Simplifying EV Charging Deployment Through Integrated EV Charging

NECA PHILADELPHIA
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TRADE SHOW EDUCATION

This session is eligible for 1 Contact Hour.

For these hours to appear on your certificate, you must:

- Have your badge scanned at the door
- Attend 90% of this presentation
- Fill out the online evaluation for this session

Learning objectives

- Gain an awareness of the different electric vehicle charging station levels and capabilities.
- Learn about the nuances of designing an electrical system to support electric vehicle charging.
- Review and compare electric vehicle charging solutions available.
- Gain an awareness of the software management platform used to monitor and control electric vehicle charging stations.

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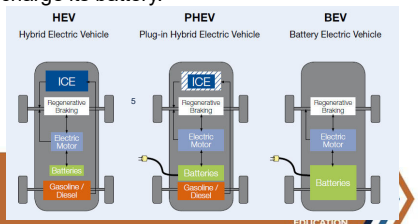
EV Charging Basics

What is an Electric Vehicle (EV)?

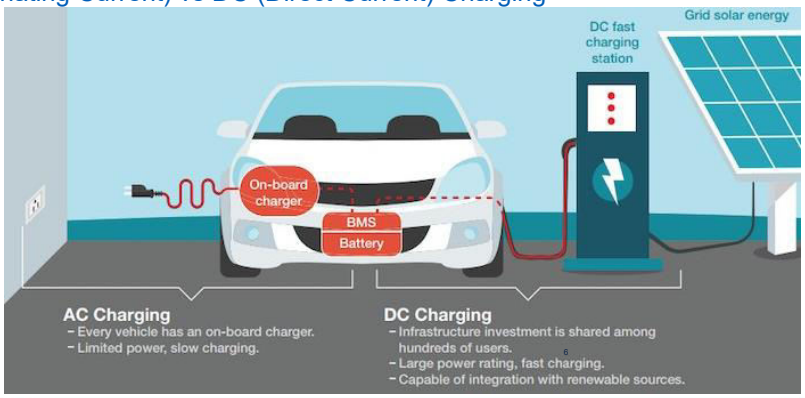
- A Battery Electric Vehicle (**BEV**) is propelled by an electric motor powered by only a battery, which in turn relies exclusively on an external electrical source for recharging.
- Plug-in Hybrid Electric Vehicles (**PHEV**) have both an internal combustion engine (ICE) and electric motor:
  - 'Hybrid' means the car has both a battery and petrol or diesel engine.
  - 'Plug-in' means you can plug the car into a charger to charge its battery.

Main differences:

- HEV can't plug the car in to charge the battery
- BEV batteries capacity are > than PHEV battery capacity



AC (Alternating Current) vs DC (Direct Current) Charging



Source: Image courtesy of Texas Instruments

The common North American connectors

CONNECTOR DESCRIPTION	J1772 standard connector for all electric vehicles except Tesla; used with Level 1 or Level 2 charging station, or with 120 VAC cord that comes with the car	CCS connector used with charging station for cars that are fast-charging capable	CHAdeMO connector used with charging station for cars that are fast-charging capable	Tesla connector used only with Tesla vehicles	Tesla connector used only with Tesla vehicles
CHARGING LEVEL	AC Level 1, AC Level 2	DC Fast	DC Fast	AC Level 2	Supercharger
POWER	1.4 kW – 19.2 kW	50 kW – 350 kW[1]	30 kW – 50 kW	10 kW – 20 kW	120 kW – 250 kW[2]

- J1772 is the standard plug for all mass market EVs. Developed with SAE & used by all major car companies
- CCS is the standard plug for DC fast charging in North America. It uses the same inlet as the J1772 but adds a couple more pins.
- CHAdeMO DC connectors are used primarily for Japanese manufactured EVs
- Tesla recently released their connector design as the North American Charging Standard (NACS)

Most common plug types

J1772 Port (AC)

J1772 Connector (AC)

CCS-1 Port(AC and DC)

CCS Connector (DC)

CHAdeMO Port (DC)

CHAdeMO Connector (DC)

Tesla Port (AC and DC)

Tesla / NACS Connector (AC and DC)

The charging stations

Example assumptions:
90 kWh battery (typically charge 20% to 80%)
Time (h) = 0.6 x 90 kWh / (rating of charger)

