Advanced Energy Partnership for Asia

Electric Vehicle Supply Equipment: An Overview of Technical Standards to Support Lao PDR Electric Vehicle Market Development

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Virtual Meeting

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Agenda

1. Electric Vehicle Supply Equipment (EVSE): Technical Standards Introduction
2. Technical Standards Focus: EVSE to Vehicle Connections
3. Technical Standards Focus: EVSE to Grid Connections

Electric Vehicle Supply Equipment (EVSE) Technical Standards Introduction

Codes and Standards

Electric vehicles (EVs) must follow strict guidance when charging to ensure safety *(National Electric Code (NEC) 625).*

Specific instruction on how to manufacture and install EV couplers *(Society of Automotive Engineers (SAE) J1772).*

What is a Code? What you need to do.

- A code is a set of rules recommended for others to follow.
- It is not a law but can be adopted into law.

What is a Standard? How to do it.

- A standard is detailed elaboration on how to meet a code.
- It is used by product designers, manufacturers, installers, and operators.

Role of Policy Makers? Select, adopt, and enforce codes and standards.

Proper selection of codes and standards can:

- Encourage EVSE and EV adoption
- Ensure safety and consistency for consumers and installers
- Provide clear expectations for manufacturers, installers, business owners.

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Purpose of Codes and Standards

Why have codes and standards? *1. Safety 2. Operations*

Installation

Business Management

Manufacturing and Design

Operations

Permitting

Images: NREL 35948, 56664, 62138, 55669, 23815

Organizations that Develop Codes and Standards

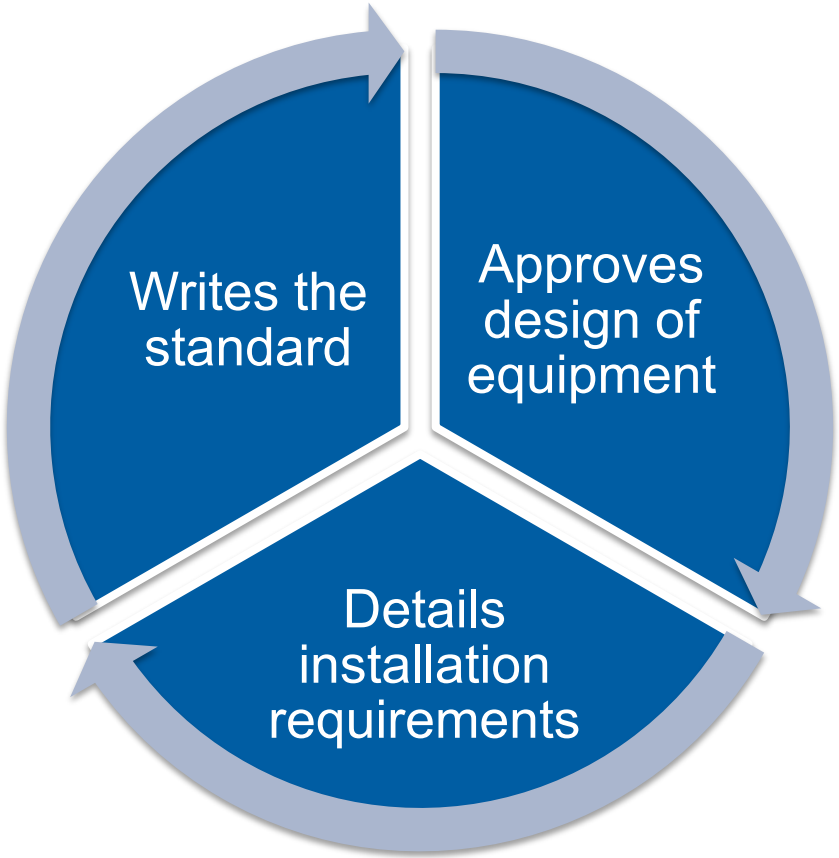
International Code Council	• Primary Focus: Building safety and fire prevention – International Building Code
International Electrotechnical Commission (IEC)	• Primary Focus: Electrical systems, services, and products – IEC 61851: EVSE types – IEC 62196: Charge coupler standard
Institute of Electrical and Electronics Engineers	• Primary Focus: Electronics and computer science – National Electric Safety Code
International Organization for Standardization	• Energy, Food Safety, Information Technology, Health and Safety – ISO 15118: Vehicle-to-grid communication interface

