Joint Office of Energy and Transportation

Electric School Bus Familiarization Webinar Series
Module 4: Charging Overview

11/20/2024

driveelectric.gov

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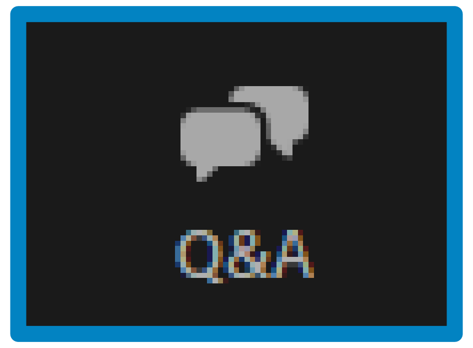

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Mission and Vision

JOINT OFFICE OF
Energy and Transportation

Mission

To accelerate an electrified transportation system that is affordable, convenient, equitable, reliable, and safe.

Vision

A future where everyone can ride and drive electric.

BIL Programs Supported by the Joint Office

The Joint Office will provide unifying guidance, technical assistance, and analysis to support the following programs:

National Electric Vehicle Infrastructure (NEVI) Formula Program (U.S. DOT)
$5 billion for states to build a national electric vehicle (EV) charging network along corridors

Charging & Fueling Infrastructure (CFI) Discretionary Grant Program (U.S. DOT)
$2.5 billion in community and corridor grants for EV charging, as well as hydrogen, natural gas, and propane fueling infrastructure

Low-No Emissions Grants Program for Transit (U.S. DOT)
$5.6 billion in support of low- and no-emission transit bus deployments

Clean School Bus Program (U.S. EPA)
$5 billion in support of electric school bus deployments

Clean School Bus Technical Assistance

The Joint Office of Energy and Transportation (Joint Office) is providing **FREE** technical assistance for the EPA's Clean School Bus program

Technical Assistance Offerings:

- **Fleets receiving funds or planning to apply are eligible**
- Proactive and reactive, hands-on assistance tailored to each fleet
- New and updated tools and resources.

Clean School Bus Technical Assistance

CleanSchoolBusTA@nrel.gov

driveelectric.gov/contact

Examples of How We Can Help

- Electric utility coordination
- Identifying available funding and incentives
- Analyzing charging infrastructure needs
- Conducting route analysis and planning
- Conducting training and workforce development
- Bus evaluation
- Analyzing energy needs and grid impact
- Identifying solar and battery storage opportunities

New Electric School Bus Familiarization Webinar Series

Brought to you by:

- Joint Office of Energy and Transportation
- National Renewable Energy Laboratory (NREL)
- International Transportation Learning Center (ITLC)
- School bus manufacturers
- Charging manufacturers

- Four-part module-based series for operators, technicians, and other school bus fleet members.
- Learn fundamentals of electric school bus (ESB) technology.
- Live Q&A during each session.
- Recordings with testing materials for internal training programs.

Agenda

Introduction from Ryan Frasier, National Renewable Energy Laboratory (NREL)

Presentations moderated by the International Transportation Learning Center (ITLC) with Q&A after each presentation

Charging Overview and Technology

- Brad Beauchamp, EV Product Segment Leader

Facility Operations and Considerations for ESBs

- Stephen Kelley, Chief Revenue Officer

Charging Standards, Maintenance and Safety

- Richie Beebe, Director of eMobility Service

Today's Moderator

John Schiavone
International Transportation Learning Center (ITLC)

Welcome

- ITLC Mission – advance training on joint labor-management basis
- Organized similar webinar series for transit buses
- Purpose – provide introductory information

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Key Terms

AC (Alternating Current) Powers drive wheels	**CAN (Controller Area Network)** Vehicle data communication	**Charging Port** Accepts external charging plug
DC (Direct Current) Battery voltage	**DC-DC Converter** Converts DC HV to lower DC voltages as needed	**ESS (Energy Storage System)** 400-900V DC battery pack
HVIL (High Voltage Interlock Loop) HV safety disconnect	**HVJB (High Voltage Junction Box)** Protected HV connections	**Inverter** Converts DC HV to AC
Regenerative Braking Uses braking energy to charge batteries	**Traction Motor** Uses AC to power vehicle (replaces ICE)	**V2G (Vehicle-to-Grid)** Uses bus to supply grid, other AC sources

Previous Webinars

Module 1: Operator Overview –

Drivers play a major role in extending battery life and range

Module 2: Technology Overview –

Direct Current (DC) from batteries is converted to Alternating Current (AC) to power Traction Motor and Wheels

Module 3: High Voltage Safety Considerations – High Voltage requires specialized training, tools and equipment to remain safe

- Basic electrical understanding becomes an essential prerequisite.

All modules available as downloads at: Electric School Bus Familiarization Training

Presentation 1

Charging Overview and Technology

Brad Beauchamp

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Learning Outcomes

In this session, you will familiarize yourself with:

- **Describe School Bus Charging Considerations for Getting Started**
- **Examine Charging Options**
- **Identify Basic Charger Terminology and Components**
- **Compare AC vs DC Charging**
- **Compare Charging Times**
- **Identify Transformers, Switch Gear and Service Disconnects**

Electric School Bus Market

- There are projects that are approved for 12k+ ESBs (over 5 years)
- There are about 3500 to 4500 ESBs running routes daily
- School Bus is a roughly 30k to 40k volume per year in the US
- There are nearly 500k opportunities for replacement
- Type C is the current volume leader (but many will accept Type D)
- There continues to be a driver shortage driving some change

What are we Charging "Fuel Tank"

The primary types of batteries used in electric vehicles today are: **lithium-ion (Li-ion), solid-state batteries, and emerging technologies like lithium-sulfur and sodium-ion.** Lithium-ion batteries are the most commonly used in electric vehicles due to their **high energy density, longer cycle life, and declining cost.**

The key components of a lithium-ion battery are:

1. **Cathode:** Typically made from materials like nickel, cobalt, and manganese.
2. **Anode:** Usually composed of graphite.
3. **Electrolyte:** A liquid medium allowing lithium ions to flow between cathode and anode.

Li-ion batteries provide a balance between energy density (capacity) and longevity, but they have challenges, such as the need for rare materials like cobalt and concerns over thermal runaway.

School Bus Charging Considerations

Type C and Type D

Charge Time: 3-8 hours

- Typical 11.5kW to 30kW Charging

Range: 100-150 miles

- 100kW and 300+kW Battery Options

Capacity Up to:

- Type C 77 Passengers
- Type D 84 Passengers

GVWR up to:

- 33,000 lbs. Type C
- 36,200 lbs. Type D (some heavier)

Propulsion System:

- Chillers, Pumps, Compressors

Motor:

- 300+ HP & 2000+ ft-lb of torque (diesel like)
- Single Speed direct to axle (typically)
- Same axle found in ICE bus

School Bus Charging Considerations

Type C and Type D

Component draw – each component contributes to battery draw

- Battery e-heater: 10kW
- Cabin e-heaters: 20kW
- A/C chiller: 2.3kW
- A/C compressor: 1kW
- Power steering pump: 2kW – 10kW
- Air conditioning: 5kW – 13kW

Regenerative braking

Driver habits (regenerative braking and ease of acceleration)

Terrain

Ambient temperature

City vs. rural driving

Understanding range estimator on dash

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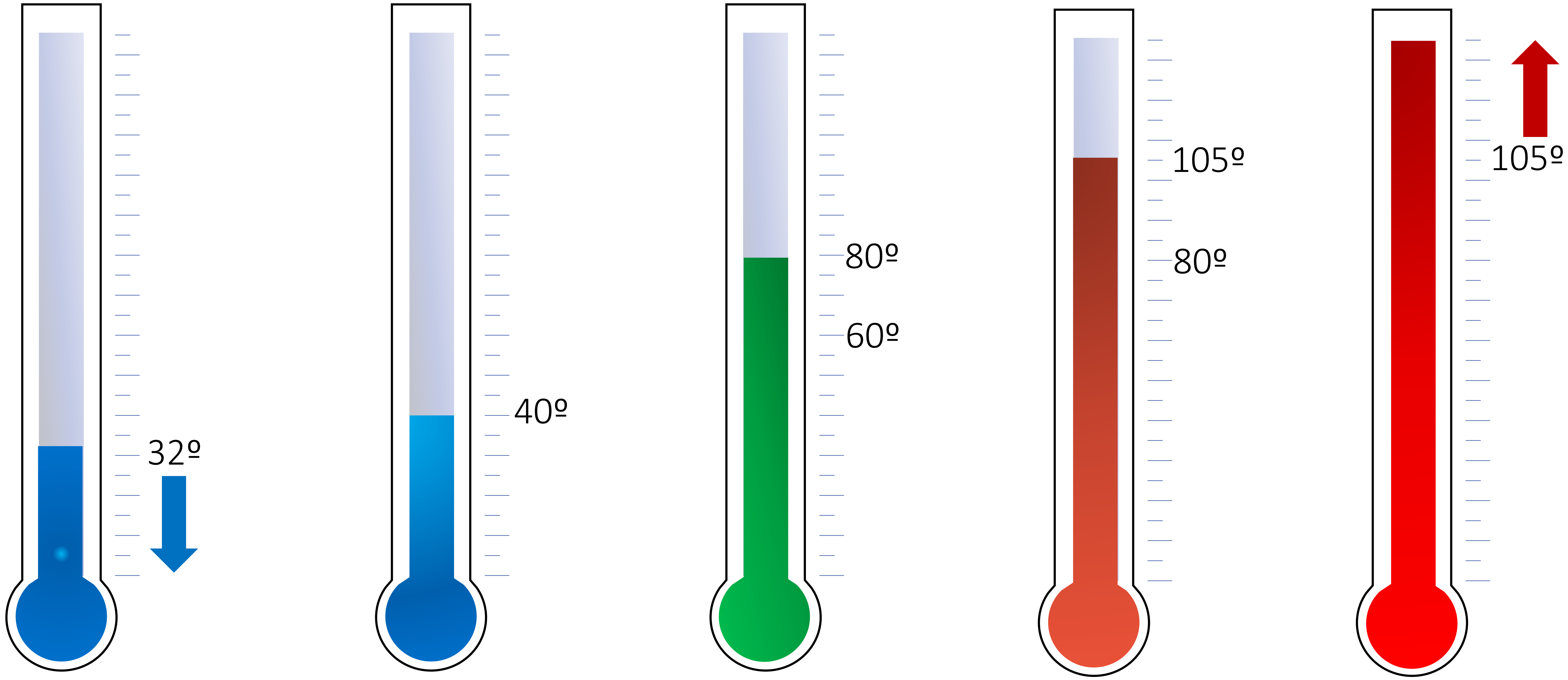
School Bus Charging Considerations

Thermal management heaters activated to raise internal battery temperature

Optimal operating range

Thermal management chiller activated to lower internal battery temperature



Batteries will not take a charge from the wall or regeneration

Batteries will charge up to 85% SOC <u>VERY SLOWLY</u>

Batteries will fully charge at normal charging rate

Batteries will charge up to 85% SOC at reduced speed

Batteries will not take a charge from the wall or regeneration

School Bus Charging Considerations

Thoughts to Get the Conversation Started

Good – LEVEL 2 - AC

- Simple Single Phase 240V power needed
- 10kW to 19.2kW (typical)
- Install can often be done with existing power
- Lower Cost Charging Equipment Available
- Good for Overnight Charging
- Starting Point for 1 to 5 buses

Better – Level 3 - DC Fast Charge

- Preferred if supplemental funding is available
- Most require 3 Phase Power
- 20kW to 60kW is typical
- Has potential to charge in less than 2 hours
- May have one for every 5 to 6 buses
- Enhanced Pre-Conditioning when needed

Best – Yard Planning Project

- Full Scale Infrastructure Phased Plan
- Not Commonly Possible

School Bus Charging Considerations

Thoughts to Get the Conversation Started

- Planning (where, how, when to charge); power requirements
- Fitting chargers in your facility/design considerations
- Managed charging; Charging management/software; Telematics
- Charger-vehicle communication interoperability
- Understanding and managing electricity costs (rate structures, managed charging)
- Depot Charging vs. Stand Alone (Take Home)
  - Demand Charges
  - Peak Tariffs
  - Site Load Management

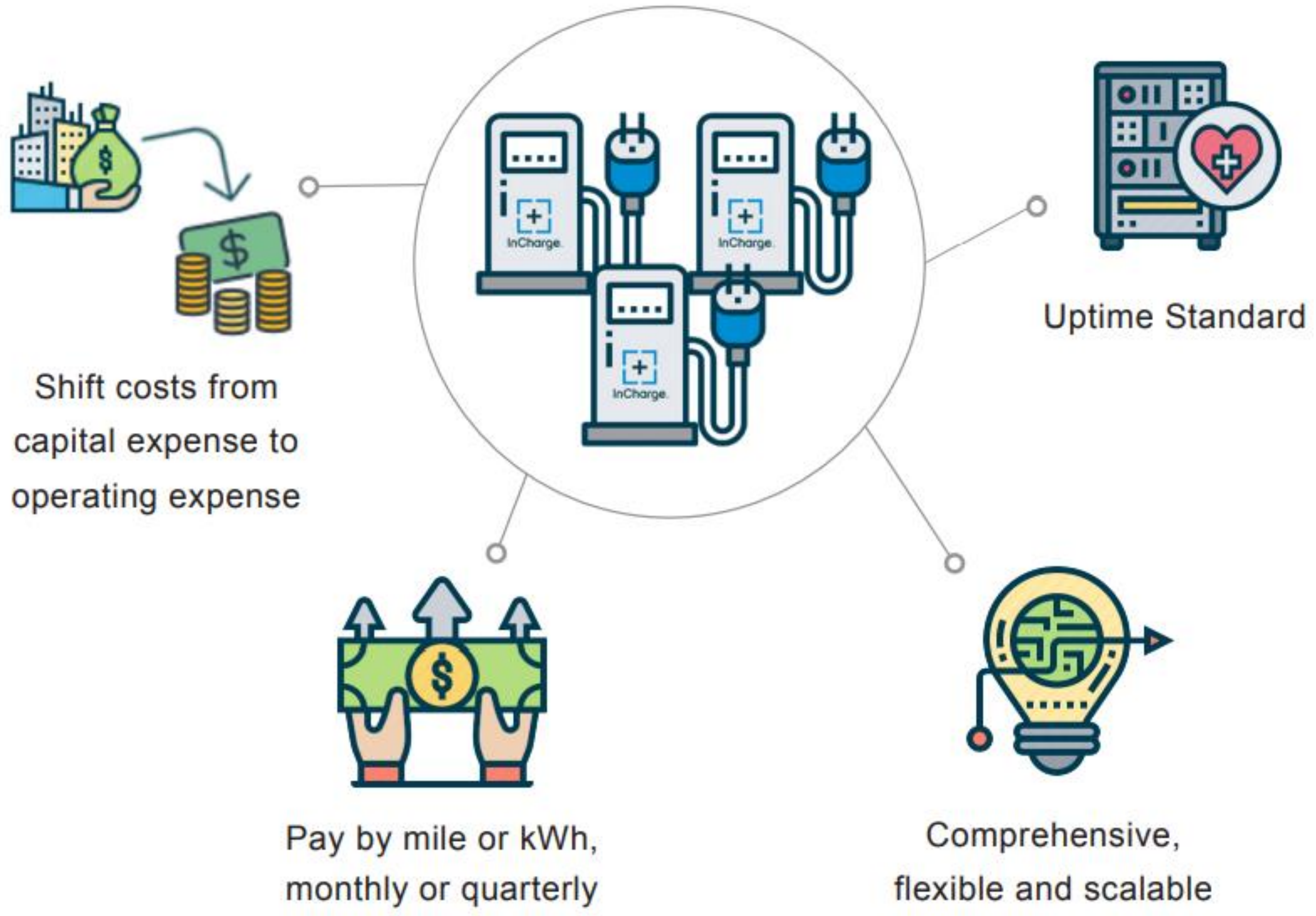
Charge Management

ESB are a great use of EVs but it is a different fleet to manage

Operators are finding large differences in:

- Charge management software capability
- Interconnectivity to elements being monitored
- Cost to charge and demand charges are being optimized
- V2G, V2B, V2V, V2X are able to be considered (beyond transportation and sometimes required)

Charging as a Service (CaaS)



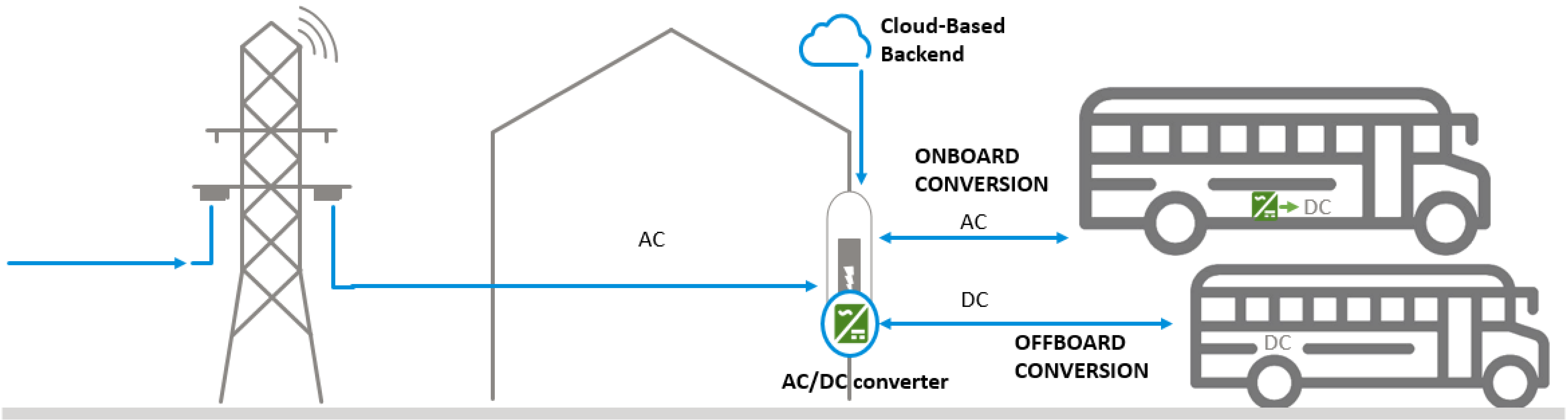
CaaS includes:

- Planning - route analysis, charging requirements, charge scheduling, etc.
- Design, engineering & permitting
- Equipment: chargers, battery energy storage, etc.
- Installation & commissioning
- Service & maintenance
- InControl Fleet Management Software
- Extended warranties
- Grant & incentive applications

Additional options:

- Electricity
- Renewable energy
- Real estate

Charging Options



POWER SUPPLY

AC transmitted over long distances

CHARGING

Two options

- DC-charging: AC/DC conversion in charging station
- AC-charging: AC/DC-conversion in vehicle

PHEV/BEV CHARGING

- Charge plug not powered until plugged into and commanded by vehicle
- Supply equipment signals presence of AC input power
- Control Pilot function

Charging Infrastructure 101

Living in an AC World

Most electrical infrastructure is based on AC. Therefore, converters are needed to convert AC to DC when charging of batteries is to occur. All chargers are fed by AC.