Rating of charger	Location	Charger Type	Charger Ampacity	Supply Voltage	80% Charge Time	30 Miles Charge Time***
1.4kW	Home	Level 1	12A	120V 1P	38.6 hours	7.1 hours
7.7kW	Home	Level 2	32A	240V 2P	7.0 hours	1.3 hours
11.5 kW	Work / Public	Level 2	48A	240V 2P	4.7 hours	0.9 hours
19.2 kW	Work / Public	Level 2	80A	240V 2P	2.8 hours *	0.5 hours *
50 kW	Public	Fast DC	**	480V 3P	1.0 hours	12 minutes
150 kW	Public	Fast DC	**	480V 3P	21 minutes	4 minutes

* If onboard converter is 11.5 kW then the time will be 4.7 hours
** Varies as charger is rated 400-1000Vdc
*** Assumes EV efficiency of 3 miles / kWh

Factors affecting charging times

- Size of the battery – a larger battery, all things being equal, will take longer to charge
- Initial state of charge of the battery – Lower state of charge will most likely charge at maximum allowable rate
- Ambient temperature – the battery follows the goldilocks principle, not too hot and not too cold
- Maximum allowable charge rate of the EV itself – each EV typically has differing maximum rates of charging (AC & DC)
- Maximum allowable charge rate of the EVSE – site infrastructure constrained? Load management enabled?
- In the EV, the Battery Management System (BMS) is the ultimate gate keeper

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Quick look at codes

International Code Council (ICC)

- EV charging requirements were ruled out of scope for the 2021 IECC; however it will most likely appear in future code releases.
- 2021 Electric Vehicles and Building Codes: A Strategy for Greenhouse Gas Reductions
  - Provides model code language that local communities can use to set their own policies
    - Sets minimum circuit to 40A and 208/240V
    - Provides table for local community to define % parking as EVSE installed, EV-capable, and EV-ready

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NFPA 70 – National Electric Code (NEC)

- Article 625 – Electric Vehicle Power Transfer System
  - Covers the electrical conductors and equipment connecting an electric vehicle to premises wiring for the charging, power export, or bidirectional current flow. (2023 ed.)
- Some key items of article 625
  - 625.42 – EV charging loads considered continuous loads for service & feeder calculations unless overall rating can be limited by:
    - 625.42(A) – EMS in accordance with 750.30
    - 625.42(B) – EVSE with adjustable settings

NEC continued

- 625.43 – Readily accessible disconnect for EVSE rated >60A or >150V to ground
  - If disconnect is remote, a plaque to be installed on the equipment denoting location of disconnecting means
- 625.46, 48, 49 & 60 – Each address bi-directional power flow
- 625.54 – GFCI protection required for receptacles installed for the connection of EV charger.

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Local regulations

- Each state is adopting various aspects of the IECC, IBC, IRC, and NEC.
  - Always check the local requirements
- Certain states go beyond the international and national codes and adopt additional policies.
  - California Type Evaluation Program (CTEP)
  - California Air Resource Board (CARB)
  - California Public Utilities Commission – Submetering protocol & EVSE communication protocols
- Other specifications
  - EnergyStar
  - NIST Handbook 44
  - International Organization for Standardization (ISO)

ENERGY STAR

NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY U.S. DEPARTMENT OF COMMERCE

ISO

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UL listing standards for EVSE

- UL 2202 – Electric Vehicle Charging System Equipment (AC to DC)
- UL 2231-1 – Standard for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits; Part 1: General Requirements
- UL 2231-2 – Standard for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems
- UL 2251 – Standard for Plugs, Receptacles, and Couplers for Electric Vehicles
- UL 2594 – Standard for Electric Vehicle Supply Equipment (AC to AC)
- UL 9741 – Standard for Bidirectional Electric Vehicle (EV) Charging Systems Equipment
- *NOTE: Eaton EV Smart Breaker Charger is also listed to UL 489 – Standard for Molded Case Circuit Breakers*

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Why Open Charge Point Protocol (OCPP)

- Provides common and open communication protocol
- Offers consistency with how charging stations communicate with charging networks
- Allows for multiple EVSE vendors to work on multiple networks
- Reduces the risk of stranded assets and vendor lock-in
- OCPP version 1.6 is most common, OCPP 2.0 (future)

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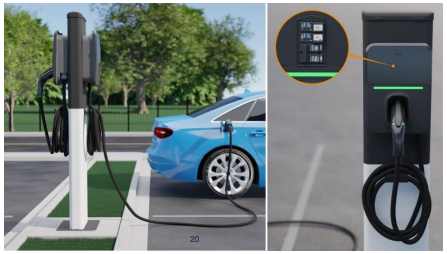
Getting started with the design

Gather information

- Determine the customer use case:
  - Multi family
  - Commercial
  - Workplace
  - Fleet
- What features are important
  - Access control
  - Monetization
- How many chargers
  - Day 1
  - Day N (future)
- What type of charger
  - Level 2
  - DC fast charger

