnel."

Load management moved to Article 130

- In 2026, Article 130 is "Energy Management Systems." Article 750 in 2026 is the grounding and bonding of limited-energy systems, so do not cite Article 750 for load management.
- Article 100: a Power Control System is "Equipment that monitors and controls power within a system to prevent overload of an electrical service, conductor, or power distribution equipment."
- **130.2:** PCS equipment "shall be listed and labeled as a power control system (PCS)." The Informational Note cites UL 3141. Charger "power sharing" counts only if the system is listed as a PCS; check the listing before you shrink a calculation.
- **120.7(B):** the PCS setting is set by qualified persons "no greater than 80 percent of the rating of the OCPD for the circuit being monitored."
- **120.7(C)(1):** if the PCS monitors only the controlled loads, use the control setting in the calculation; if it monitors controlled and other loads, use the minimum operating current of the controlled loads.
- **130.70(A):** settings are in amperes, and "The PCS control setting shall be considered as a continuous load."
- **130.80(A):** the equipment is marked with the control settings, the loads managed, and the "date of calculation and identification of the qualified person."

Load calculation: 120.57 (220.57 in 2023)

"For each EVSE served, the load shall be calculated at [the] nameplate rating of the equipment, if available," and at a default value only when there is no nameplate. That default is 7,200 W (the local code text is damaged at the number; confirm in the printed code). The older "greater of 7,200 VA or nameplate" wording is out of date. The 125% continuous-load factor is applied when sizing conductors and breakers: branch circuits 210.19(A)(1) and 210.20(A); feeders 215.4(A)(1) and 215.5 (215.2 and 215.3 in 2023).

Confirmed: 625.43 in the 2026 NEC

The 2026 NEC lays out 625.43 (Disconnecting Means) in four parts.

- **(A)** Every EVSE and WPTE gets a disconnecting means as (B) through (D) require.
- **(B)** At multifamily dwellings, a plaque or directory on each charger and its disconnect shows which serves which.
- **(C)** Every permanently connected charger needs a disconnect "installed in a readily accessible location" that is "lockable open in accordance with 110.25." If it is remote, a plaque on the charger says where it is. Cord-and-plug chargers rated 60 A or less, or 150 V or less to ground, may use the plug.
- **(D)** At anything other than a one- or two-family dwelling, permanently connected chargers also need a clearly identified emergency disconnect within sight of the equipment and within 6.0 m (20 ft). It must kill power to all chargers within sight of it, be marked "EVSE EMERGENCY DISCONNECT" and "WARNING: ELECTRIC VEHICLE(S) WILL REMAIN ENERGIZED" per 110.22(A), be manual reset, and open all ungrounded conductors at once. The (C) disconnect can do this job if it meets all of (D).

Topic	NEC 2026	NEC 2023
EVSE load in calculations	120.57	220.57
Feeder conductor size / feeder overcurrent protection	215.4 / 215.5	215.2 / 215.3
Load management	625.42(A) Power Control Systems → Article 130 Part II, 120.7	Energy management system rules
Transformer overcurrent protection	450.5(B)	450.3(B)

Part G — Sizing an EV Circuit Start to Finish

The worksheet: nameplate amps → × 1.25 → breaker (standard sizes, 240.6(A)) → conductor at 75°C (Table 310.16) → equipment grounding conductor (Table 250.122) → voltage drop → terminal check → label. Ampacities for 250 kcmil and larger and EGC sizes above 100 A in the local code text are hard to read, so confirm those rows in the printed tables.

Worked example 3: a 48 A Level 2 branch circuit

Step	Rule	Math	Result
Continuous load	625.41, 210.20(A)	48×1.25	60 A
Breaker	240.6(A)	60 A is a standard size	60 A 2-pole
Conductor	Table 310.16, 75°C	#8 Cu = 50 A (fails); #6 Cu = 65 A	#6 Cu
EGC	Table 250.122	60 A breaker	#10 Cu
Load for the panel calculation	120.57 nameplate	48×208	9,984 VA (11,520 VA at 240 V)

Manufacturer check, Tesla Gen 3 Wall Connector manual: "60 amp circuit breaker" gives "Max output 48 A"; "For 75°C rated circuit breaker, use minimum 6AWG, 90°C THWN-2-rated copper"; terminals accept "12-4 AWG, copper only," torqued to "50 in-lb (5.6 Nm)."