Codes and Standards Can Be Interrelated

	Standard or Code	Subject	Content
Code	**NEC Article 625** National Electric Code	EV Charging System Equipment	• Electrical conductors and equipment external to EV • Connection and installation of EVSE ➢ References SAE J-1772 and UL 2251
Standard	**SAE J-1772** Society of Automotive Engineers	EV Conductive Charge Coupler	• Operational, functional, and dimensional requirements for the vehicle inlet and mating connector ➢ References NEC 625 and UL 2251
Standard	**UL 2251** Underwriters Laboratories	Design & Safety	• Design and safety of plug, cord, receptacle, connectors • Verifies equipment load rating ➢ References SAE J-1772 and NEC 625

Creation and Enforcement of Standards

SAE International



Underwriters Laboratories

National Electric Code

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Key Codes and Standards: EVSE Types and Connectors

Standard	Subject	Important Content
IEC 61851	EV charger types; Communication and safety requirements	• Mode 1 – AC portable charger, no communication requirements • Mode 2 – AC portable charger with communication and safety requirements • Mode 3 – AC stationary charger with communication and safety requirements • Mode 4 – DC stationary charger with communication and safety requirements
IEC 62196	Plugs; Socket-outlets; Vehicle connectors and inlets	• Type 1 – Same as SAE J1772 (also known as 'Yazaki connector'), common in US and Japan • Type 2 – Known as 'Mennekes connector', common in European Union • Type 3 – Mainly used in France and Italy

Interoperability and Communications

Interoperability

1. **Ability for networks to communicate with other networks**
   - Facilitates network roaming (members of one network can charge on another network easily)

2. **Ability for different chargers to interact with each other and with other charging management systems**
   - Allows network providers and site hosts to better manage EVSE
   - Enables databases like station locator websites or mobile applications

3. **Ability for EVs to interact with different chargers**
   - Communicate a safe connection 'handshake' between EV and EVSE
   - Emerging technologies like Vehicle-to-grid reverse charging or 'plug and charge' seamless payment

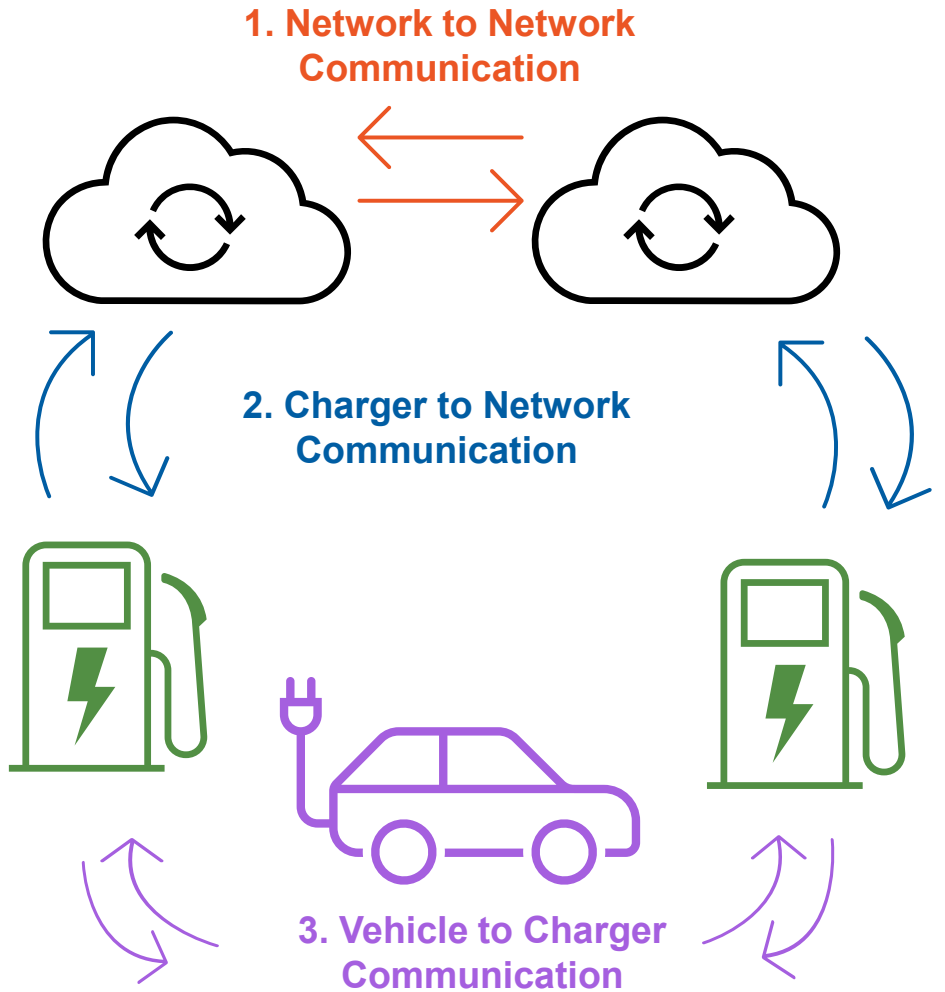


Figure: Adapted from MJ Bradley & Associates

Interoperability: OCPI and OCPP

- **Open Charge Point Interface (OCPI)** is a protocol used by charging networks to allow 'roaming'.
  - Use Company A's app to pay for charging done on Company B's charging station.