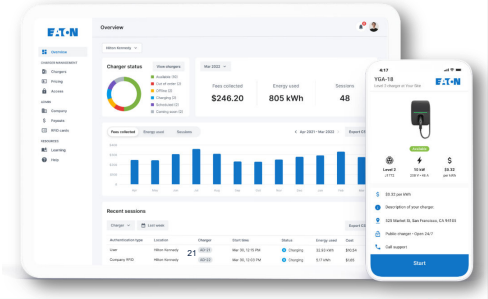
Gather information continued

- Where will chargers be located
  - Parking deck
  - Open parking lot
  - On street
  - Indoors (fleet, dealerships)
- New or existing construction
  - Existing infrastructure capability
  - Utility power availability
  - Current load on the system
  - Plan for future EV chargers



Managing charging stations

- Provides centralized way for customer to monitor, monetize, and control charging stations
- Cloud based solutions are typical
  - Requires reliable network connectivity
- Subscription based licensing is typical



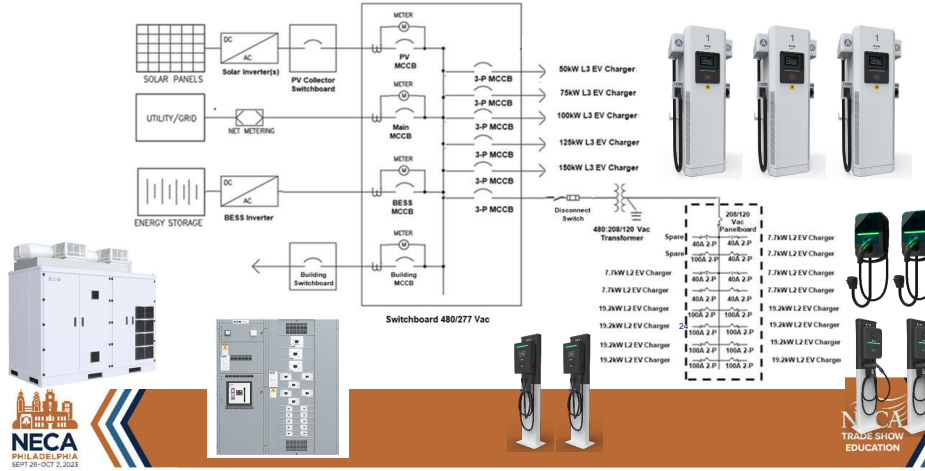
Eaton Charger Network Manager (CNM)

Common features & functionality

- Reporting / visibility
- Driver engagement
- Access control
- Pricing/transaction management
- Load management
- Vehicle integration
- Systems integration

Designing the solution

It is more than just the charger



Example - Workplace

- Mix of fleet, employee, and visitor charging
- Use case:
  - Access control for corporate fleet vehicles. Free charging
  - Discounted charging for employees
  - Monetized charging for visitors
- Mix of charging stations
  - (6) 32A charging stations for visitors
  - (6) 48A charging stations for employees
  - (6) 80A charging stations for fleet vehicles
  - (2) 100kW DC charging stations for maintenance

Example continued

- Assumptions:
  - Level 2 AC chargers supplied from 208Y/120VAC 3-phase
  - DC fast chargers supplied from 480V 3-phase
  - kVA = kW (Level 2 AC EVSE)
  - New dedicated service for EV charging

From Eaton Green Motion Building Technical Data Sheet

Output electrical ratings	– Voltage: 208-240 Vac, 60 Hz – Max current: 40 A – Power: 9.6 kW at 240 Vac; 8.3 kW at 208 Vac

- Nuances
  - Most level 2 AC chargers have a power rating based on 240V L-L
  - Some vendors show both 240V and 208V ratings
  - 208V L-L results in a slightly lower power rating
    - 32A EVSE = 6.66kW @ 208V
    - 40A EVSE = 8.32kW @ 208V
    - 48A EVSE = 9.98kW @ 208V
    - 80A EVSE = 16.64kW @ 208V

Example continued (Level 2 AC calculations)