Worked example 4: a 10-charger panel with a Power Control System

Ten 48 A Level 2 chargers on a 208Y/120 V three-phase panel, phase pairs rotated AB, BC, CA.

1. **No PCS:** $10 \times 9,984 = 99,840$ VA. Balanced line current = $99,840 \div (1.732 \times 208) = 277.1$ A. $\times 1.25 = 346.4$ A, so a 350 A feeder breaker and a 400 A panel.
2. **With a PCS:** the spare capacity is only a 200 A feeder. A listed PCS monitoring that feeder is set no higher than $0.80 \times 200 = \mathbf{160\text{ A}}$ (120.7(B)). The setting is a continuous load (130.70(A)): $160 \times 1.25 = 200$ A, so the 200 A feeder works. The calculated load is 160 A (120.7(C)(1)), and 625.42(A) caps the feeder load at the PCS maximum.
3. **What the cars get:** with all 10 charging, $1.732 \times 208 \times 160 = 57.6$ kVA, about 5.76 kVA (27.7 A) per car. One car alone still gets its full 48 A.
4. **Branch circuits stay full size:** each is still 60 A with #6 Cu (example 3), because this PCS watches the feeder, not each branch.
5. **Label it** per 130.80(A): settings, loads managed, date of calculation, and the qualified person.

Worked example 5: a 150 kW DC fast charger feeder at 480 V (generic)

Assume 95% efficiency and 0.99 power factor. These are assumptions for practice; always use the real nameplate.

1. Input kVA = $150 \div (0.95 \times 0.99) = 159.5$ kVA.
2. $I = 159,500 \div (1.732 \times 480) = 191.9$ A.
3. $\times 1.25 = 239.9$ A, so a 250 A breaker.
4. Conductor: 250 kcmil Cu at 75°C = 255 A. EGC for a 250 A breaker: #4 Cu (Table 250.122).

Worked example 6: the same job with a real nameplate (ABB Terra 184, 180 kW)

The ABB installation manual lists "Maximum rated input current 230 A," "Recommended input circuit breaker 300 A," "Short circuit current rating 65 kA," input cable rated to 75°C, and "Diameter of the PE conductor: The same as the diameter of the phase conductors."

1. $230 \times 1.25 = 287.5$ A, so a 300 A breaker (240.6(A)), matching ABB's recommendation.
2. Conductor at 75°C: 300 kcmil Cu = 285 A fails; 350 kcmil Cu = 310 A passes.
3. Ground (PE) conductor: ABB wants it the same size as the phase conductors, larger than the Table 250.122 minimum. The manual governs.
4. Lug torque for L1, L2, L3, and PE: "Between 33 and 44 Nm" (292–389 lb-in).

Worked example 7: a transformer for four DC fast chargers

1. **Load** (120.57, nameplate): 4×192 kVA = 768 kVA; 4×230 A = 920 A. $\times 1.25 = 1,150$ A, so a 1,200 A main.
2. **Transformer size.** Eaton's pad-mount guide lists standard sizes including 500, 750, 1000, and 1500 kVA, with 750 to 3750 kVA at 5.75% impedance (Z). 750 kVA would run at 102% of its rating, so pick 1000 kVA unless the utility or engineer sets a PCS site limit. Eaton lists loads "controlled by solid-state or similar devices" as an unusual service condition, which describes charger rectifiers.
3. **Secondary full-load amps:** $1,000,000 \div (1.732 \times 480) = 1,202.8$ A.
4. **Available fault current** (Bussmann point-to-point method, infinite utility): $1,202.8 \div 0.0575 = 20,918$ A, about **20.9 kA**. At the –7.5% impedance tolerance (5.32% Z): **22.6 kA**.
5. **Compare to the charger:** both are below the ABB 65 kA short-circuit current rating. The 625.5(2) marking and the 110.24 fault-current label exist so the inspector can make this comparison.