Alternating Current (AC): Efficient for transport over long distances

Direct Current (DC): Travels one direction. DC is needed to charge a battery

Kilowatt: (kW): Rate of energy flow (water metaphor: gallons per minute a hose can deliver)

Kilowatt Hour (kWh): Quantity of electricity (water metaphor: a gallon)

Kilowatt per Mile: The unit in which efficiency is measured. How many kWh does it take to drive a mile?

If you plug in your EV to a 50-kW charging station running at full power for 1 hour (50 kW x 1= 50 kWh)

Basic Charging Terminology

What is a Watt, Amp, Volt, Kilowatt and Kilowatt-hour?

Ampere (Amp, A)

This is like the amount of electricity flowing through a wire. More Amps means more electricity is flowing. Similar to the amount of water flowing through a pipe. The higher the current the larger the diameter of the cable.

Volt (V)

This is like the pressure pushing the electricity along. Higher voltage means more "pressure", which can push more electricity (Amps) through the system.

Kilowatt (kW)

A unit of measurement for the **rate of power** an electrical device or load consumes. The higher the rating, the more electrical power is required for the device to function. One kW is equal to 1,000 W.

Kilowatt-Hour (kWh)

The measurement of energy **usage** of an electrical device or load. The higher the rate of power (kW) of an electrical device and the longer it is used (hours), the more energy it consumes (kWh).

Charging Terminology & Battery Management

Battery/Charger Communication (BMS)

Battery Management System (BMS)

Software that allows the **"pack"** to communicate with the vehicle, accessories and charger. It allows the cells, modules and packs to charge and discharge in parameters for maximum and safe utilization of the energy storage of battery.

Pack Communication

The method the pack communicates internally to the cell level and with the outside world it serves. Takes on energy from charger, and provides energy to run accessories and propulsion in the most efficient and safe manner it can.

DC to DC (Buck Booster)

On-board current and voltage "traffic control" to satisfy the requirements of the EV and the outside world that serves it. Raises, lowers and distributes the needed voltage and current in the DC side of the system.

AC to DC Converter

Takes the Alternating Current (AC in Single and Three Phase) and uses diodes to turn it to Direct Current (DC). Alternators in vehicles have been doing this for more than 60 years!!

DC to AC Inverter

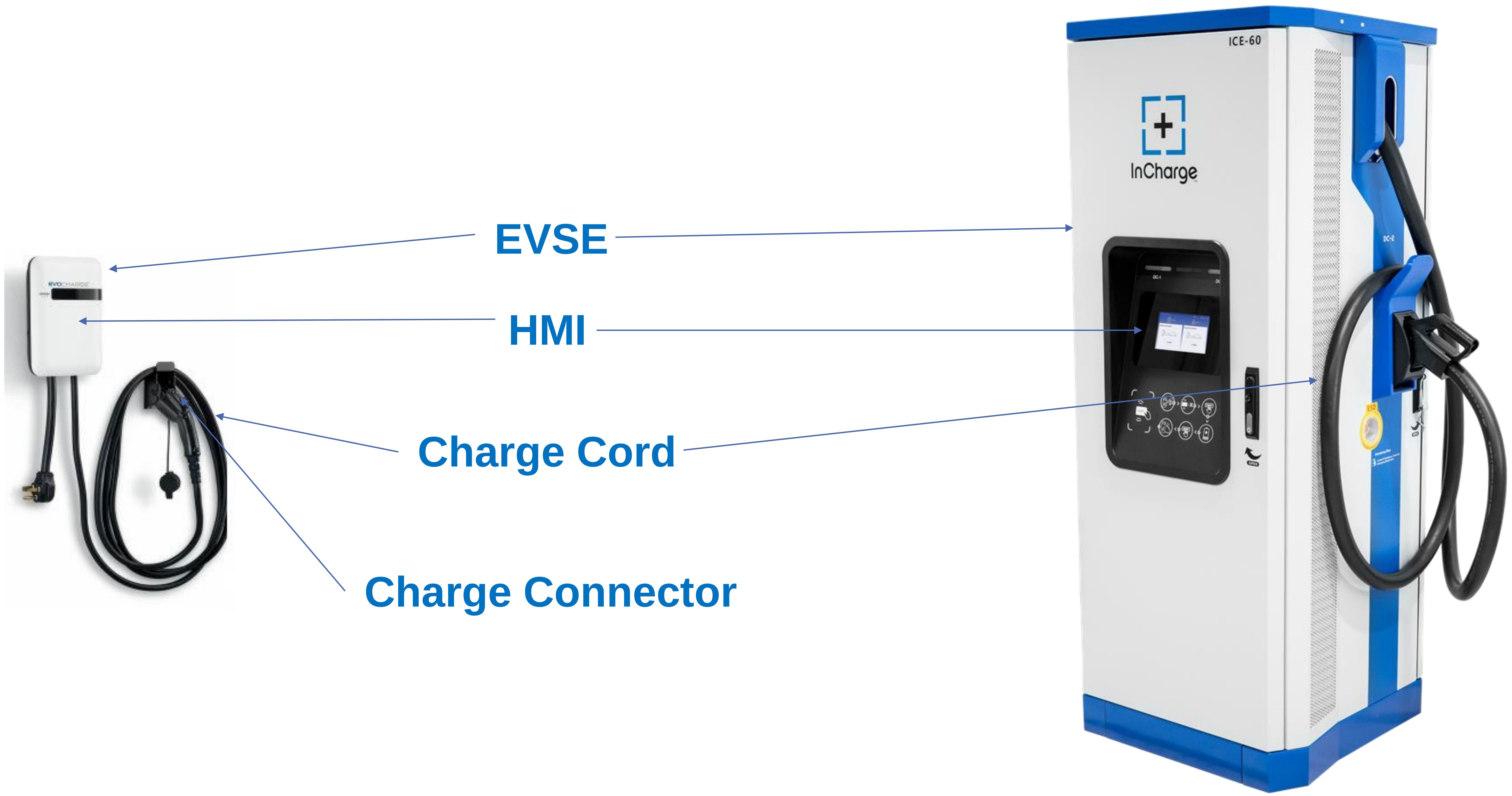
This is taking the Direct Current (DC) and electronically turning it to Alternating Current (AC).

Basic Charger Terminology and Components

1. EVSE – Electric Vehicle Service Equipment; “The Charger”
2. HMI – Human Machine Interface; “Buttons, Screens or Switches for Operation”
3. Charge Cord – The Cable on the Charger for electricity flow to the Charge Connector
4. Charge Connector – Connects the Charger to the Vehicle

Both AC and DC at all levels have similar interface

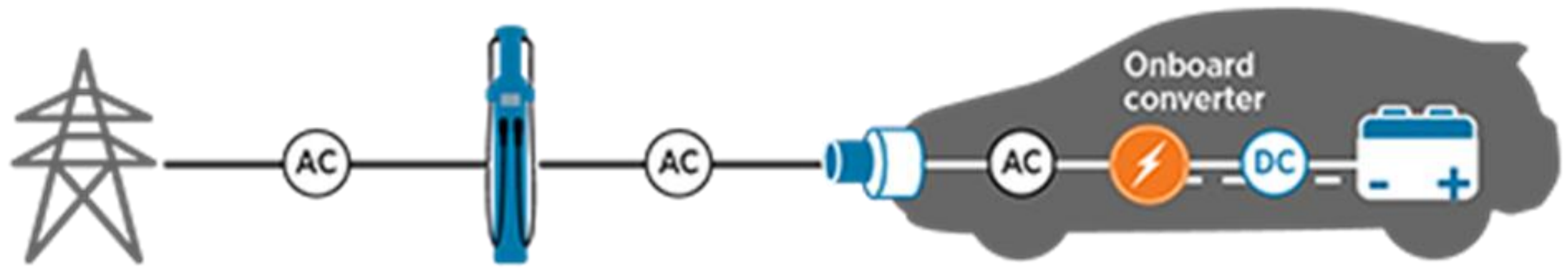
J1772 CCS1 – Connector Type and Compatibility



Charging 101: AC vs DC Charging

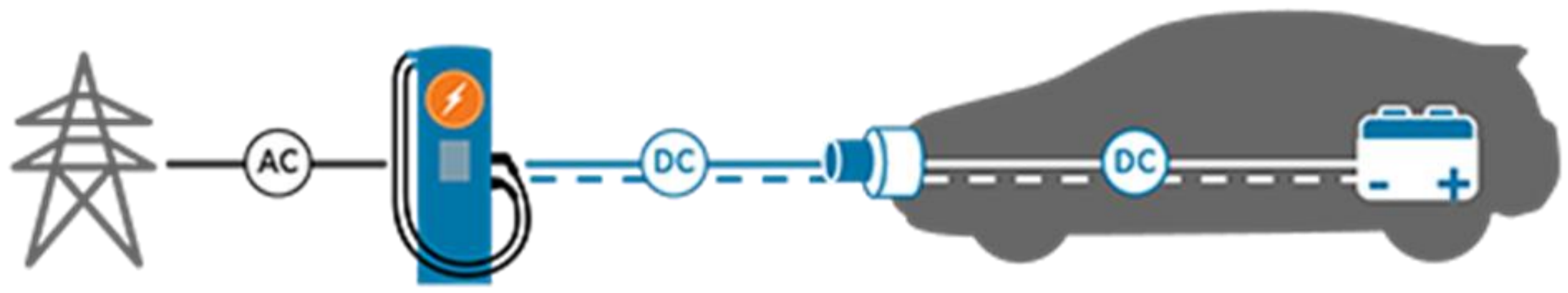
AC Charging

AC charging, sometimes called "Level 2", delivers electric power to the vehicle, which the vehicle then converts to DC – or battery – power using an onboard converter. AC uses single phase power



DC Charging

With DC charging, or "DC fast," the charger itself converts AC power to DC before delivering it straight into the vehicle's battery DC usually uses 3-phase 480v power.



Max Charge Rate and Sizing a Charger

AC Charging

- Determine the maximum charge rate by checking the onboard converter of the vehicle. Can be found in the owner's manual, the manufacturer's website, or by consulting with the dealer.
- To size a charger, identify the capacity of the vehicle's onboard converter. Charger's power output should **match** this capacity. If a vehicle has an onboard converter that can handle up to 7.4 kW, an ideal AC charger would be 7.4 kW. You can exceed this to future proof the site.

DC Charging

- Maximum charge rate is determined by the charger and the vehicle's acceptance rate. This can be found in the owner's manual, the manufacturer's website, or consulting with the dealer.
- To size a charger, identify the vehicle's maximum DC charging rate. The charger's power output is one factor, the others are dual time, Mile to KWH conversation, etc.

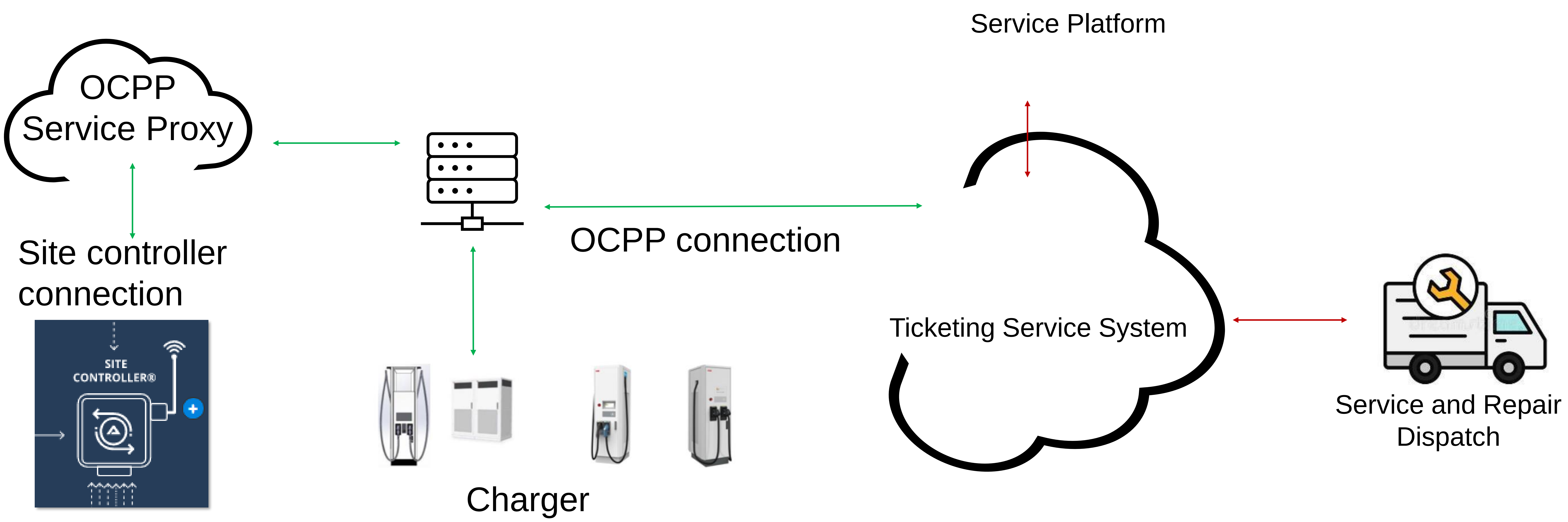
Dumb vs Smart Chargers (Dumb)

- Good in “portable” applications
- Can assist in determining if a bus has a charging issue
- Useful in the service shop for maintenance and repair
- Temporary charging at an alternate location

AC (Level 2) **Examples of Dumb Chargers** **DC Fast Charger**

Smart Charging

Remote management software are vertically integrated solutions that focus on lowering Total Cost of Ownership and focus on higher reliability and service



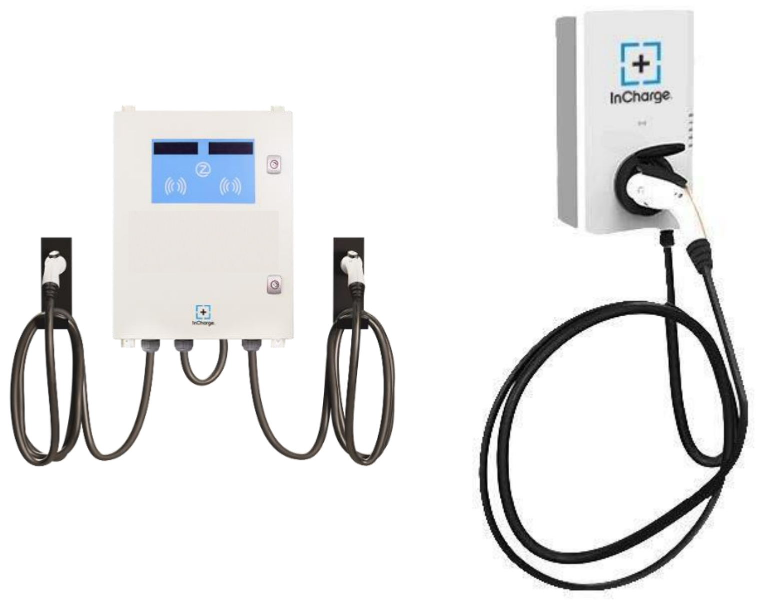
Charger Plug Types

	U.S.A.
Standard	SAE
AC	 J1772
DC	 J1772

Common Types of Chargers for School Buses

Typical charging times (AC vs DC)

AC Charging	DC Charging
< ~40 miles	40+ miles
Lower power requirements	Hilly or mountainous regions Cost-effective charging tariffs Accessible, flexible charging



Level AC Chargers	DC Fast Chargers
Level 2 (9.6 - 19.2 kW)	22 kW – 600 kW

How long does it take each charger to dispense 100 kWh*?

Voltage Input	Chargers	Power (kW)	Estimated time (in hours and minutes)
208Vac	ICE		
	40A	8.3	12 hrs
	80A	16.6	6 hrs
	Dual 80A	16.6	6 hrs
	ABB		
	Terra 40	8.3	12 hrs
	Terra 80	16.6	6 hrs
	Terra 24 1-Phase	22.5	21 hrs 22 minn
240Vac	ICE		
	40A	9.6	10 hrs 25 min
	80A	19.2	5 hrs 13 min
	Dual 80A	19.2	5 hrs 13 min
	ABB		
	Terra AC 40	9.6	10 hrs 25 min
	Terra AC 80	19.2	5 hrs 13 min
	Terra 24 1-Phase	22.5	4 hrs 26 min

480 Vac	ICE		
	ICE-30	30	3 hrs 20 min
	ICE-60	60	1 hr 40 min
	ICE-120	120	50 min
	ICE-180	180	34 min
	ICE-240	240	25 min
	ICE-360	360	17 min
	ICE-480	480	13 min
	ICE-600	500	12 min
	ICE-Cube	240	25 min
	22 V2X	22	4 hrs 33 min
	44 V2X	44	2 hrs 16 min
	66 V2X	66	1 hr 31 min
	ABB		
	Terra 24 3-Phase	22	4 hrs 33 min
	Terra 54/54 HV UL	50	2 hrs
	T124	120	50 min
	T184	180	34 min
	Terra HP	175	34 min
	Terra HP (dynamic 1 vehicle)	350	17 min

*note that these are estimates

Charging Infrastructure | Cold Weather

Initial Cell Temperature	Time required before charging starts (mins)
0C (32F)	9
-10C (14F)	39
-18C (0F)	45
-25C (-13F)	88

Limitations of Level 2 charging in cold weather conditions:

- Takes 8 hours to fully charge a 155kWh battery when temps are 70 degrees F.
- In cold climates, batteries must reach 40 degrees F to take a charge
- The Thermal Management System includes a 10kW heater dedicated to warming batteries
- While plugged into a 19.2kW Level 2 charger, this will leave only 9.2kW of power remaining to charge the batteries (19.2kW – 10kW = 9.2kW)
  - Could extend charge time to ~14 hours + additional time to get batteries to proper temperature to accept a charge

Transformers & Switchgear

Transformer

All encompassing term for stepping down (or up) the line voltage to satisfy the charger (EVSE) and vehicle requirements. Transformer output is rated in kVA (kilovolt-ampere) and is sized to meet the need of the chargers being installed.