EV Charger Panel Calculator																
Panel Phase Voltage		208		Phases		3		Configuration		Wye						
Left Side of Panel					Phase Loading (kVA)							Right Side of Panel				
Circuit Number	Load Description	kVA @ 208 Vac	MCCB Poles	MCCB Trip Amps	Phase A	Phase B	Phase C	Phase A	Phase B	Phase C	MCCB Trip Amps	MCCB Poles	kVA @ 208 Vac	Load Description	Circuit Number
1	Charger 1	16.64	2	100	8.32			8.32			100	2	16.64	Charger 2	2
3				100		8.32			8.32		100				4
5	Charger 3	16.64	2	100			8.32			8.32	100	2	16.64	Charger 4	6
7				100	8.32			8.32			100				8
9	Charger 5	16.64	2	100		8.32			8.32		100	2	16.64	Charger 6	10
11				100			8.32			8.32	100				12
13	Charger 7	6.66	2	40	3.33			3.33			40	2	6.66	Charger 8	14
15				40		3.33			3.33		40				16
17	Charger 9	6.66	2	40			3.33			3.33	40	2	6.66	Charger 10	18
19				40	3.33			3.33			40				20
21	Charger 11	6.66	2	40		3.33			3.33		40	2	6.66	Charger 12	22
23				40			3.33			3.33	40				24
25	Charger 13	9.98	2	60	4.99			4.99			60	2	9.98	Charger 14	26
27				60		4.99			4.99		60				28
29	Charger 15	9.98	2	60			4.99			4.99	60	2	9.98	Charger 16	30
31				60	4.99			4.99			60				32
33	Charger 17	9.98	2	60		4.99			4.99		60	2	9.98	Charger 18	34
35				60			4.99			4.99	60				36

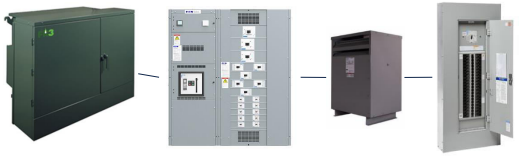
Phase A Loading (kVA)	Phase B Loading (kVA)	Phase C Loading (kVA)	Phase A Loading (A)	Phase B Loading (A)	Phase C Loading (A)
66.56	66.56	66.56	555	555	555
Total kVA			Total 3ph Amps		
199.68			554.3		

Items to consider:

- Load balancing across 3-phase
  - Number of chargers in multiples of 3
  - Selective placement of feeder breakers
- Account for phase imbalance in design

Example continued (calculations)

- DC Fast charger
  - Use nameplate data for input current
  - 100kW DCFC → 129A input @ 480VAC
  - Requires 175A input breaker
  - Power required @ 480V ~ 108kW
- Total system power required
  - (2x)108kW + 200kW = 416kW



- <u>Potential solution:</u>
  - 500kVA MV:LV transformer
    - 13.8kV : 480V
  - 800A Service entrance panel or switchboard
    - Utility metering compartment
    - (2) 175A feeder breaker for DC fast charger
    - (1) 350A feeder breaker for Level 2 panel
  - 225kVA transformer
    - 480V : 208Y/120V
  - 800A panel or switchboard
    - 208Y/120V
    - Feeder breakers for Level 2 EVSE

What about using Level 2 nameplate data

EV Charger Panel Calculator																
Panel Phase Voltage		208		Phases		3		Configuration		Wye						
Left Side of Panel					Phase Loading (kVA)						Right Side of Panel					
Circuit Number	Load Description	kVA @ 208 Vac	MCCB Poles	MCCB Trip Amps	Phase A	Phase B	Phase C	Phase A	Phase B	Phase C	MCCB Trip Amps	MCCB Poles	kVA @ 208 Vac	Load Description	Circuit Number
1	Charger 1	19.20	2	100	9.60			9.60			100	2	19.20	Charger 2	2
3				100		9.60			9.60		100				4
5	Charger 3	19.20	2	100			9.60			9.60	100	2	19.20	Charger 4	6
7				100	9.60			9.60			100				8
9	Charger 5	19.20	2	100		9.60			9.60		100	2	19.20	Charger 6	10
11				100			9.60			9.60	100				12
13	Charger 7	7.68	2	40	3.84			3.84			40	2	7.68	Charger 8	14
15				40		3.84			3.84		40				16
17	Charger 9	7.68	2	40			3.84			3.84	40	2	7.68	Charger 10	18
19				40	3.84			3.84			40				20
21	Charger 11	7.68	2	40		3.84			3.84		40	2	7.68	Charger 12	22
23				40			3.84			3.84	40				24
25	Charger 13	11.52	2	60	5.76			5.76			60	2	11.52	Charger 14	26
27				60		5.76			5.76		60				28
29	Charger 15	11.52	2	60			5.76			5.76	60	2	11.52	Charger 16	30
31				60	5.76			5.76			60				32
33	Charger 17	11.52	2	60		5.76			5.76		60	2	11.52	Charger 18	34
35				60			5.76			5.76	60				36

Phase A Loading (kVA)	Phase B Loading (kVA)	Phase C Loading (kVA)	Phase A Loading (A)	Phase B Loading (A)	Phase C Loading (A)
76.80	76.80	76.80	640	640	640
Total kVA			Total 3ph Amps		
230.40			639.5		

- Conservative approach
- Total kVA and amperage increases
- Phase imbalance can also change

Updated calculations

- DC fast charger remains the same
- Total system power required
  - (2x)108kW + 231kW = 447kW
- MV:LV transformer size stays the same @ 500kVA
- Next standard LV:LV transformer size is 300kVA
- Level 2 EV panelboard increases to 1000A
  - Calculated load of 639.5A x 1.25 = 799.4A
    - 800A can be used but provides very little contingency

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What about… ?