Worked example 8: a dry-type transformer for the Level 2 panel in example 4. 99.8 kVA of chargers on a 112.5 kVA 480 V delta to 208Y/120 V transformer. Primary full-load amps = $112,500 \div (1.732 \times 480) = 135.3$ A. With primary-only protection at 125%: 169.1 A, so the next standard size, 175 A (Table 450.5(B) Note 1). Secondary full-load amps = 312.3 A. With primary and secondary protection, the secondary may be up to 125% = 390 A, so 400 A, and the primary may go up to 250% (338 A maximum).

Worked example 9: voltage drop to the far stalls

The NEC has no mandatory voltage-drop limit for these circuits. The Informational Notes to 210.19 and 215.4(A) recommend 3% on a branch circuit or feeder and 5% total. Resistance from Chapter 9 Table 8, uncoated copper at 75°C, ohms per 1000 ft: #6 0.491, #4 0.308, 250 kcmil 0.0515. DC resistance ignores reactance; it is close enough for #1/0 and smaller and slightly low for large conductors.

Circuit	Math	Drop
Level 2, 48 A, 208 V single-phase, 150 ft one way, #6	$2 \times 150 \times 0.491 \times 48 \div 1000$	7.07 V = 3.40% (over 3%)
Same circuit upsized to #4	$2 \times 150 \times 0.308 \times 48 \div 1000$	4.43 V = 2.13%
DC fast, 191.9 A, 480 V three-phase, 600 ft, 250 kcmil	$1.732 \times 600 \times 0.0515 \times 191.9 \div 1000$	10.27 V = 2.14%

Check the terminals before you upsize. The ChargePoint CT4000 guide: its "AC terminal blocks... accept a maximum size of 16 mm² (6 AWG)... If using a larger gauge wire to accommodate a long run, reduce the wire size at the disconnect." A #4 run needs a splice or reducing point the charger's terminals accept.

Part H — Pad to Plug: Install and Commissioning

Step by step: setting a pedestal charger (ChargePoint CPF50)

1. Pour the pad with the bolt pattern template: "Four bolts set into concrete with two nuts and two washers for each bolt with the bolt extending 63.5 mm (2 1/2 in) above the surface."
2. Leave a "Conduit stub-up measuring approximately 0.3 m (1 ft) above the concrete surface" and "Approximately 1.5 m (5 ft) of service wiring extending above the concrete surface."
3. Take off the top nuts and washers, set the pedestal over the conduit, and level it with the lower nuts. "Torque the top nuts to 122 Nm (90 ft-lbs)." Re-check level after each adjustment.
4. Land the EGC on the pedestal ground lug first, then L1 and L2.
5. Size the breaker: "As shipped, a CPF50 charging station provides up to 50 A of output current." $50 \times 1.25 = 62.5$ A, so the next standard size is 70 A (240.6(A)). Confirm against ChargePoint's breaker table for the model.
6. Place the network gateway "within 45 m (150 ft) line-of-sight." "Up to nine CPF50s can communicate with a ChargePoint Gateway," and the gateway goes on a "maximum 20 A branch circuit breaker."

Tools the guide lists: bubble level, #2 and #3 Phillips, T10 security Torx, voltage tester, 1/2" drive torque wrench good to at least 122 N·m, and a 1-1/16" deep socket.

Other manufacturer rules worth knowing

- **ChargePoint CT4000 bollard:** base-plate nuts "at least 1416 in-lbs (160 Nm)." On an existing slab "at least 6" thick," bolts "at least 15" from the front edge, at least 12" from the side edges, and at least 6" from the rear edge," in 3/4" holes "at least 6" deep" with epoxy. Circuits: "Two independent 40A branch circuits" for a dual-port unit at 30 A each. "Do NOT provide GFCI protection at panel." "Use new circuit breakers only." Do not connect to "120/240

VAC 3 phase delta, corner-grounded" or ungrounded wye supplies. Cable length "18' (5.5 meters)."