Single Phase vs. 3 Phase

- Globally, AC Electricity is generated in three phase form, which allows efficiency for transmitting power over long distances.
- Three Phase is used at the end point for large electrical loads, like DC Fast Charging a School Bus battery. Not as readily accessible as single phase, so is often more costly up front for upgrades, but can have economic benefits over time.
- Single phase (common in the US and Canada) is using 1 of the 3 Phases. It is the common residential and commercial facilities. AC (Level 2) chargers largely operate off of single phase power.

Switch Gear

What controls electrical loads. It can be automated, remote or in some cases manually controlled. For fleet, or depot charging, it is a necessary component of the installation.

Service Disconnect

A method of turning electricity off to service the EVSE. Service Disconnects are common in hard wired components to allow safe repair or replacement of the equipment

When to choose AC Charging

AC Charger Recommendations

- AC Chargers provide a slower charge due to the conversion of AC to DC power within the vehicle. Recommended when the charging solution doesn't need to be immediate.
- Lower cost and if the infrastructure is single phase power (220v-240v).
- Due to this, AC Chargers are best for when the vehicle can be stagnant for longer durations, like overnight charging.
- Not all vehicles can accept higher charge capacities, making ACL2 Chargers a more cost-effective option.
- These chargers are also ideal for smaller battery pack requirements since they require less charging time to reach full capacity, making the chargers more practical and efficient.
- Shorter routes that consume less KWh to refill the battery.

When to choose DC Charging

DC Charger Recommendations

- DC Chargers are a quicker charging option because they eliminate the need to convert AC to DC power, making charging a more time-efficient option.
- DC Chargers are recommended for situations when vehicles have shorter dwell times, due to their capability of charging more vehicles at higher rates.
- Longer routes, larger batteries and shorter dwell times or multiple vehicles are better suited for DC charging because of the speed and efficiency.
- 480v 3-phase power already on site
- DC Fast Charging (DCFC) is another option that provides high-power DC charging at higher rates compared to standard DC chargers.
    - These are also good for quick public places, like rest stops or gas stations, for the shortest charging time.

Questions and Answers

Presentation 2

Facility Operations and Considerations for ESBs

Stephen Kelley

Learning Outcomes

In this session, you will familiarize yourself with:

- **Describe the elements of planning and power requirements**
- **Describe the considerations needed for fitting chargers and design considerations**
- **Discuss examples of location planning**
- **Explain the process of charger-vehicle communication and interoperability**
- **Explain managed charging, and the inclusion of charging management software and telematics**
- **Describe electric cost management**

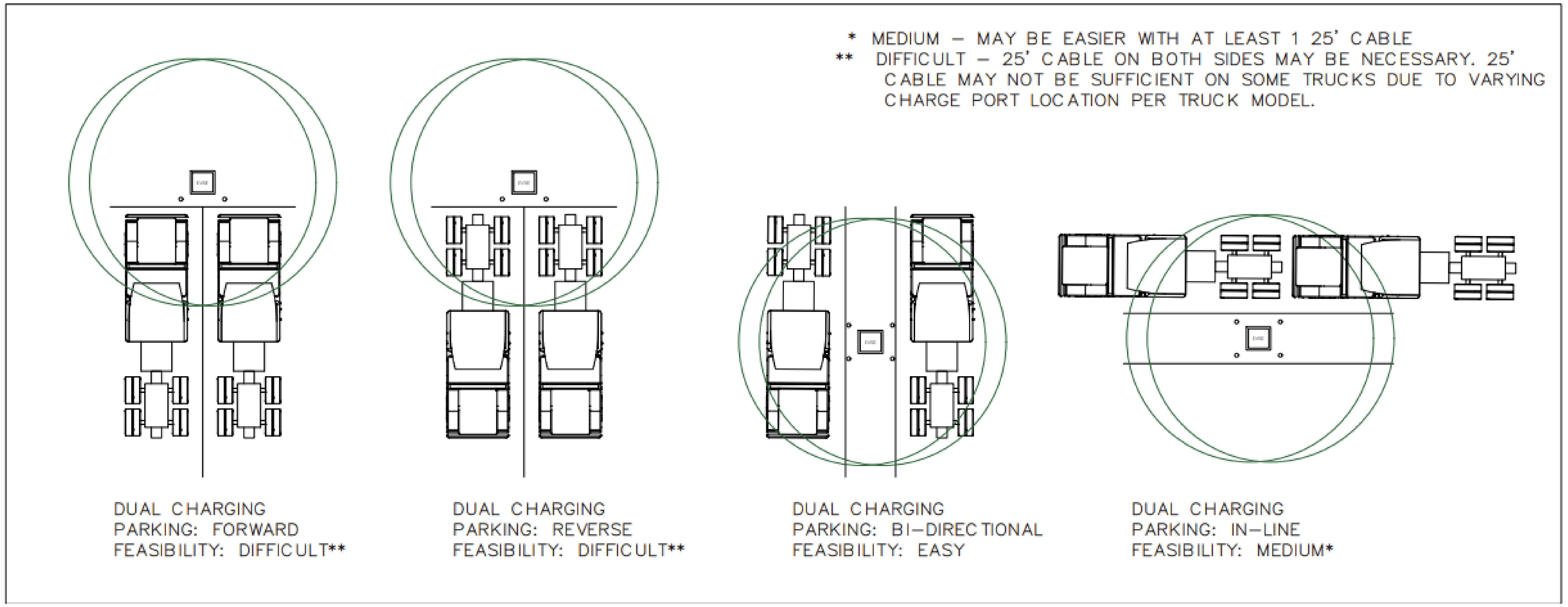
Agenda

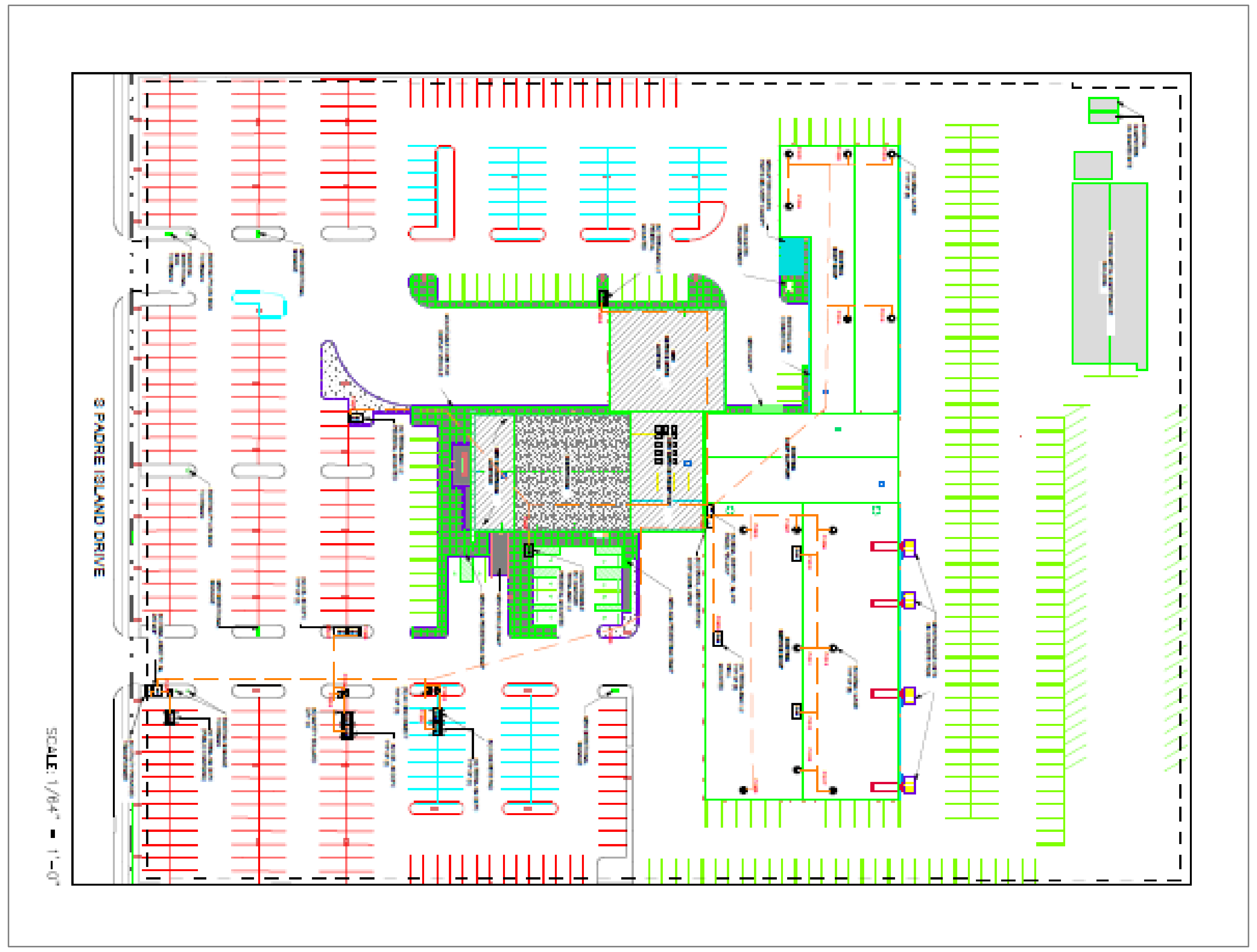
- Planning (where, how, when to charge); power requirements
- Fitting chargers in your facility/design considerations
- Charger-vehicle communication - sequence between bus and charger – interoperability
- Managed charging; Charging management/software; Telematics
- Understanding and managing electricity costs (rate structures, managed charging)

Planning

Get started with every advantage

Electrification of EV fleets is a new kind of endeavor for businesses looking into sustainability. Properly assessing all factors in fleet operations avoids expensive cost pitfalls with a comprehensive plan.





Planning

Fleet vehicle review

- Max vehicle charge rate
- Mile/kWh Conversion rate
- Thermal load management
- Battery Nominal voltage

Logistics analysis

- Miles driven
- Dwell time
- Operational flow
- Weather and terrain

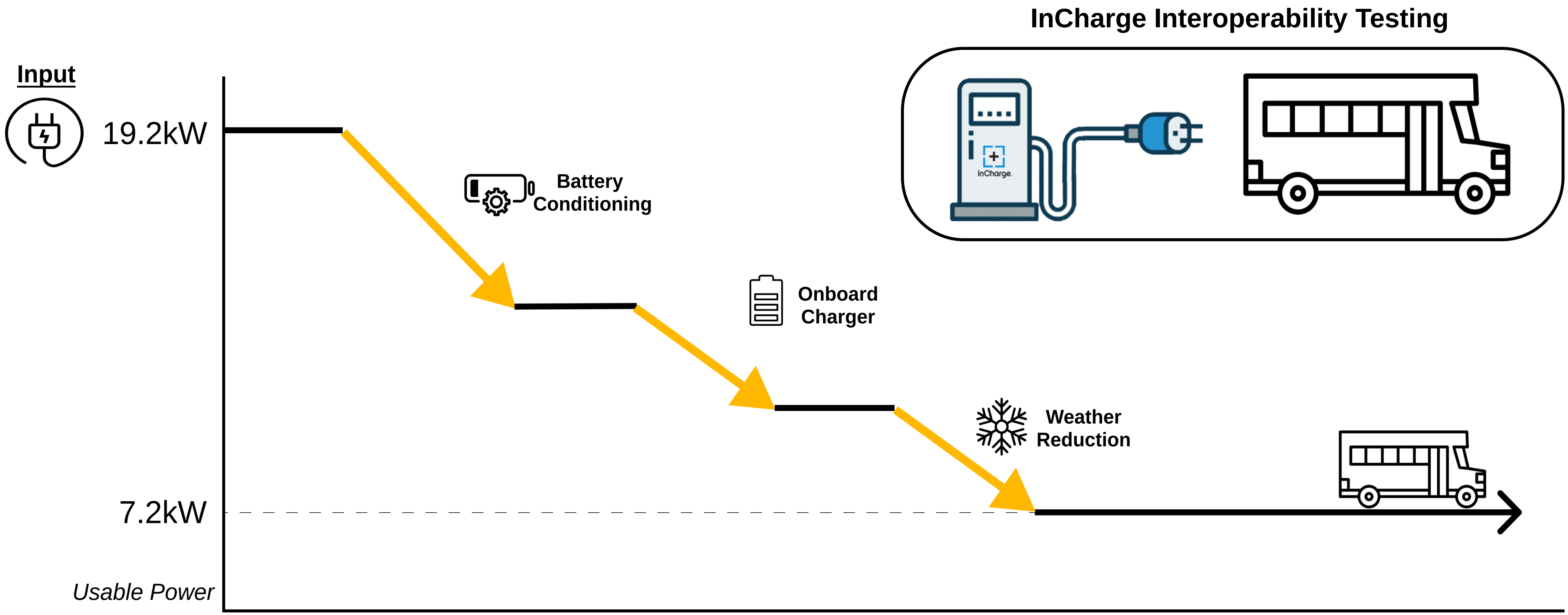
In-person site visit

- Available power
- 480v or 240v
- Panel location
- Charging port location
- Optimal charger location
- Future proofing

Utility

- Utility integration & coordination
- Charger recommendation
- Utility tariffs
- Financing/grant eligibility and application support

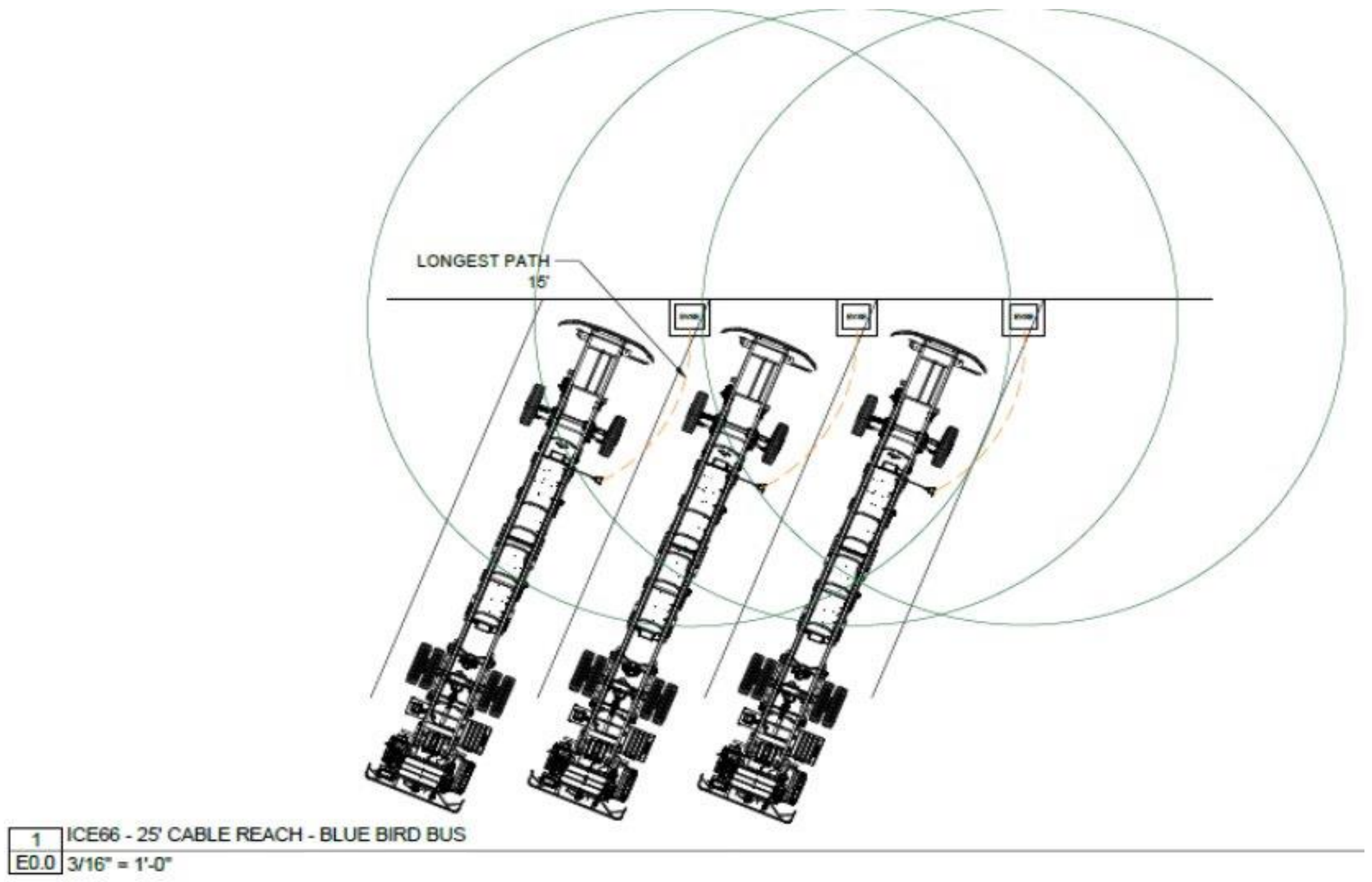
Fleet Vehicle/Logistics Review: The Charging Reality



Guiding Principles - Design

- Don't underestimate the value and amount of work
- Distance is the enemy (i.e. some energy lost as heat in a long run 16 ft. vs. 25 ft. cable)
- Reduce major civil work where possible (underground work, trenching, getting anywhere near water flow)
- Placement of chargers should fit the operations optimum traffic pattern
- On-site design verification (Google Earth can be deceiving. Conditions can change on the ground fast)
- Tariffs matter - incentives

Location, Location, Location



- Charger size based on all-day routing needs
- Physical location of charger impacts cable reach, user interaction
- Bus port location for the fleet (front or rear)
- Snow removal equipment needs impact bollards or wheel stops

New Services - Location

A new service requires real estate

- Pathway from utility pole to transformer
- Access to transformer typically 10 feet front
- Switchgear six feet in front with bollards around it
- Good – linear of charger lineup
- Best – middle of charger lineup
- Utility will drive most of these choices, but you can influence

What does it take to build a large site?