- Power Factor
  - SAE J2894 recommends a total power factor value of 95% for L1, L2, and DC charging.
  - EV on board chargers are power factor corrected
  - Eaton testing has shown EV's exhibit close to unity PF when charging
  - A separate public technical report from EPRI (Electric Power Research Institute) discusses power quality of on board chargers.
    - https://www.epri.com/research/products/1024809

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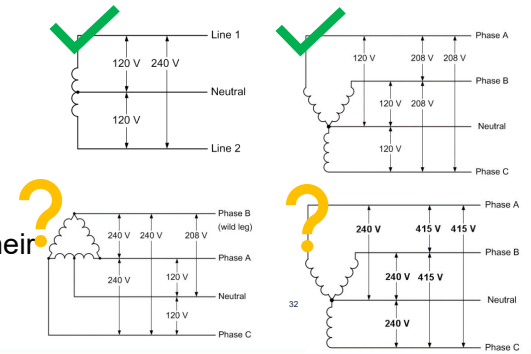
What about… ?

- Higher voltage for higher power
  - 240Y/138V 3-phase?
  - 240V Delta?
  - 415Y/240V 3-phase?
  - 240V Hi-leg delta?
- Always check with EVSE and EV manufacturer if their equipment supports.



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Integrated EV Charging Solutions

Buildings require a comprehensive infrastructure solution to enable sustainable, resilient and cost-effective performance

Eaton's comprehensive EV charging infrastructure offerings will include equipment, software and engineering services solutions.

EV charging
AC Level 2 and DC fast chargers for residential, commercial and fleet operations

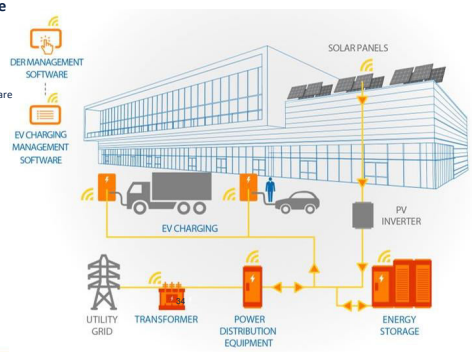
Battery storage
Eaton x Storage Battery Energy Storage System (BESS) includes batteries, inverters and management software to shave peak demand cost for EV charging applications

EV Charge management software
Enables users to operate a network of charging stations, from charging point management and power management to financial rules

Microgrids and Distributed Energy Resource (DER) integration
Incorporate local solar photovoltaics and other renewables into EV charging infrastructure to help meet sustainability goals

Power distribution equipment and grid connection upgrades
Installation and upgrades of electrical equipment, including transformers, switchgear, switchboards, circuit breakers and battery storage

Electrical engineering services
Includes feasibility analysis of planned EV deployment sites, power systems analysis of electrical infrastructure, electrical system conceptual design and configurations, system protection analysis and recommendations, automation and control solutions and turnkey electrical services

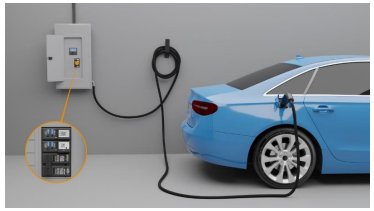


EV Smart Breaker Charger

- 32A (7.7kW @ 240V) AC Level 2 Charger with integral **communications, control & revenue grade metering**
  - 2P 40A BR & BAB styles
- Energy Star Certified
- Open approach through cloud APIs and OCPP enables integration with your preferred charging management solution.
  - OCPP = Open Charge Point Protocol
- The universal J1772™ charging connector is compatible with any EV meeting the SAE J1772™ charging standard
- UL listed and tested for electrical safety and features 20mA ground fault protection

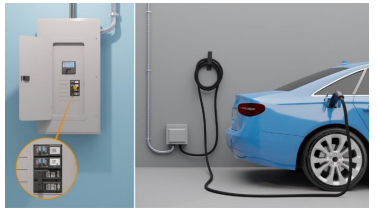
EV Smart Breaker Charger

EV Smart Breaker Charger



Direct Connect Kit

- **7.7 kW, 240 VAC, 32 Amp**, Smart Charger, J1772 Connector, 25' Cable & Cable Bracket.