- **ABB Terra DC fast foundation:** "Make sure that the top surface of the foundation is above the ground level, to prevent intrusion of water"; "Apply the full cable slack"; "Fill the foundation with gravel or another substance to prevent rodents."
- **Mounting height:** 625.50 sets the connector storage at 24" or more above grade outdoors. The US Access Board recommends operable parts "no higher than 48 inches" and at least 15". Set holsters between them. The CPF50 wall bracket mounts "1270 mm (50 in) above the floor."
- **Bollards and wheel stops** are not an NEC rule. Their size and spacing come from the site design guide or the civil drawings.

Accessible charging stalls (US Access Board design recommendations). It recommends "at least two EV charging spaces with accessible mobility features." The vehicle space is "at least 132 inches (11 feet) wide" and "240 inches (20 feet)" long, with an access aisle "at least 60 inches (5 feet) wide and the full length"; a pull-through space is "at least sixteen (16) feet" wide. The charger sits on an accessible route. The conduit stub sets where the charger goes, so check the accessible stall layout before the pad is poured.

Step by step: commissioning

1. **Lock out and test.** LOTO per OSHA 1910.147 (construction: 1926.417) and test for absence of voltage at each point of work (NFPA 70E 120.6).
2. **Torque** every lug to the label or manual value with a calibrated tool, and mark it (110.14(D)).
3. **Insulation-test new feeders** with the charger electronics disconnected (Module 1.9 Part F), to the value in the project spec.
4. **Check rotation** on three-phase DC fast supplies with a phase rotation meter before landing, where the manufacturer requires it.
5. **Energize and measure.** The CT4000 checklist: "Line-to-Line measures 208/240VAC. Line-to-Earth measures 120VAC."
6. **Program the maximum current to match the breaker.** Tesla: "Circuit breaker size is programmed during the commissioning process." ABB: "Set the maximum AC input current in amperes... The correct AC input value is the responsibility of the service engineer." If you turn a charger down, label the adjusted setting (625.42(B)).
7. **Run the self-test and a test charge.** The CT4000 and Tesla units run a built-in CCID check at power-up. Then plug in a vehicle and complete a session.
8. **Bring it online.** OCPP (Open Charge Point Protocol) connects the charger to its network: 1.6 is "widely used," 2.0.1 is the "new industry standard," and 2.1 adds bidirectional charging (Open Charge Alliance). Set the OCPP parameters per the manual. A ChargePoint gateway LED can take "up to 20 minutes" to go solid green.

9. **Apply every label:** 625.5 field markings; the 625.42(B) adjusted-current label; the 130.80 PCS label; 625.43 plaques and emergency-disconnect markings; the 408.4 directory; the 110.24 fault-current label at the service.
10. **Hand over the paperwork.** The CPF50 post-install checklist records the "Panel ID# / Breaker #" for each charger for the person who activates it.

DC fast chargers store energy. ABB's de-energizing procedure measures AC and then DC down to 0 V before work. Its fault table warns that "dangerous voltage is present on the EV charge cable... Wait 5 minutes." The 480 V switchboards feeding DC fast chargers usually carry arc-flash labels; wear the PPE on the label.

Common mistakes

Mistake	Why it's wrong	Fix
Charger set to 48 A on a 50 A breaker	$48 \times 1.25 = 60$ A, more than 50	Set it to 40 A and label it (625.42(B)), or install a 60 A breaker with #6 Cu
Adding chargers to an undersized service with no PCS	The calculation exceeds the service	Listed PCS per Article 130 and 120.7, or upgrade the service
Counting unlisted "power sharing" as load management	130.2 requires a listed and labeled PCS	Check for the UL 3141 listing
No emergency disconnect at a commercial site	625.43(D)	Within sight and 20 ft, marked, manual reset
Disconnect not lockable, or remote with no plaque	625.43(C), 110.25	Lock-off kit; plaque on the charger
Connector stored too low or cable dragging	625.50; cord length limit in 625.17(C)	24" or more outdoors; listed cable management
GFCI breaker ahead of a charger with its own CCID	Nuisance trips; CT4000 says not to	Standard breaker per the manual
Upsized wire that won't fit the terminal	CT4000 terminals stop at #6	Reduce at the disconnect or a splice
Used breaker	The manufacturer prohibits it	New breaker
Charger on a corner-grounded delta	Not permitted by the CT4000	Different supply
Citing Article 750 or "greater of 7,200 VA" on a 2026 job	Out of date	Article 130 and 120.57