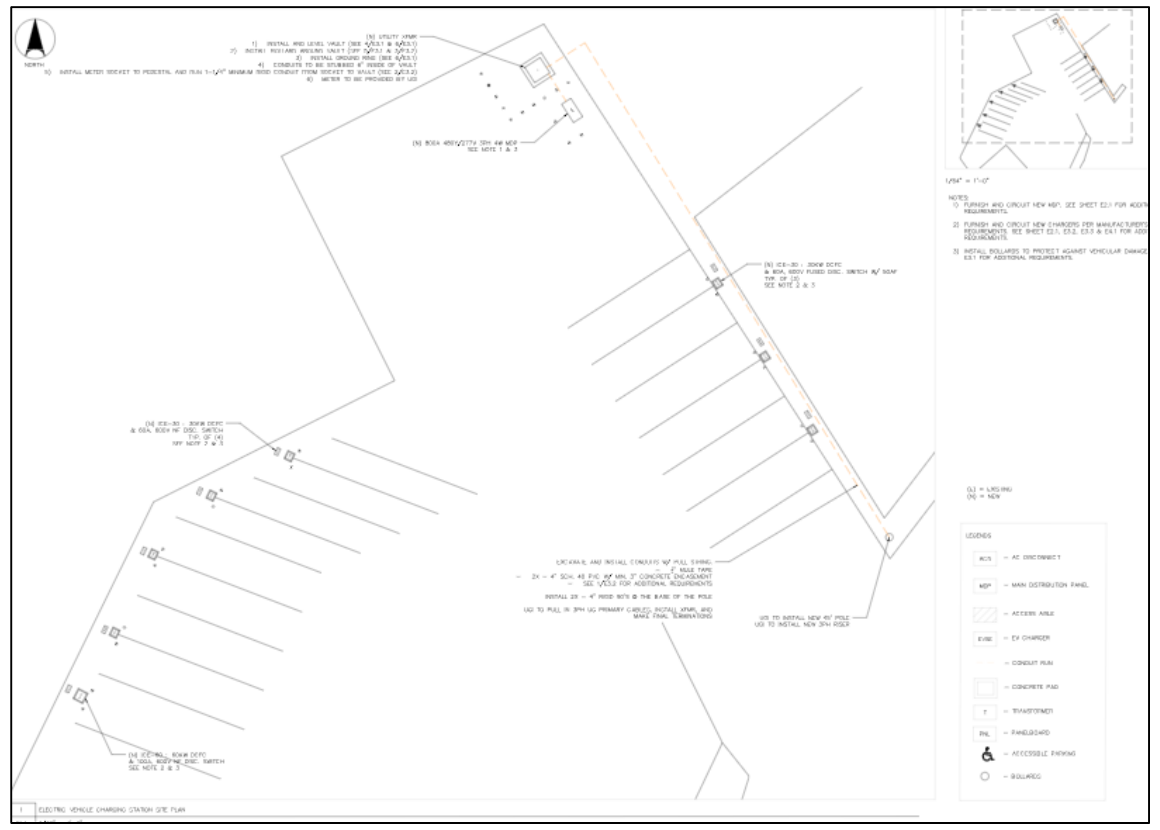
- Underground utility marking
- Trenching, pavement, cut, trenching disposal
- Nice clean dirt can hide a problem (you may not know what you find underground)

Utility upgrade impact

- Pathway from utility pole to transformer
- Requires concrete the entire length to encase the MV conduits
- Time, cost, operations planning around drive over areas

Example: White Transit School Buses: Nanticoke, PA

1. District awarded 15 buses through the 2022 EPA Clean School Bus rebate program
2. Route analysis determined 1-60 kW, and 7-30 kW dual cord 25-foot cable charger selection for buses
3. Brought in an 800-amp 480-volt service to the location
   - Futureproofed allowing the District to add more chargers
4. Safety requirements change from District:
   - Buses pull in
   - Bollards
   - Charger placement is more center/offset of a space not on the line to reach the charging port on the Thomas Jouley



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Flexible Installations

Compatibility is Key

Interoperability ensures reliability

Challenge

Finding compatible charging infrastructure to support your needs

Solution

Ensure interoperability testing occurred between the charger and vehicle and that the charger is right sized for route demands

Interoperability testing confirms compatibility between your chargers and your buses.

Select chargers based on their ability to meet your route demands.

The Importance of Interoperability Testing

EV and charger compatibility

Why are these tests important?

- Verify EV and EVSE compatibility
- Confirm in-built features work as expected (complete load management)
- Prevent charging during negative scenarios (during slack, current demand)
- Evaluate unique behaviors (every EV performs differently)
- Meet customer specific requirement(s) (i.e. length of time to enter sleep mode)

Increased Uptime & Reliability
Uncover potential problems in a testing environment before they happen in real-world scenarios.

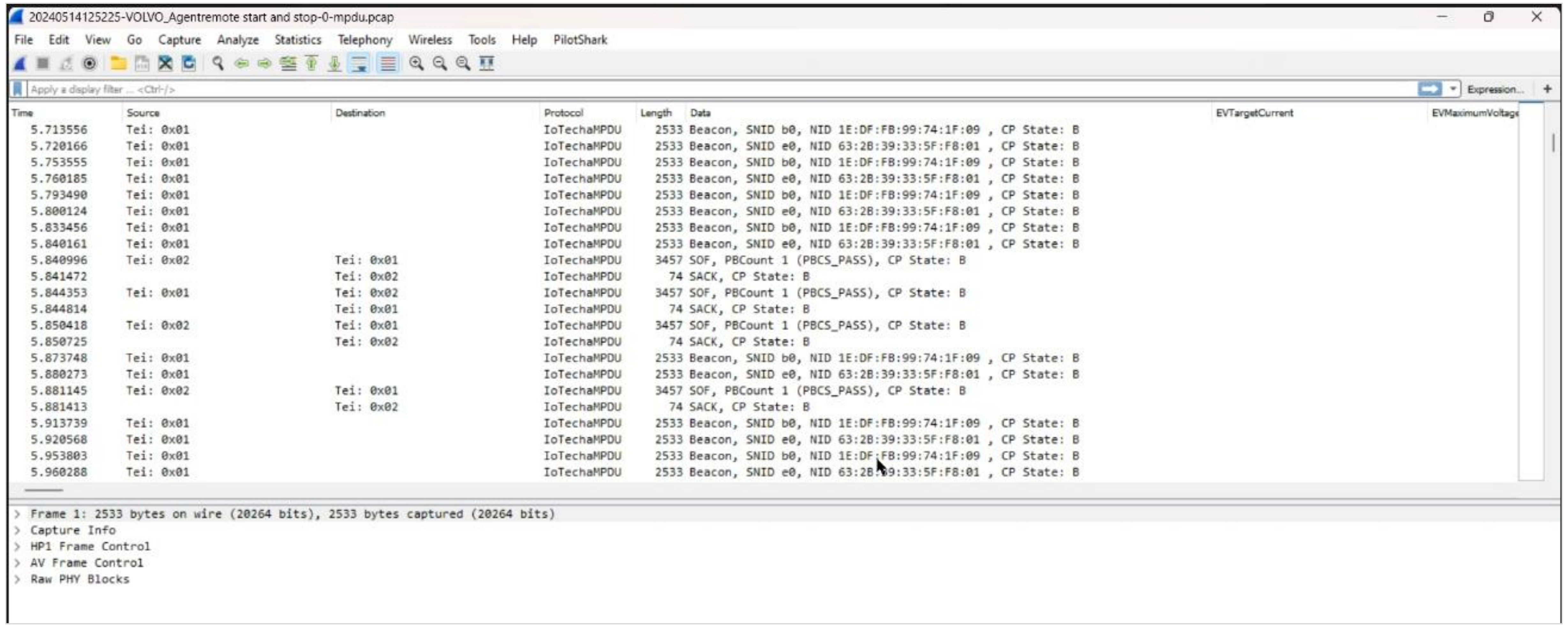
Ongoing Testing
Test new software and firmware updates prior to going into the field.

Charger & Vehicle Compatibility
Adapt to a variety of vehicle needs at every site with fleet charging capabilities.

Market Growth
Add vehicles to your fleet without the hassle of incompatibility.

Our Interoperability Process & Differentiators

23 tests for EV and charger compatibility



Differentiators in the process

- We test firmware to firmware for EV and EVSE
- We provide the PCAP files, check every element that meets the SLAC (complete communication protocol from the EV to EVSE)
- We provide the high-level reports for OEM partners.
- Competitors don't keep a record a record of the versions of the charger firmware, EV versions & EVSE
- We provide a lot of customized charging testing for every OEMs versus our competitor that only do general testing.

INTERNATIONAL TRANSPORTATION LEARNING CENTER

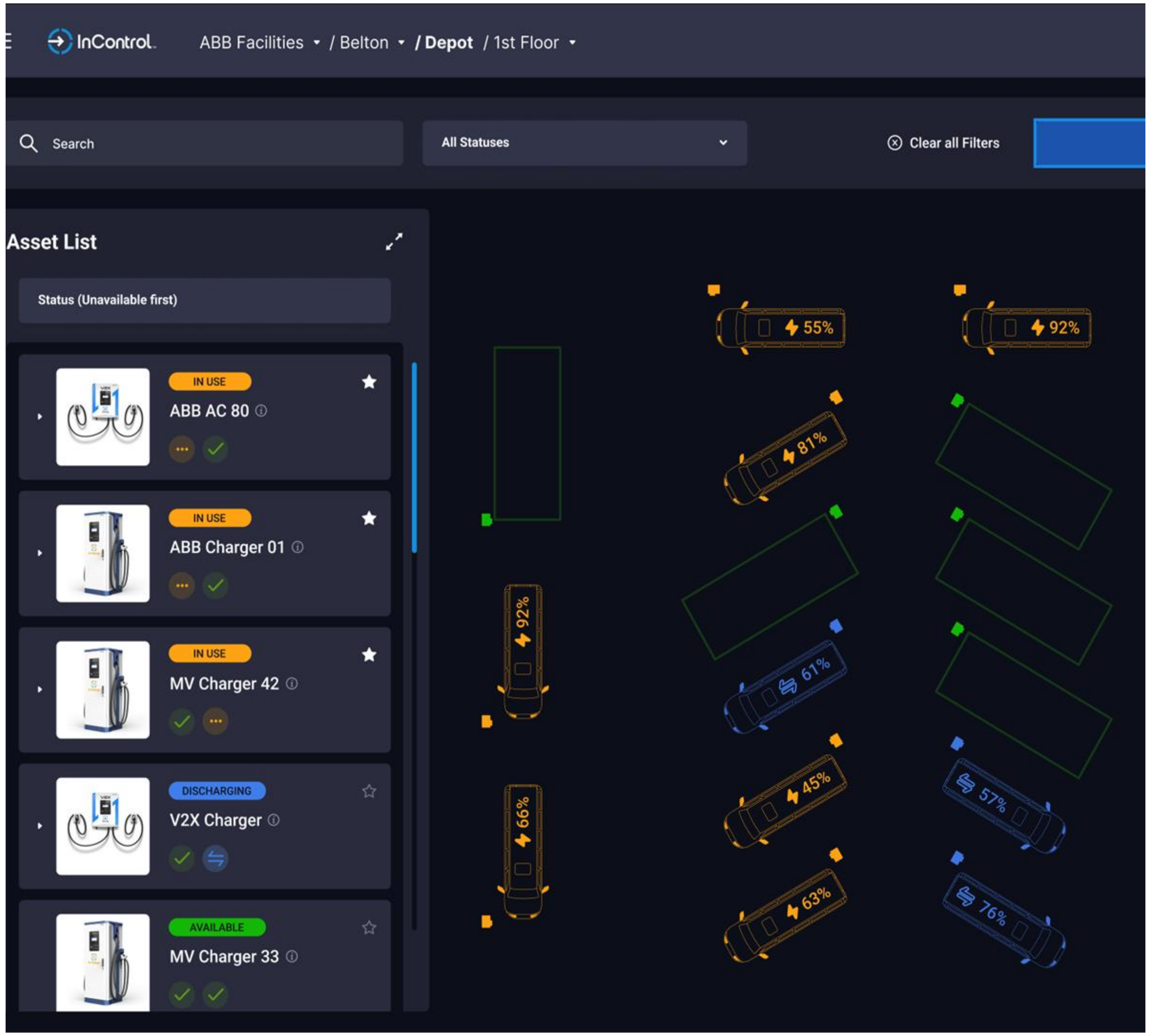
Our Interoperability Process & Differentiators

Testing Scenarios

1. Freevend Testing
2. Agent Remote start and stop
3. RFID / OTP
4. Autocharge
5. Power Limitation charging
6. Delayed Charging
7. Schedule start charging
8. Scheduled Stop Charging
9. Power Limitation Site level
10. Delayed Charging Site level
11. Schedule start Charging Site level
12. Schedule Stop Charging Site Level
13. PL with Schedule start and schedule stop Charger Level
14. PL with Schedule start and Schedule stop Site level
15. Timeout session Charging
16. Various way of stop Charging
17. High Voltage charging
18. Standalone Charging
19. Current Switch Charging
20. Plug Switch charging
21. Full Hold Charging
22. Alternative Charging
23. Smart Charging

Fleet Charge Management Software

How are fleets benefitting from InControl?



Lower installation cost

Quickly see if everything is working correctly

Lower your electric bill

Reduce demand and high energy costs

Reduced need for utility upgrades

Scale infrastructure without costly upgrades

Higher uptime and faster service

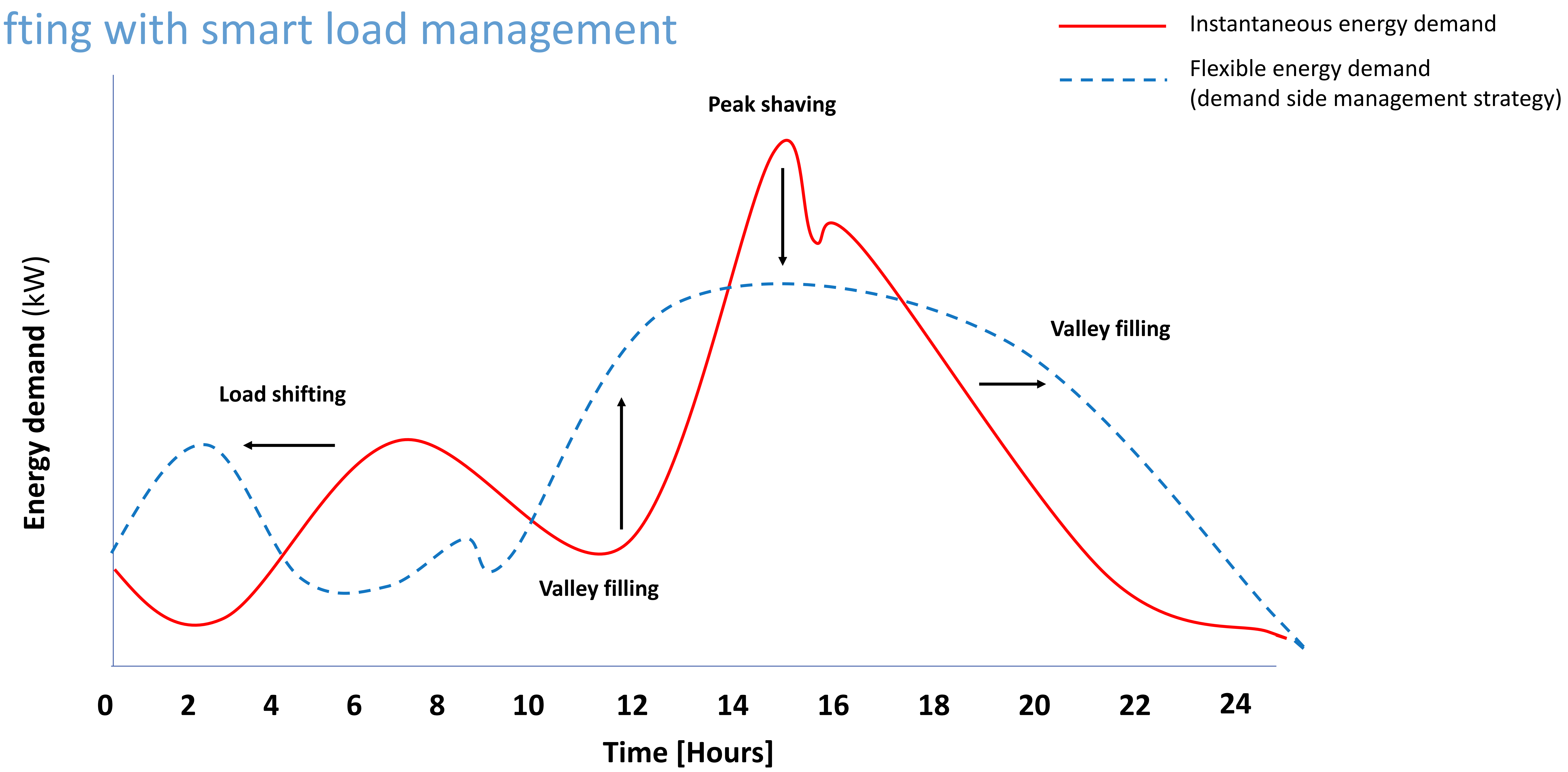
Remote reset and create service ticket
OEM integration