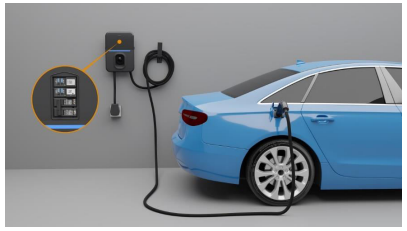


Direct Connect Kit + Junction Box

****For applications more than 25' from a Load Center or Panel Board**

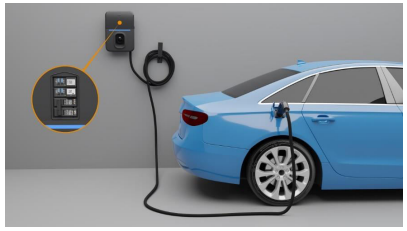
- **7.7 kW, 240 VAC, 32 Amp**, Smart Charger, Junction Box, J1772 Connector, 25' Cable & Cable Bracket.

EV Smart Breaker Charger



Plug-In Version

7.7 kW, Smart Charger 240VAC, 32 Amp, J1772 Connector, 25’ Cord, Built-In Cord Management, NEMA 14-50 plug



Hard Wired

7.7 kW, Smart Charger 240VAC, 32 Amp, J1772 Connector, 25’ Cord, Built-In Cord Management

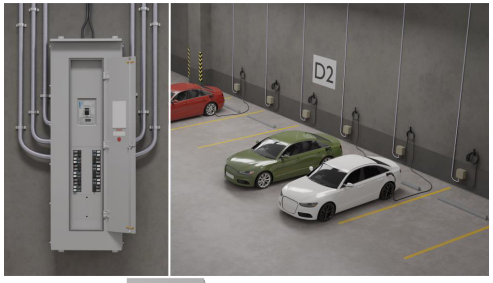
Manage individual charging with ease

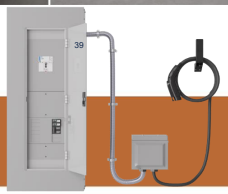
EV Charger Manager app

- Easily commission charger and connect to Wi-Fi
- Monitor and control charging status from anywhere
- Remotely start and stop charging sessions
- Schedule charging sessions during off-peak times
- Receive notification on charging status, power outage and ground fault
- Track energy usage with real-time statistics and insights
- Manage multiple users and chargers

EV Panpelboard using EV Smart Breaker Chargers

- EV Charging Smart Breakers (EV Chargers) integrated in panelboards for cleaner, cost effective installations
- Expandable up to 6 Chargers per Panelboard for PRL3X designs and up to 18 Chargers in IFS (Integrated Facility Systems)
- Better protection against vandalism, expensive components hidden inside a supply closet
- Adding new EV chargers is as easy as adding a new circuit breaker.
- Remotely monitor EV chargers, manage access to users and control the rate of charge (load management)
- OCPP 1.6J enables integration with your preferred charge management solution.





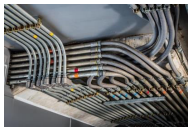
EV Busway provides a comprehensive overhead charging solution for fleets

Leveraging Eaton’s vast power distribution experience:

- Compact compared to cable/conduit
- Can provide a cleaner installation
- Cost effective adaptability
  - Expand as you need
  - Busway fittings and taps
- Can relocate busplugs where the power is needed
- Can quickly and easily add busplugs

Solution includes:

- 80A EV Bus Plug (19.2kW @ 240VAC)
- Integrated 100A circuit breaker
- 25’ cord-set with J1772
- Busway system
  - Plug-in busway segments
  - Cable tap box or bus flange for connection to switchboard/panelboard
  - Non plug-in segments for areas not needing charging
  - Other options as necessary to build out the solution including elbows, thru-wall flanges, tees, offsets
- Cable Management system



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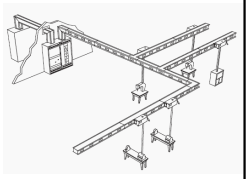
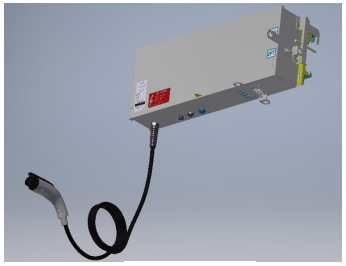