NEC 2026 Checkpoints (2023 number in parentheses where it moved)

- **625.2, 625.4, 625.5** listing, qualified persons, field markings • **625.40, 625.41, 625.42(A)/(B)** individual circuits, continuous load, PCS and adjustable settings • **625.43(A)-(D)** disconnects and emergency disconnect • **625.44, 625.46, 625.47, 625.48, 625.50, 625.54.**
- **Article 130** (130.2, 130.70, 130.80) Power Control Systems • **120.7** PCS in load calculations • **120.57** (220.57) EVSE load.
- **210.19, 210.20(A)** branch circuits • **215.4(A), 215.5** (215.2, 215.3) feeders • **240.6(A)** standard sizes • **Table 310.16** • **Table 250.122.**
- **450.5(B)** (450.3(B)) transformer protection • **110.24** available fault current • **110.26** working space • **110.28** enclosure types • **314.30** handholes • **408.4** directories.
- Informational Notes to **210.19** and **215.4(A)**: 3% / 5% voltage drop • Chapter 9 Table 8.

Hands-On Field Exercise

- Walk a job site (or a set of site photos) and name, in order, every stage of the power flow from the utility connection to one charger.
- Read a handhole lid on site: what is the load rating, and what does the marking say is inside?
- Identify three enclosures' NEMA ratings by sight, then confirm each on its nameplate.
- Check a DC fast charger nameplate with the three-phase formula and compare its short-circuit rating to the service's fault-current label.
- Size a 48 A Level 2 circuit start to finish (breaker, wire, EGC, voltage drop at 150 ft, terminal check).
- Rework the 10-charger panel for a 225 A feeder: find the PCS setting and the current per car with all 10 charging.
- Commission a charger from the manufacturer's checklist: torque, measure voltages, program the current, test charge, label.
- Explain in your own words why the utility steps down from medium voltage on site instead of running 480 V from the street.

Sources used in this module (public documents)

- NFPA 70, National Electrical Code 2026 (free read-only access at [nfpa.org](https://www.nfpa.org)): Articles 100, 110, 120, 130, 210, 215, 240, 250, 310, 314, 408, 450, 625; Chapter 9 Table 8.
- Alabama Power, Rules and Regulations for Electric Service, and Customer-Owned Meter Equipment: alabamapower.com
- US Department of Energy Alternative Fuels Data Center, Developing Infrastructure to Charge Electric Vehicles: afdc.energy.gov
- ABB Terra 94/104/124/184 UL Operation and Installation Manual and Product Guide: abb.com
- ChargePoint CPF50 Installation Guide and Site Design Guide, CT4000 Installation Guide: chargepoint.com
- Tesla Gen 3 Wall Connector Installation Manual: tesla.com
- SAE J1772 and J3400: sae.org. CharIN CCS: charin.global. Open Charge Alliance, OCPP: openchargealliance.org

- 23 CFR 680.106 and 680.108 (NEVI standards): law.cornell.edu
- US Access Board, Design Recommendations for Accessible EV Charging Stations: access-board.gov
- Eaton Consulting Application Guide, Pad-Mounted Transformers; Eaton Bussmann Selecting Protective Devices: eaton.com
- New York Department of Public Service, EV load interconnection filing: dps.ny.gov. Federal Pacific, MV substations for EV charging: federalpacific.com
- OSHA 29 CFR 1910.147, 1910.333, 1926.417: osha.gov. NFPA 70E, 2024 edition: nfpa.org
- Wolfsped, EV Charging Power Topologies Design Guidebook: wolfsped.com. Schneider Electric, Electrical Distribution Fundamentals Design Guide: se.com. IAEI Magazine, Code Talk on EV infrastructure and the 2026 NEC: iaei.org

Next: Module 2.1 — Safety, LOTO & Troubleshooting. Modules 1.8 (the raceway), 1.9 (the box), and 1.10 (the power flow) together cover a site from the utility to the charger.