Data & analytics

Control tower analysis
API integration into other systems
Telematics integration

Lowering your total cost of ownership

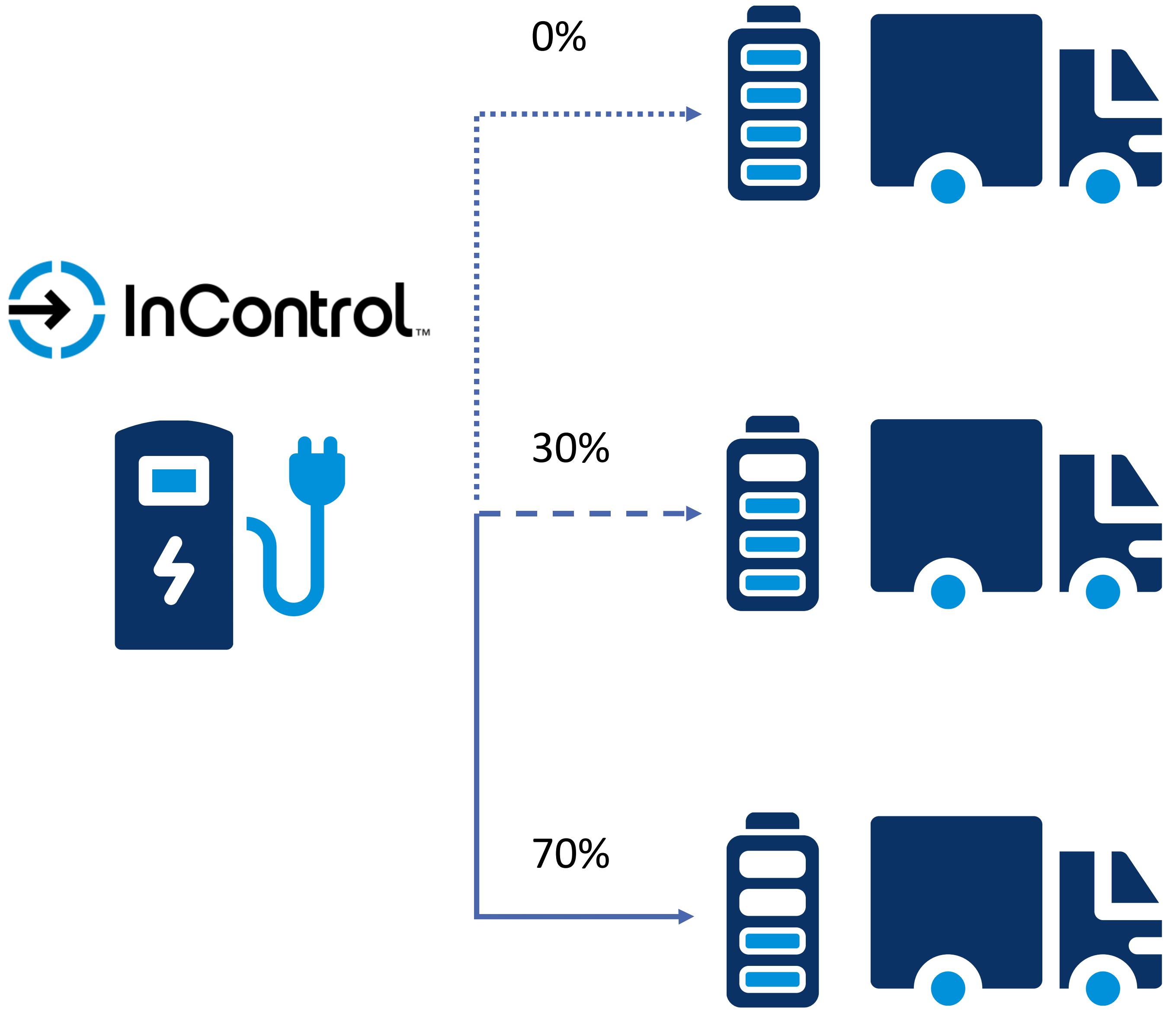
Time shifting with smart load management



Dynamic Load Management

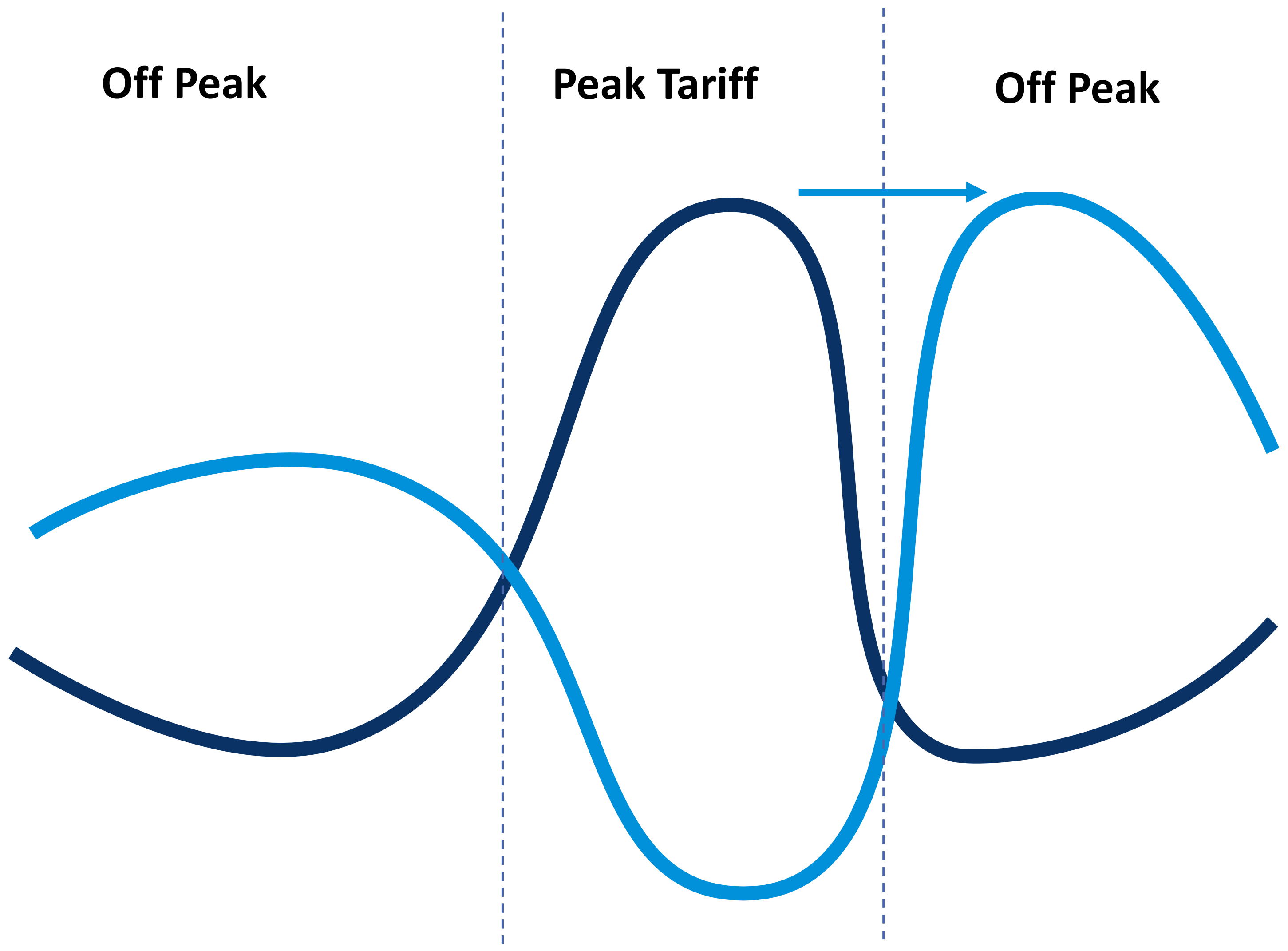
Automated Power Balancing

InControl will automatically distribute electricity based on state of charge, maximizing effective charge time.



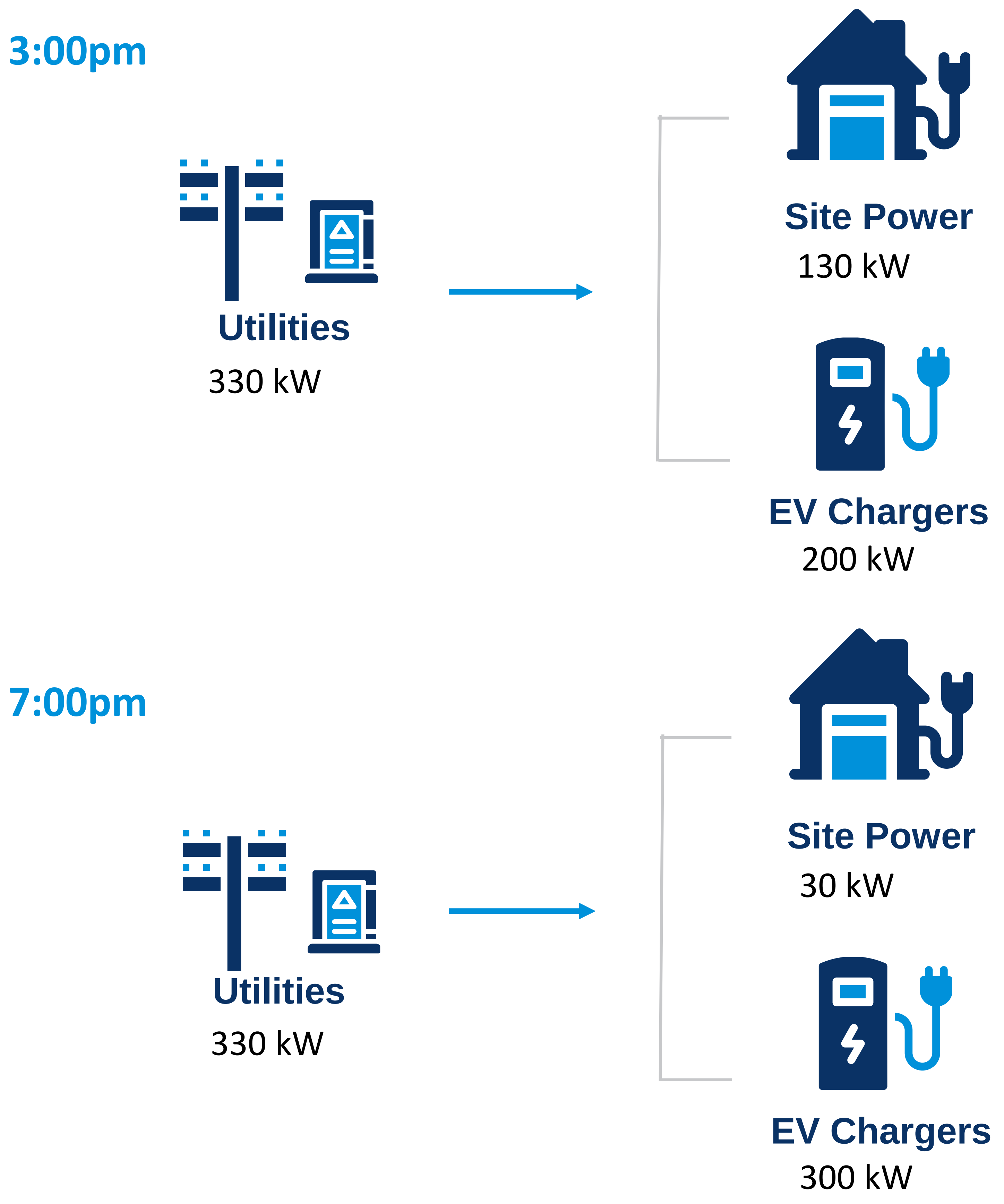
Time Shifting

Avoid Time of Use tariffs, when charging at peak times can be extremely costly. InControl will automatically delay charging to cheaper times.



Site Load Management

Limit utility upgrades by managing the maximum draw power used by all chargers at specific times.



Smart Load Management

Lower costs with intelligent fleet charging automation

Demand Charges
A CMS can automatically distribute electricity based on state of charge, maximizing effective charge time

Peak Tariffs
Avoid Time-of-Use tariffs, when charging at peak times can be extremely costly. A CMS can automatically delay charging to cheaper times

Site Load Management
Limit utility upgrades by managing the maximum draw power used by all chargers at specific times

With dynamic load management, from 2022 to now, the District has been able to optimize for time of use rates and save 70% on energy costs.

Without dynamic load management, school district charging stations might operate at full capacity simultaneously, straining the local electrical grid and leading to peak demand charges from the utility provider. This could significantly increase energy costs for a school district.

If that happens, it could easily lead to inefficient use of resources and potentially longer wait times for users and delayed routes for students.

For example, a school district in the Inland Empire of California leverages Dynamic Load Management with CMS, to reduce energy costs and operate more efficiently.

Questions and Answers

Presentation 3

Charging Standards, Maintenance, and Safety

Richie Beebe

Learning Outcomes

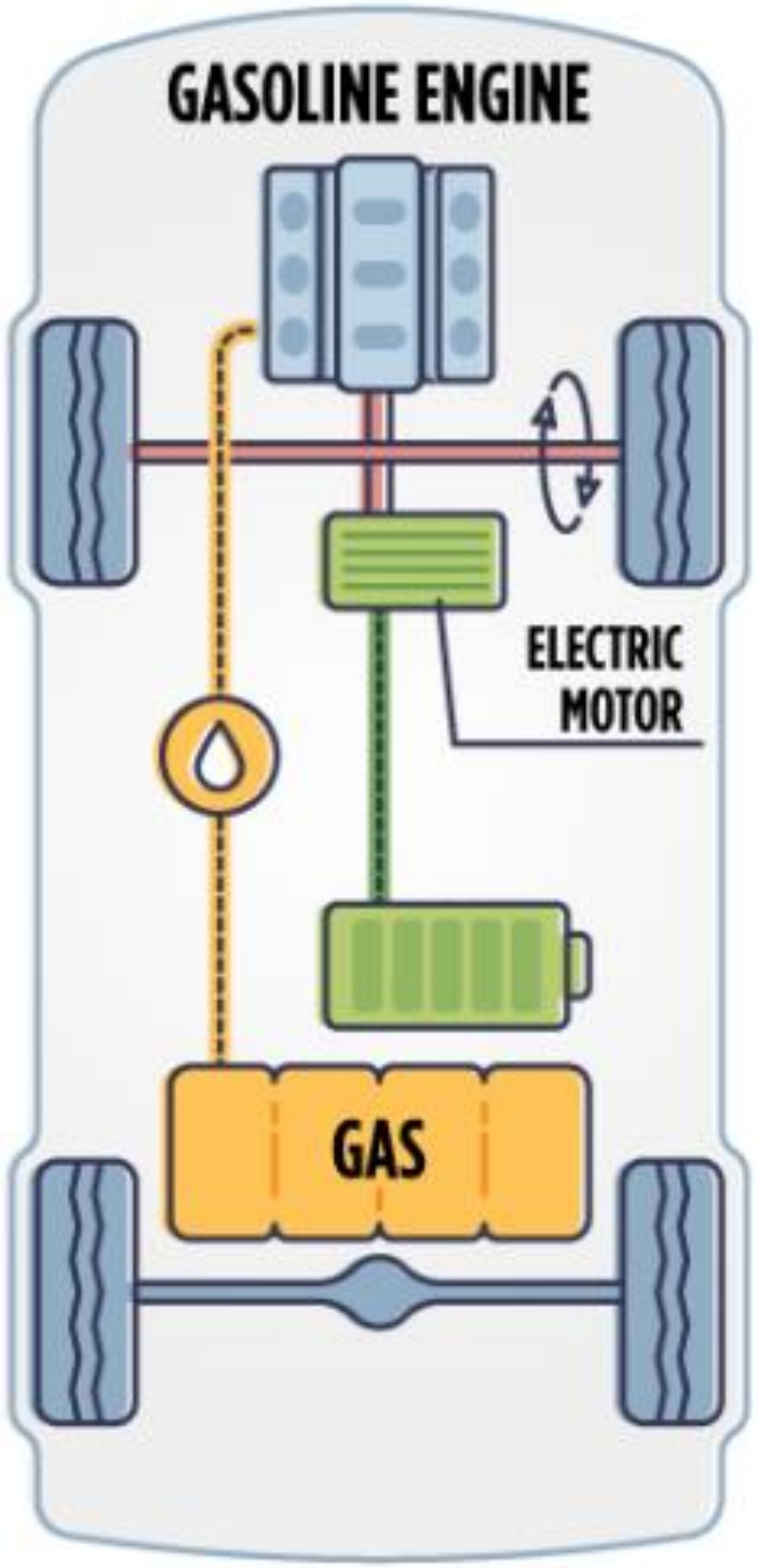
In this session, you will familiarize yourself with:

- **Identify the types of electric vehicles (EV) and charge port designs**
- **Describe the differences in levels of EV charging**
- **Identify the primary types of chargers and adapters**
- **Identify the personal protective equipment (PPE) for performing high voltage work**
- **Describe Lockout Tagout practices, tools and equipment**
- **Describe best practices for charger and equipment maintenance**