EV Busplugs



Energy Storage: xStorage 250-1000

250kW 1-hour configuration

1000kW 1-hour configuration

Ratings
250kW to 1000kW
- Parallel for higher capacity

250kWh or 340kWh cabinets
- Parallel for longer run times

Listings
System: UL 9540
PCS: UL 1741 SA, IEEE1547
Batteries: UL 1973, 9540A

Applications
EV Fast Charging
Peak Shaving
Load Shifting
Demand Response
Backup Power
Solar Self Consumption

PCS
480V AC
760-1500V DC
60Hz
>98% efficiency
58" x 62" x 90" WxDxH
3500lb
NEMA 3R
Liquid cooled

Battery cabinet
CATL 280Ah LFP
8000 cycles, 70% @ end of life
-25°C to 55°C ambient
Fire suppression
52" x 52" x 92" WxDxH
7800lb
IP66
Liquid cooled

Communications
Modbus TCP
4G / 5G network
REST API
- Telemetry data
- Alarm conditions

Brightlayer PredictPulse™
- Remote monitoring
- Energy management controls
- Analytics

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Eaton EV Charging Software Solutions

Manage EV Smart Breaker Charger with ease

Green Motion EV Charger Manager app

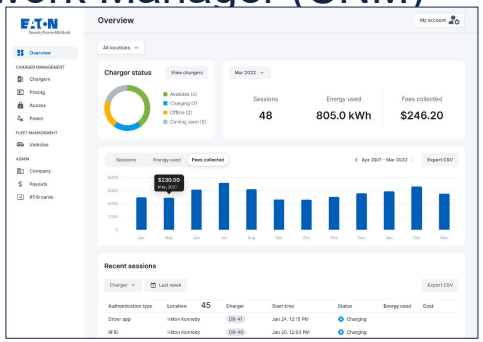
GET IT ON Google Play

Download on the App Store

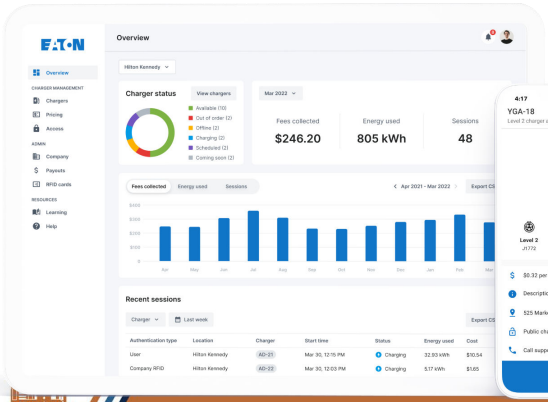
- Residential app focused on the Electric Vehicle driver
- Easily commission charger and connect to Wi-Fi
- Monitor and control charging status from anywhere
- Remotely start and stop charging sessions
- Schedule charging sessions during off-peak times
- Receive notification on charging status, power outage and ground fault
- Track energy usage with real-time statistics and insights
- Manage multiple users and chargers

Eaton Charging Network Manager (CNM)

- Eaton's charging network manager software provides the all-in-one management system to control you charging stations. This tightly integrated Electric Vehicle charge station and management software solution provides a robust, reliable, easy-to-deploy and easy-to-manage product suite for applications ranging from fleet to commercial to residential.



Admin User Experience



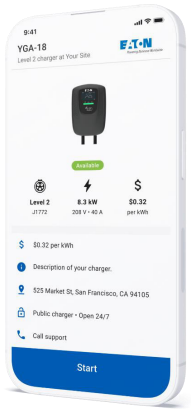
- Dashboard
- Station status
- Access control
- Pricing policy creation
- Vehicle association
- Basic reporting
- RFID configuration

Driver Experience

- Approach the station
- Scan the QR code sticker with your mc
- Login if required for access or payment
- Plug-in and walk away

Scan me →

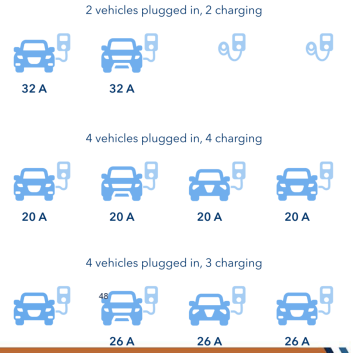
EJC-DEMO-0112
1 (800) 796-0478



Cut capex spend with power management

Power management is your built-in rebuttal for cost-sensitive customers. Our partners have reported saving up to **$400K** compared to the cost of infrastructure upgrades.