- **Open Charge Point Protocol (OCPP)** is a language between the EVSE and the network management system.
  - Physically separates the appliance aspects of the EVSE from the network back-end component
  - Prevents stranded assets
  - Allows site host to switch networks if needed or wanted without replacing entire EVSE

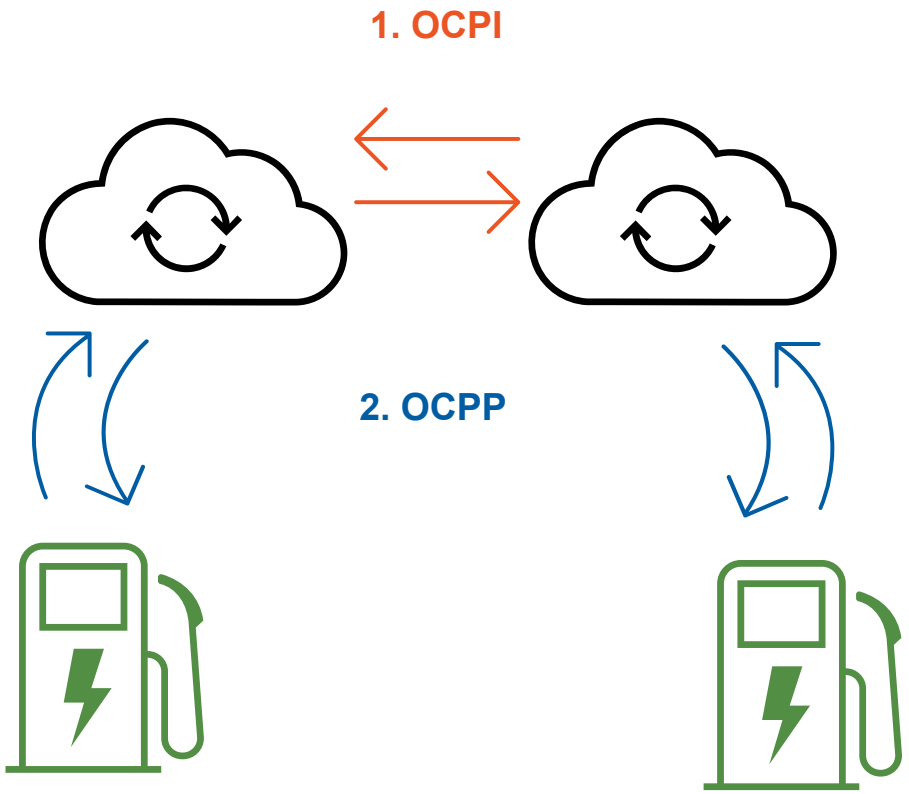
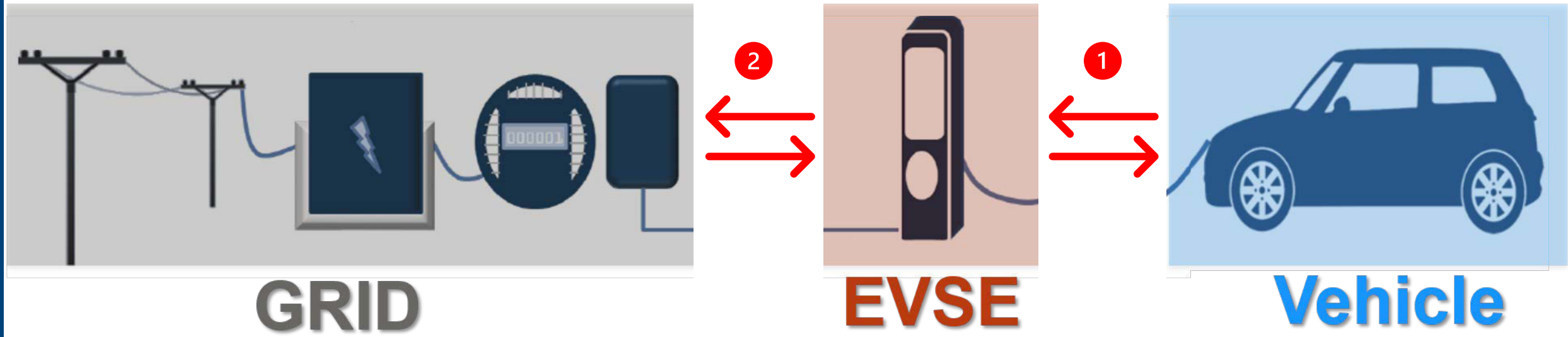


Figure: Adapted from MJ Bradley & Associates

Where are standards most important?