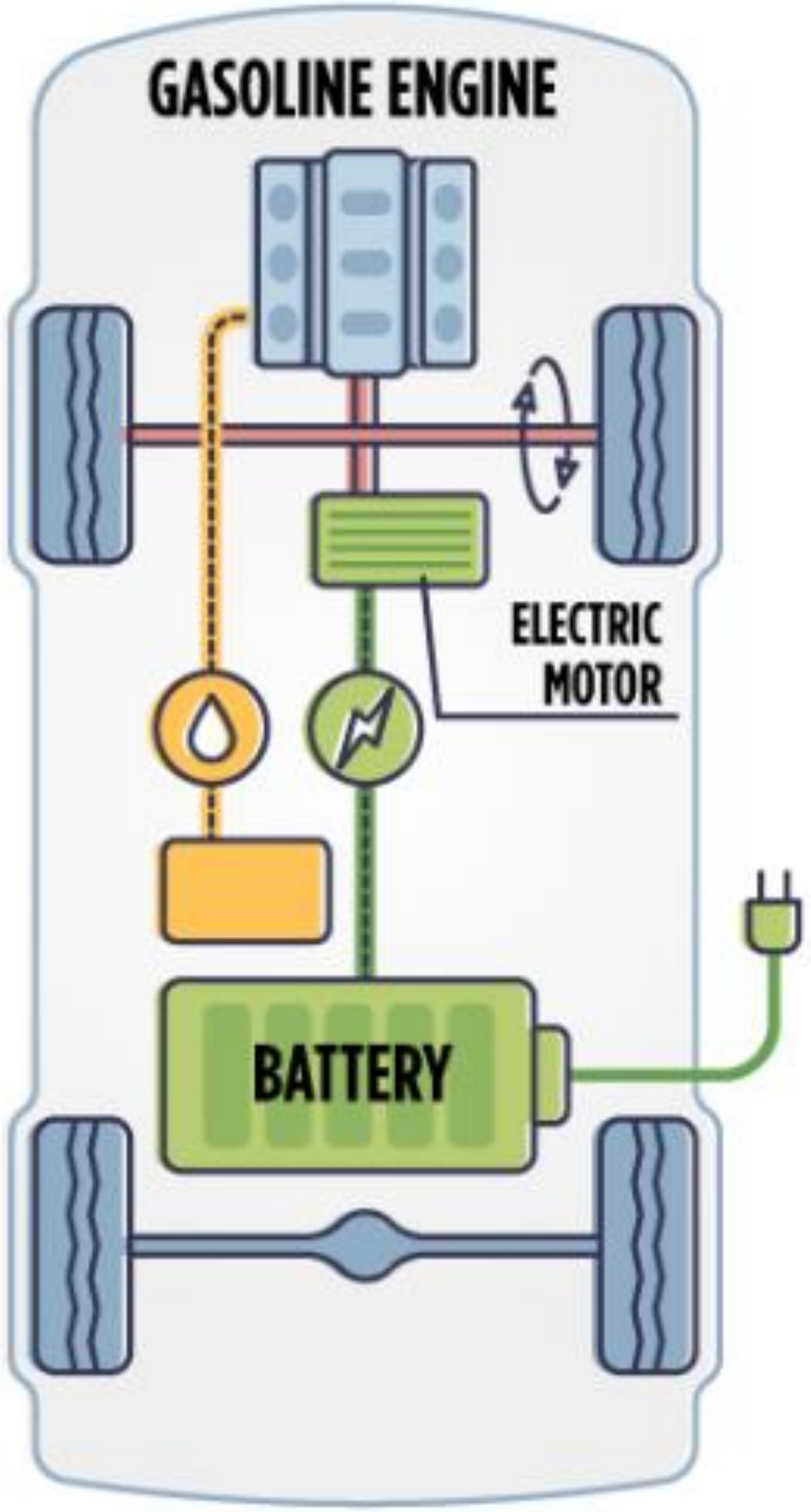
Types of EV Port Designs for Charging

Designs
Levels of Charging
Adapters

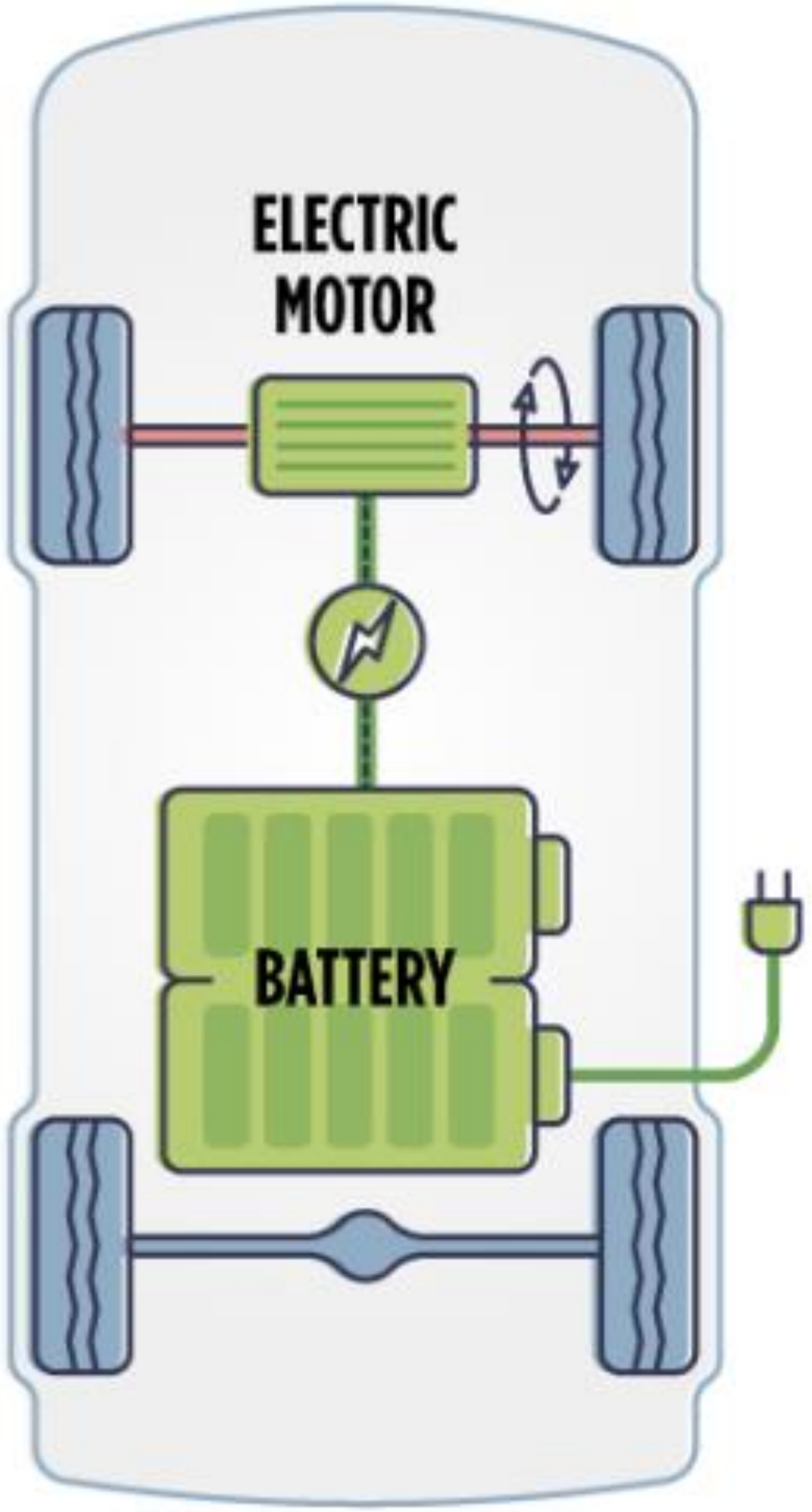
EV Types



HEV: Hybrid EV



PHEV: Plug-In Hybrid EV



BEV: Battery EV

Electric Vehicle Supply Equipment (EVSE)

Electric Charging Station/Equipment

Supplies electric energy to BEV & PHEV

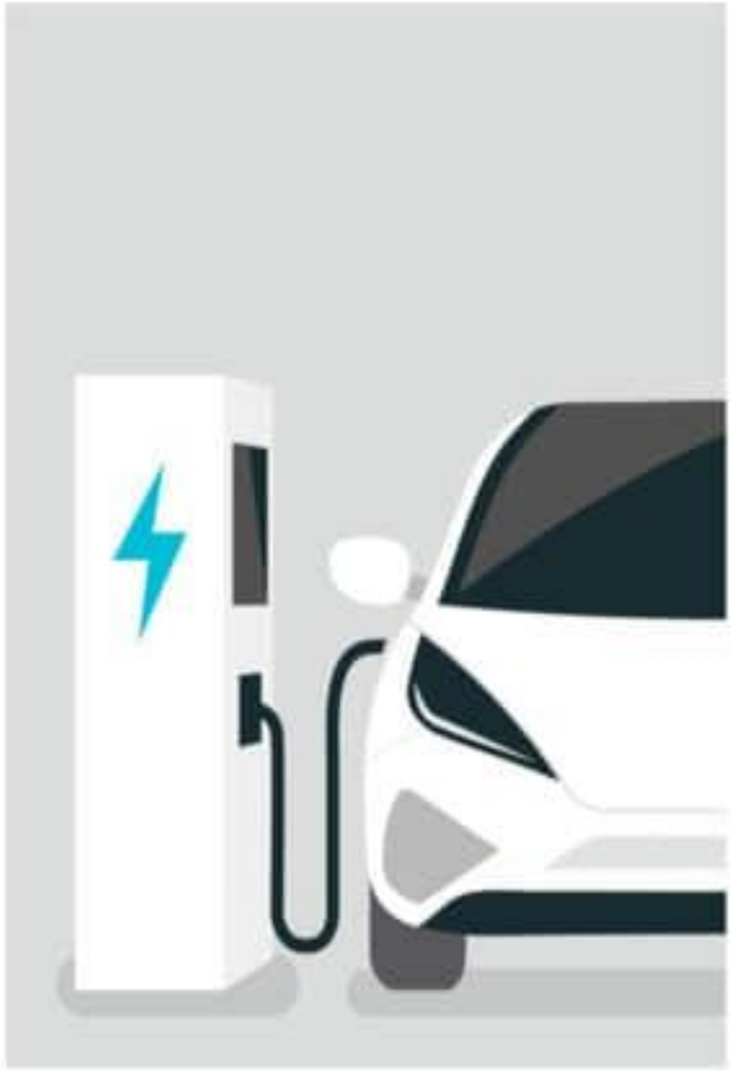
Various terms are used

- Charge points
- Electric recharging points
- Charging station

Various charging levels

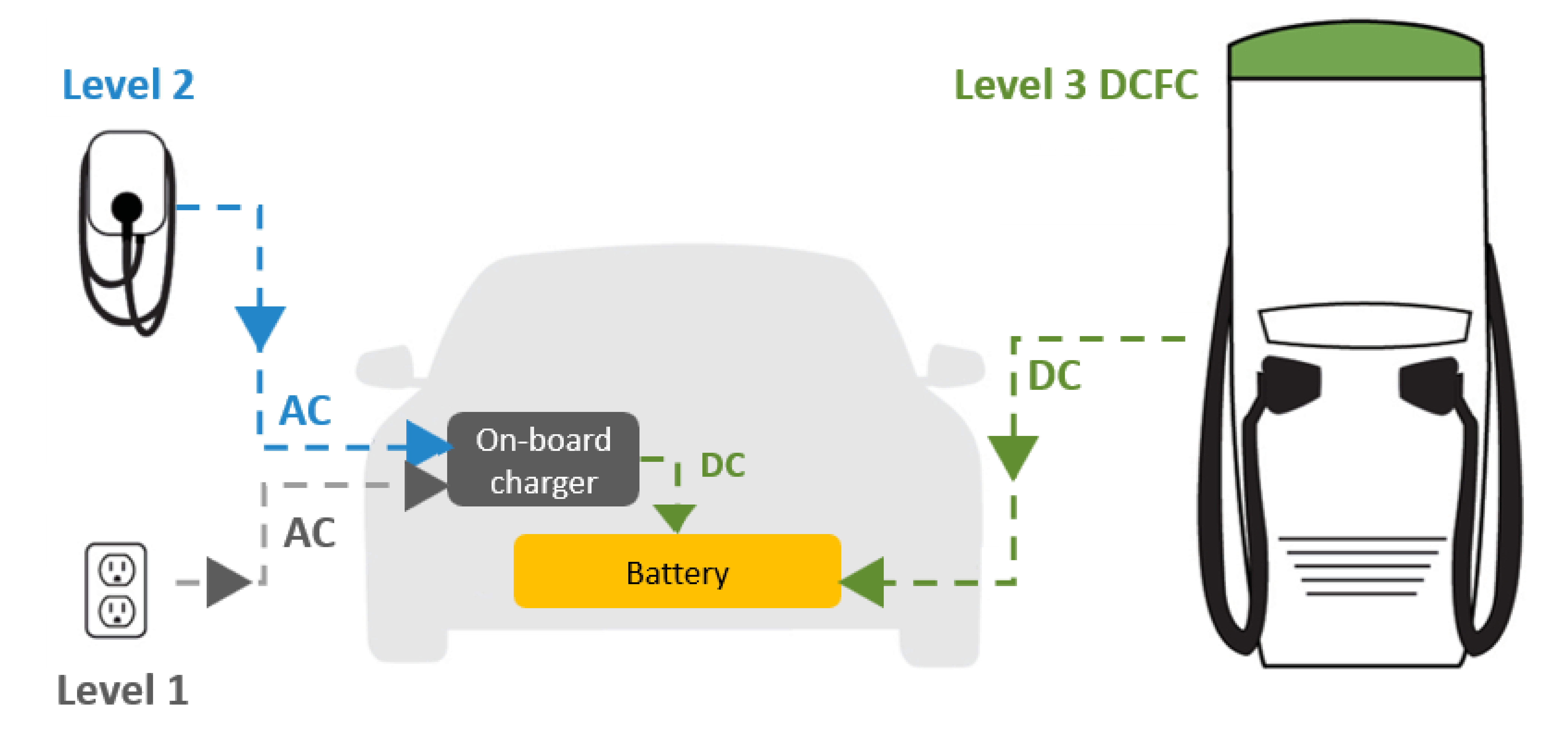
LEVEL 1

LEVEL 2

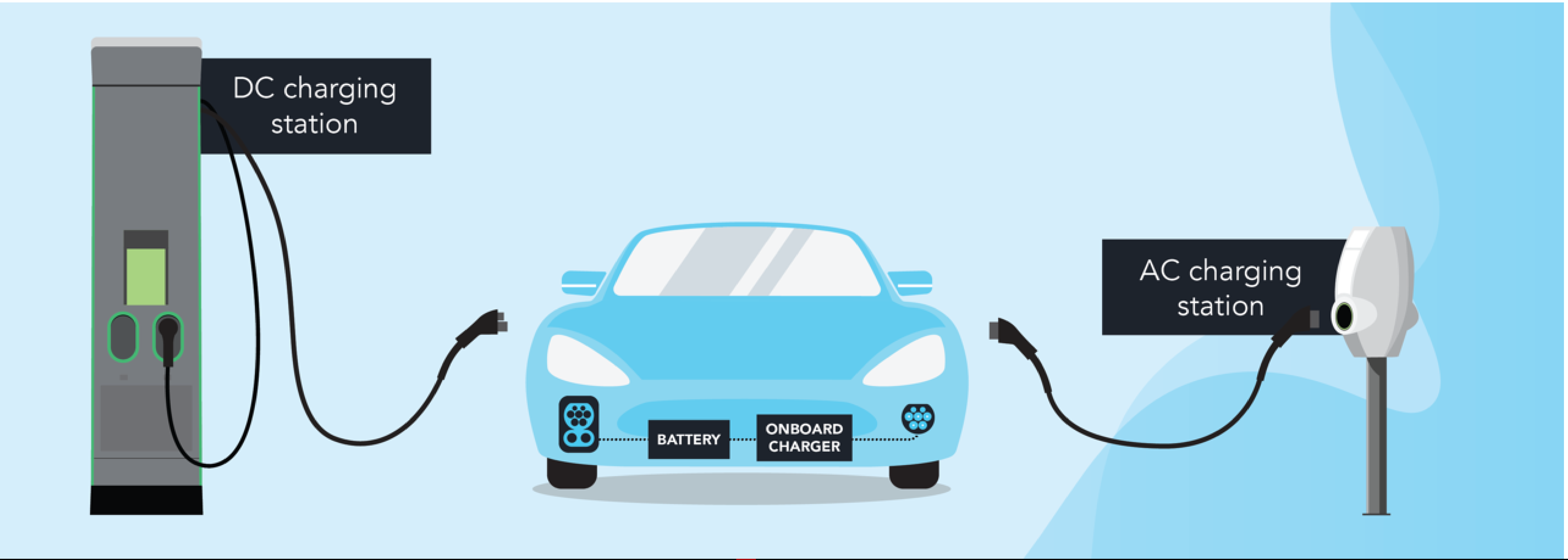


LEVEL 3

How EVSE Charges the Onboard Battery



Charger Input Power Needs



DC Bypasses onboard charger - direct to battery

DC charger – Power input:

- 208VAC 3-Phase Utility power
- 480VAC 3-Phase Utility power
- DC Coupled – solar/battery storage (not common)

AC must be rectified with the onboard charger

AC charger – Power input:

- 208VAC 2-Phases
- 240VAC 1-Phase
- 120VAC 1-Phase

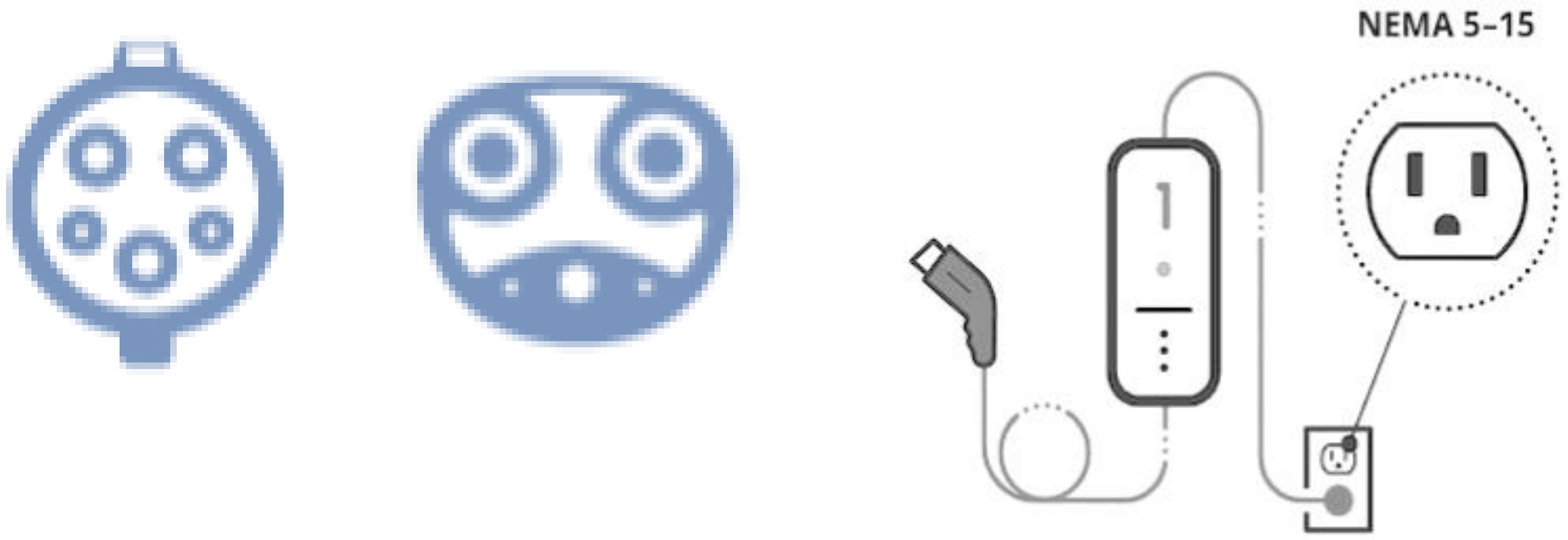
EV Charging: LEVEL 1

VOLTAGE
120V 1-Phase AC

AMPS
12–16 Amps

CHARGING LOAD
1.4–1.9 kW

CHARGING TIME
3–5 Miles per Hour



EV Charging: LEVEL 2

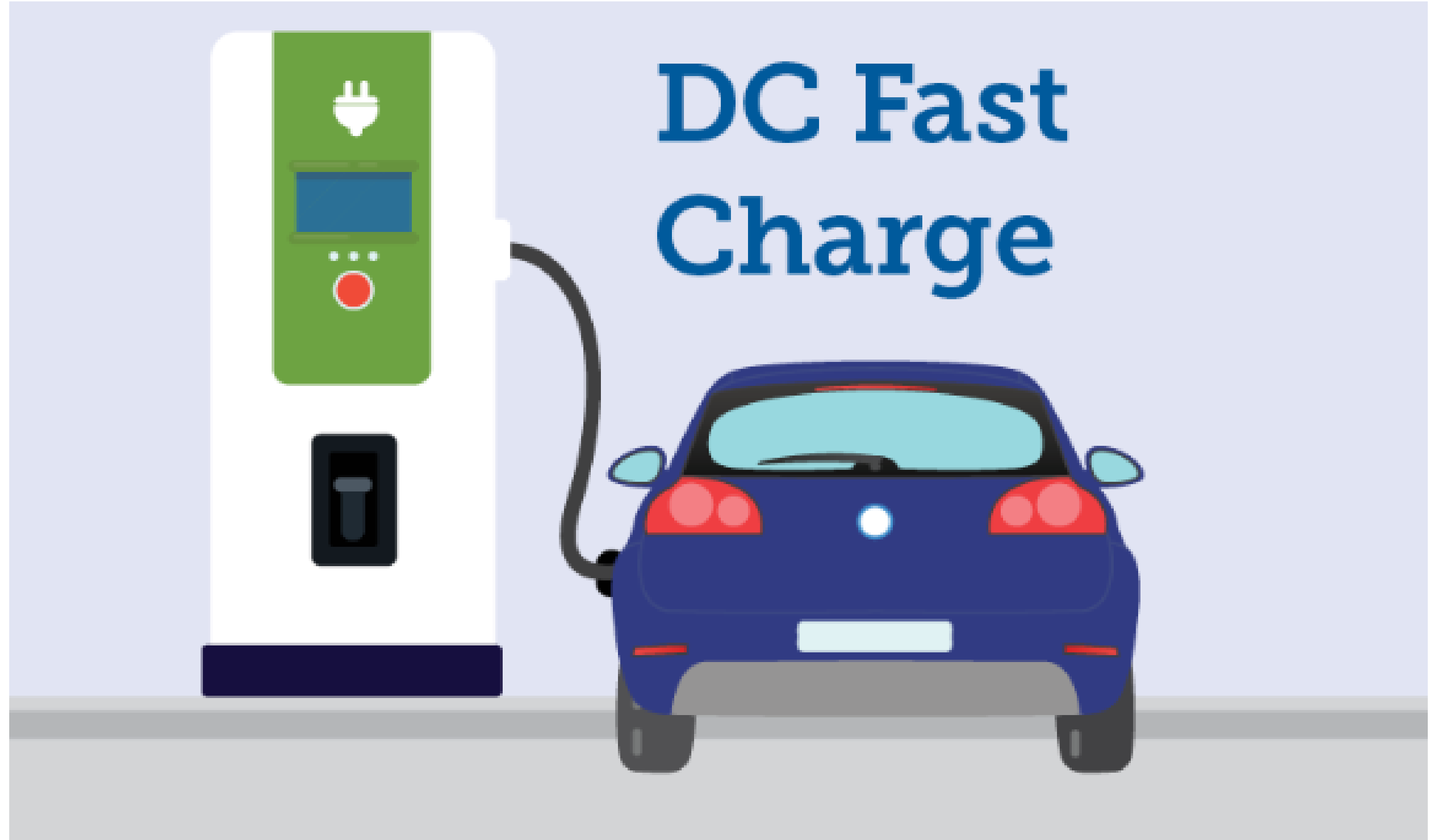
VOLTAGE
208V or 240V 1-Phase AC

AMPS
12–80 Amps (Typ. 32 Amps)

CHARGING LOAD
2.5–19.2 kW (Typ. 6.6 kW)

CHARGING TIME
12–60 Miles per Hour

EV Charging: LEVEL 3

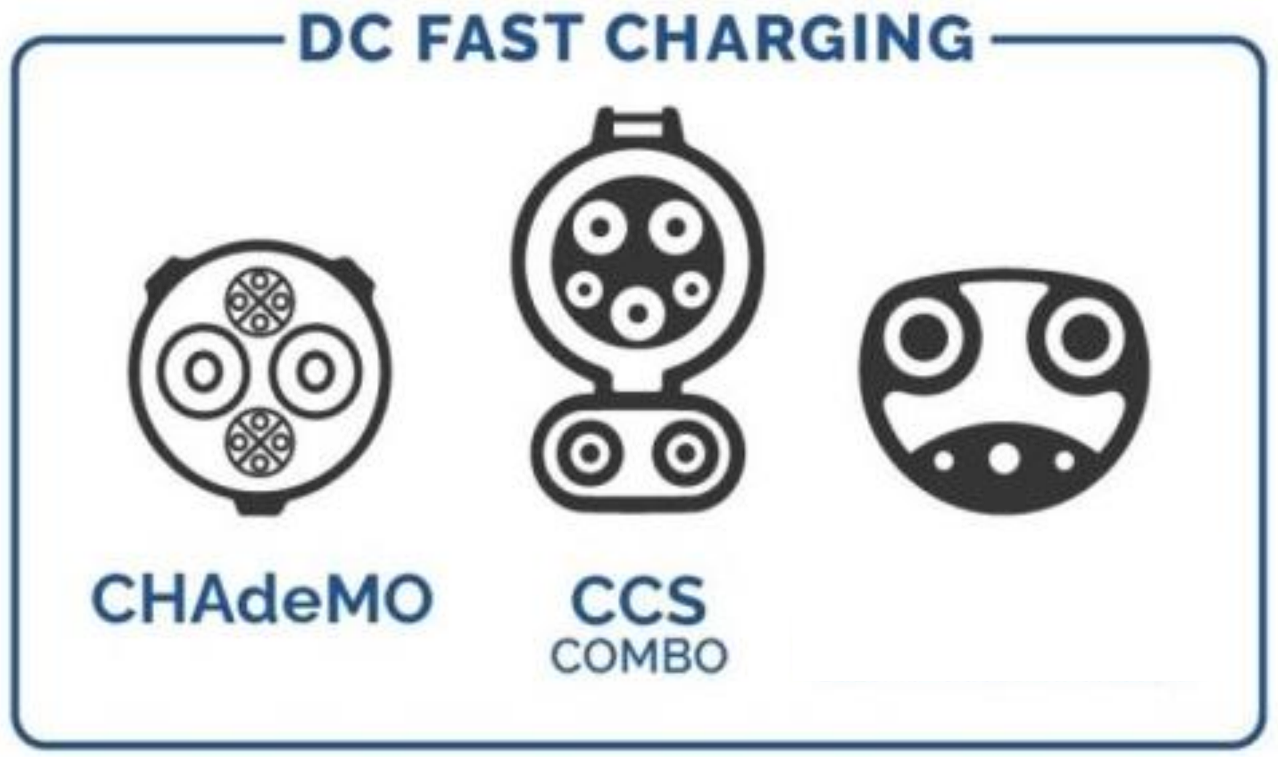


VOLTAGE
208V or 480V 3-Phase AC

AMPS
>100 Amps

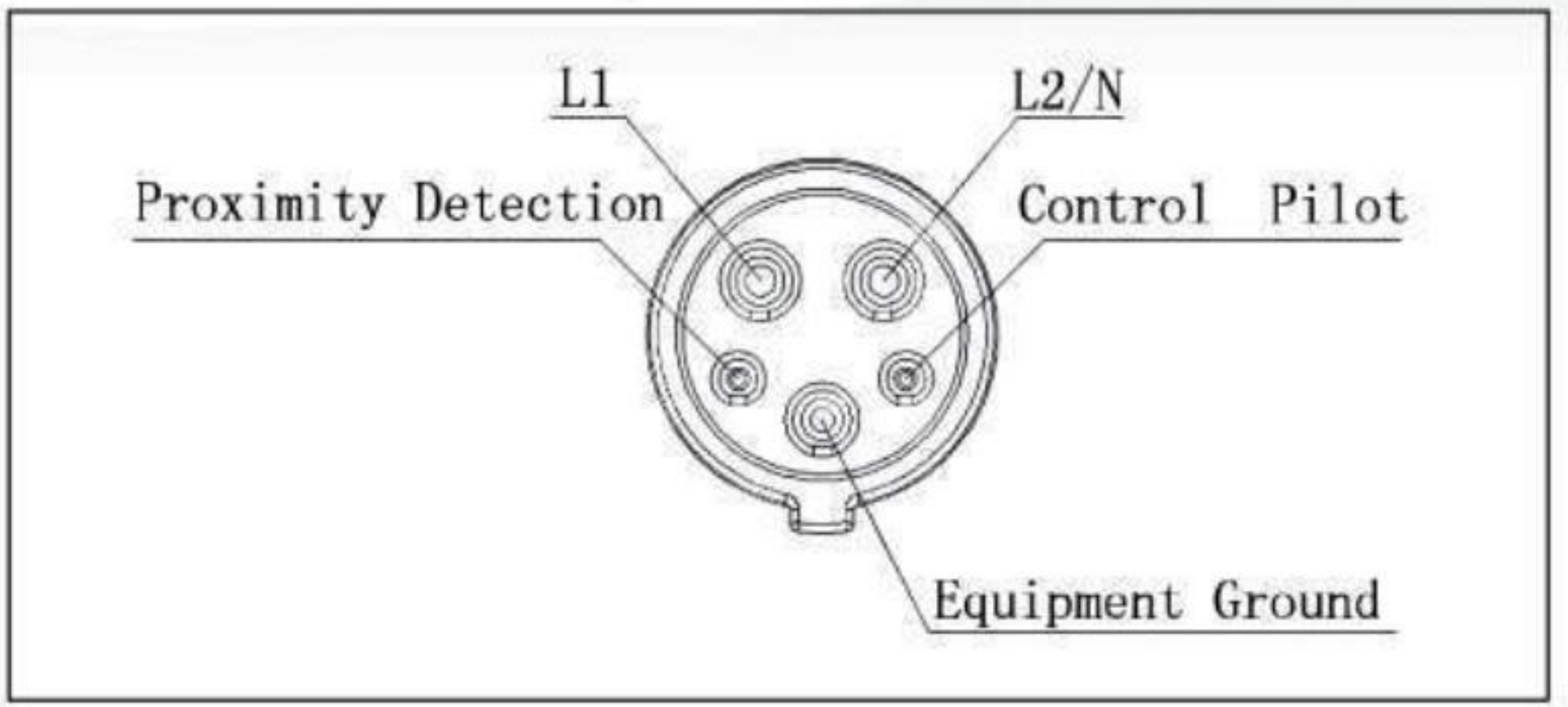
CHARGING LOAD
50–350 kW

CHARGING TIME
60–80 Miles in 20 Minutes



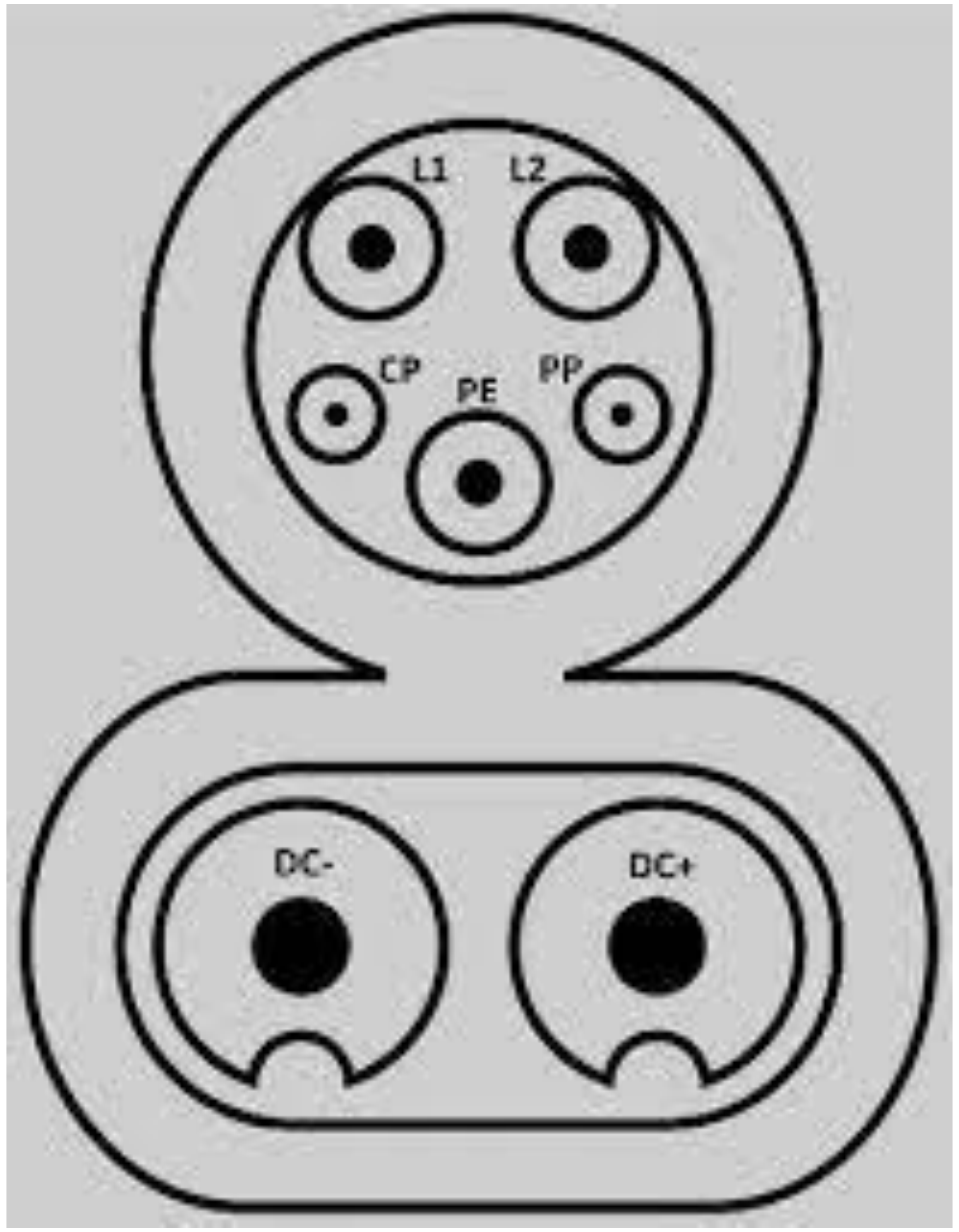
Level 1 & 2 Connectors North America

J1772 (AC Output)



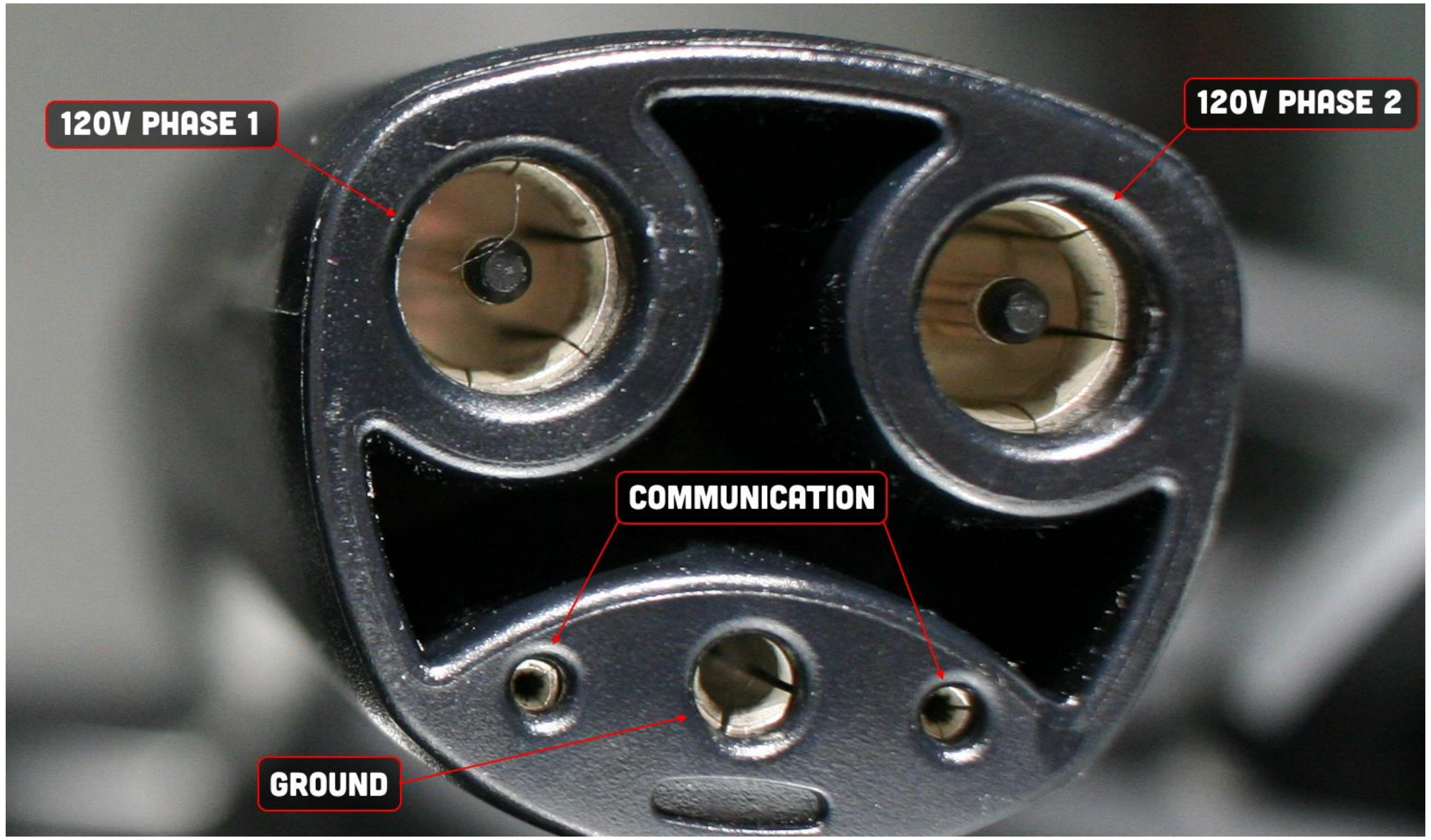
Level 3 DC Fast Charging Connector

CCS-1 or J1772 Combo (North America)