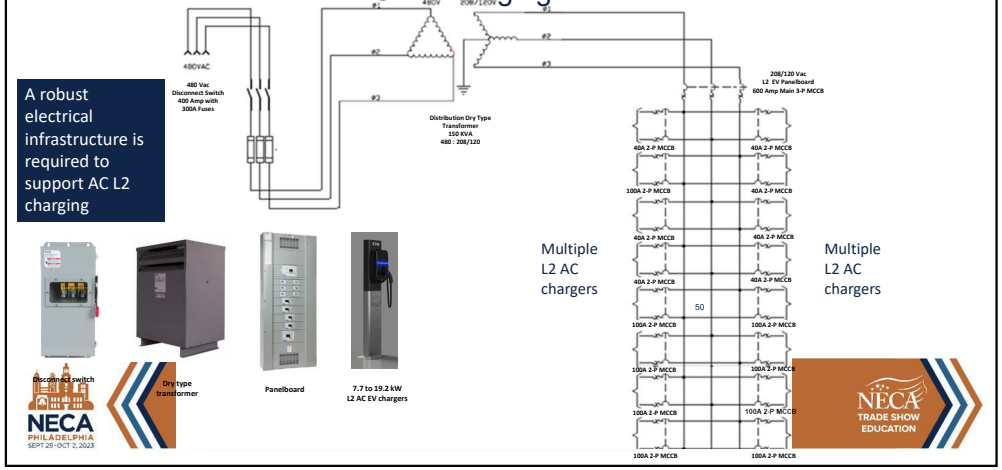
- Active load balancing adjusts output amperage based on the number of vehicles charging and the amount of power they're consuming.
- You can view power allocation and usage and directly in the dashboard.
- Get flexibility as you scale. Save now, and install up to **4X more chargers** on a limited electrical service. Our solution is **guaranteed** not to trip your breaker.



Eaton EV Infrastructure Solutions

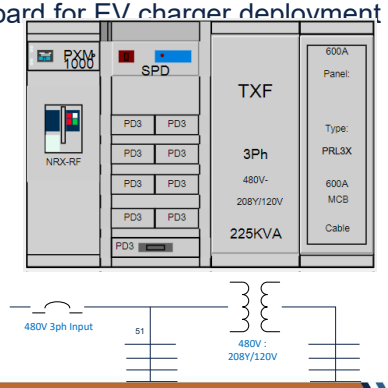
A closer look at AC L2 charging electrical infrastructure

A robust electrical infrastructure is required to support AC L2 charging

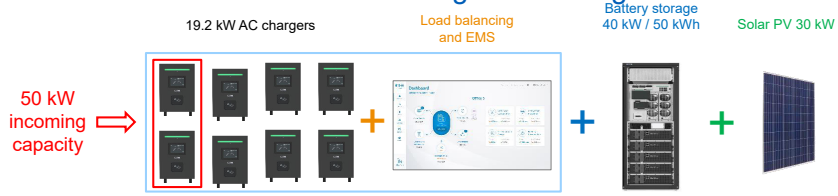


Integrated Facility System (IFS) Switchboard for EV charger deployment

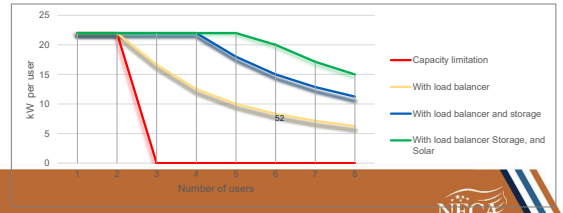
- Compact all-in-one infrastructure package



Further off-set the strain on the grid by co-locating Distributed Energy Resources & using load management



- The combination of DER management, energy storage and solar allows increased
  - **number of chargers installed**
  - **available power per charger**
- Leading to
  - **better user experience** at peak time
  - improved business performance
  - potential for **grid support**



Key take aways

Learning objectives

- Gain an awareness of the different electric vehicle charging station levels and capabilities.
- Learn about the nuances of designing an electrical system to support electric vehicle charging.
- Review and compare electric vehicle charging solutions available.
- Gain an awareness of the software management platform used to monitor and control electric vehicle charging stations.

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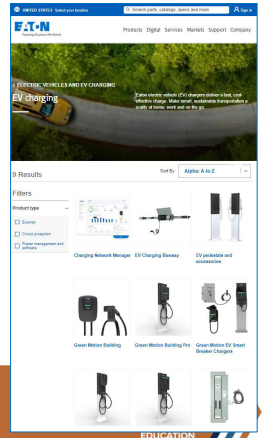
Questions?

Additional resources

- Eaton EV Charging Solutions
- Connect with your local Eaton representative for additional information
- Connect with your local Eaton Application Engineer for design support



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Complete the Online Evaluation

NECA PHILADELPHIA SEPT 29-OCT 2, 2023

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