North American Charging Standard (NACS)

Formerly called Tesla Supercharger Connector



Adapters

NACS CCS-1

NACS Chademo

NACS J1772

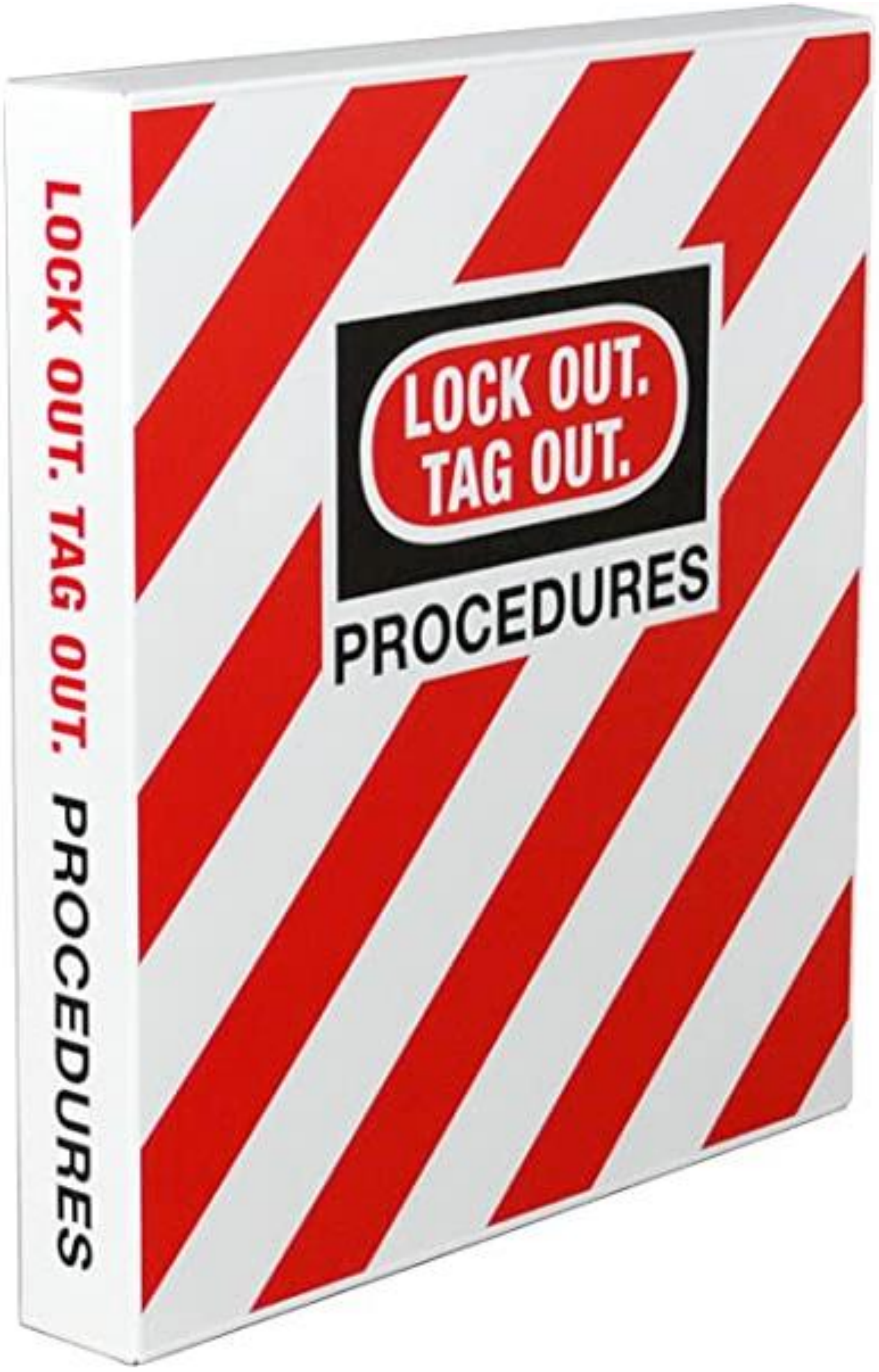
Safety Precautions

Personal Protective Equipment(PPE)
Lock out Tag out(LOTO)
EV Tools

Personal Protective Equipment – Arc Flash Gear - *HIGH VOLTAGE!*

1. Coveralls
2. Dielectric hard hat with arc flash shield (2)
3. Balaclava
4. UV safety glasses
5. Rubber protective gloves with leather overtop –
   Class Types based on Voltage
6. Ear Plugs

Establishing an: Electrically Safe Work Condition (ESWC)

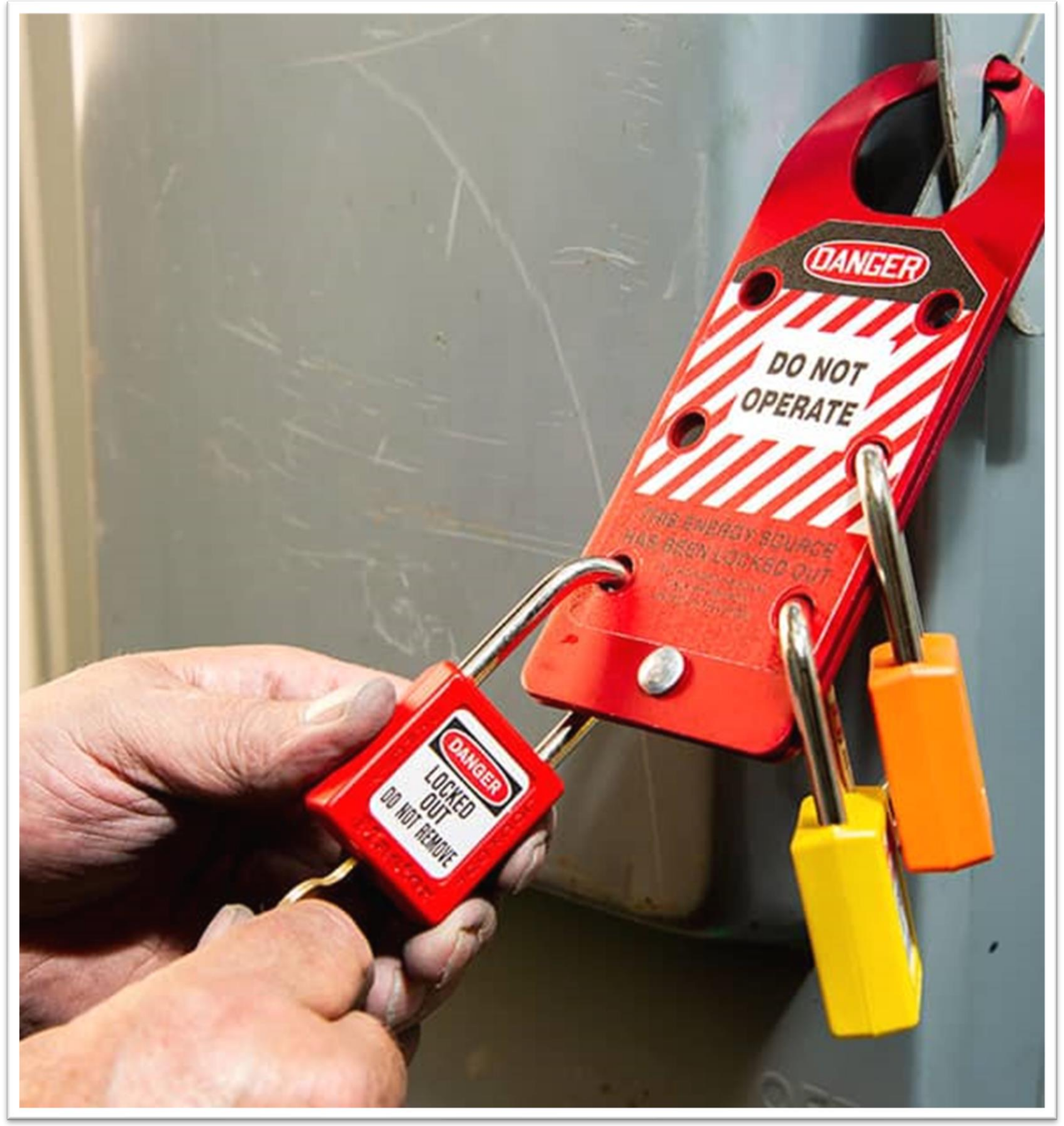


- ✓ Prevent the unexpected energization or startup of machinery and equipment
- ✓ Designed to shut down equipment
- ✓ Control all energy sources
- ✓ Render the machine in its safest state possible
- ✓ Documented
- ✓ Evaluated

Lockout Tagout

Each Authorized Person working on equipment must:

- Apply their own lock and tag to all energy sources
- Keep control of the key assigned to their locks
- Do not mess with anyone else's lock or key
- Keep other (unauthorized) employees away from your area
- Report issues or updates about equipment as necessary



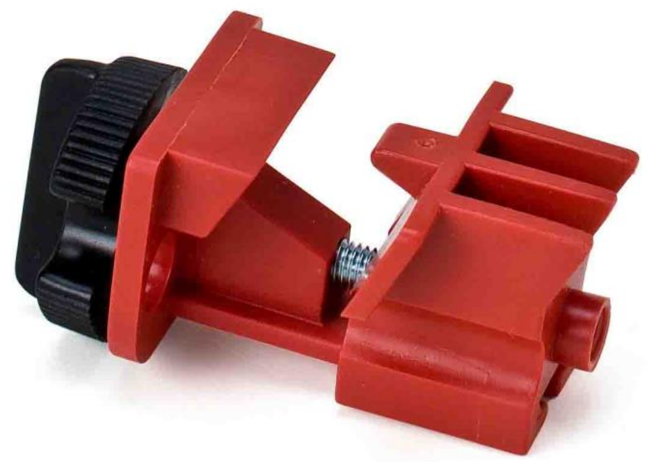
Lockout Tagout

Tools Needed for Lock Out, Tag Out (LOTO)

Locks

Hardware

Tags



Energy Isolation Devices

This equipment must meet requirements to be LOTO compliant.

Fire Classes and Symbols

- Wood, cloth, paper, rubber, and some plastics
- Flammable liquids, gasses, and greases
- Electrical equipment
- Combustible metals (magnesium, titanium, zirconium, and sodium)
- Vegetable or cooking oils, fats

Fire Extinguisher – Best Practices

The most important thing is your safety!

1. Put out the fire if you can

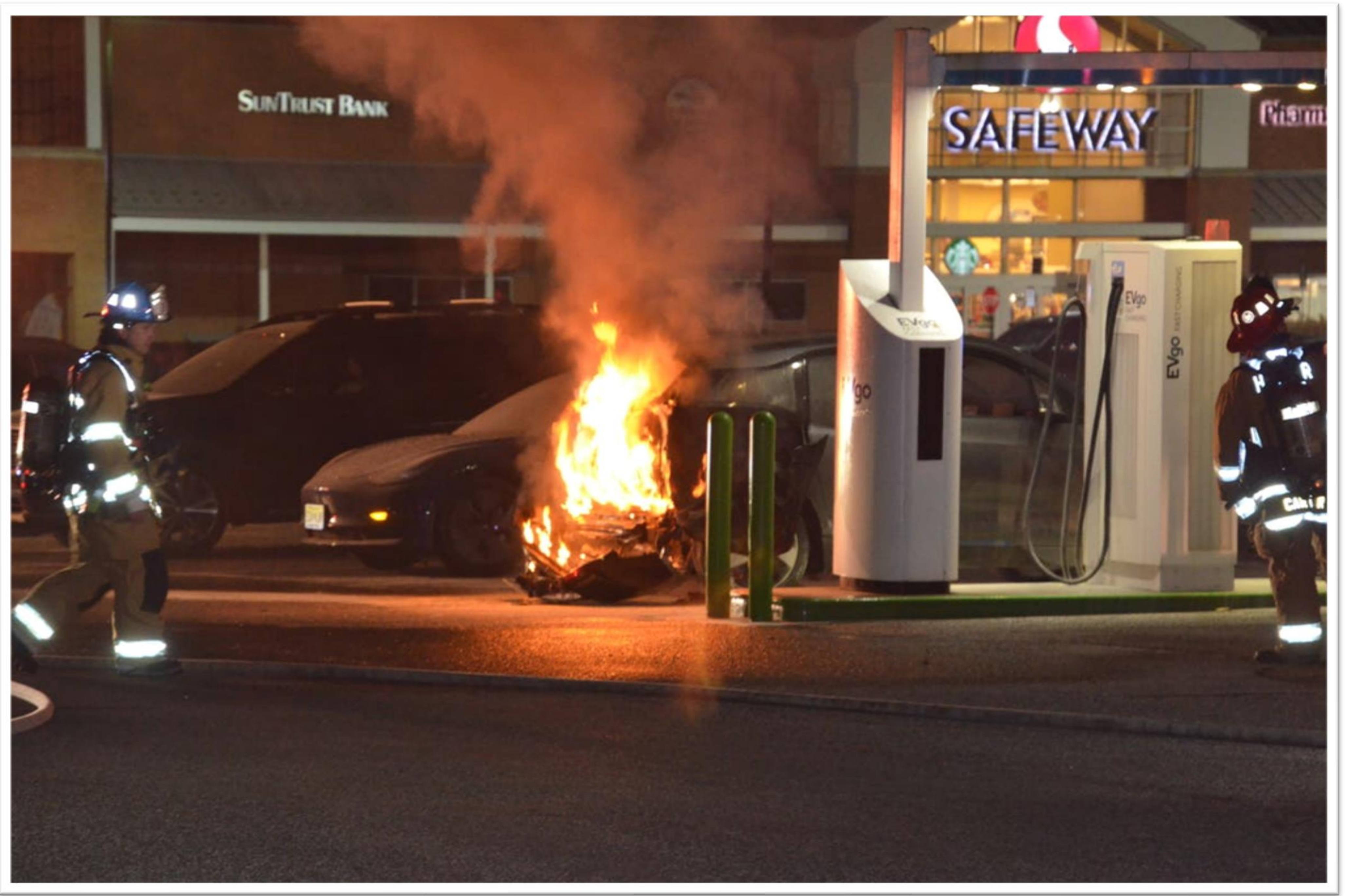
Only attempt to put out a dispenser, not a transformer or energy source.

2. Back away

Get clear of the fire as soon as possible.

3. Call 911

Inform them of the type of fire
(aka: what is on fire).



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EV Tools

Tool Name	Description	Uses
PPE	Personal protective equipment	Safety
LOTO Equipment	Locks, hardware and tags	Safety
Torque Screwdriver	Screwdriver with torque settings	Terminate electrical wiring
Torque Wrench	Wrench with torque settings	Secure pedestal to anchor bolts
3/8 Ratchet SAE/Metric	Ratchet and sockets	Install
Cell Reader	To verify cell service	-
Cat 5/6 Tester	Test to see if connection/wire is good	-
Security Bit Set	Special bit for hardware	Getting into equipment
Precision Screwdriver	Special use screwdriver	-
Magnetic Torpedo Level	Small tool to check level	-
10 in 1 screwdriver	Multi bit screwdriver (multi use)	-
AC/DC Multi Meter	Voltage tester	-
Wire Cutters	Hand tool for cutting wire	-
Wire Strippers	Hand tool for stripping wires	-

Charger Maintenance

Best Practices
Overview

Best Practices

Recommended

- Being prepared for the work at hand – Tools, PPE, LOTO
- Training certification specific to the OEM
- Being familiar with the product with hands-on training
- Site assessment prior to starting work

Types of Maintenance

Recommended

Commissioning

- New installation
- Verify the units were installed properly

Preventative Maintenance

- Scheduled – Annually, Quarterly, Monthly
- Visual Checks
- Coolant check
- Filter cleaning/replacement
- Torque Checks

Types of Maintenance

Recommended

Break-fix or Corrective repairs

- Wear and tear
- Vandalism
- Cable Management
- Human Machine Interface (HMI)

Inspection

- Modem connection or Cellular
- Charger Offline
- Voltage Inspection

Questions and Answers

ESB Familiarization Webinars

Webinar Sessions:

- Module 1: Operator Overview
- Module 2: Electric School Bus Technology Overview
- Module 3: High Voltage Safety Considerations
- Module 4: Charging Overview

All modules available as downloads at: Electric School Bus Familiarization Training

Thank you!

Today's Presentation:

Module: Charging Overview

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