1. The interface between the EVSE and the vehicle
2. The interface between the grid and the EVSE

Figure: Adapted from MJ Bradley & Associates

EVSE to Vehicle Connections

What are some common standards?

- SAE J1772 – North America (Type 1)
  - 5-pin AC charging port – Level 1 and Level 2
  - 7-pin DC charging port – Combined Charging Standard (CCS1)
- IEC 61851/62196 – Europe and other emerging markets (Type 2)
  - 7-pin AC charging port
  - 9-pin DC charging port (CCS2)
- AC charging uses power directly from the electric grid
- DC charging uses two additional dedicated DC pins
- All chargers require additional pins for communication or controls

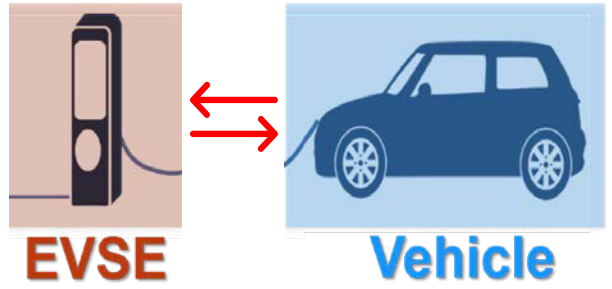


Figure: Adapted from MJ Bradley & Associates

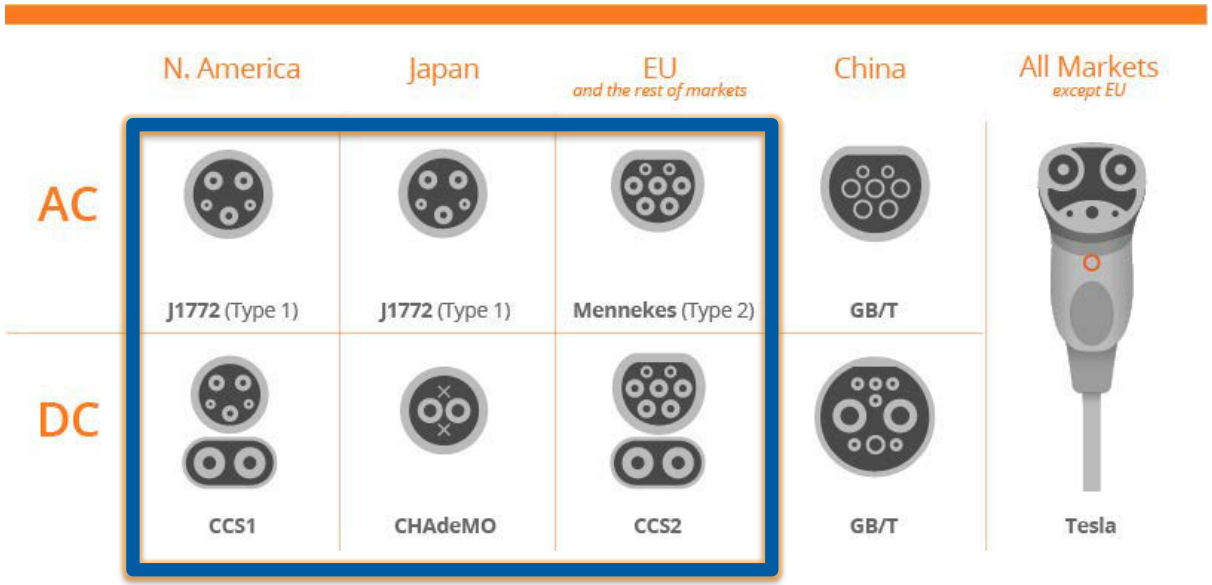


Figure: https://evcharging.enelx.com/images/PR/Articles/blog/EMW_plugs_.jpg

How powerful is the SAE J1772?

- SAE J1772 standard has specific requirements for power quality but has a wide range of permitted power output for each charging level.
- AC Level 1 requires 120 V which is common in both residential and commercial buildings.
- AC Level 2 requires 208 V for commercial buildings or 240 V for residential buildings.
- DC Level 1 and Level 2 are both capable of receiving and supplying a wide range of input and output voltages.

EVSE standard power limits may exceed interconnection limits (regulations may be stricter than standards).

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

Image: Kelly Bragg, NREL

How powerful is the SAE J1772?

- Many EVSE do not operate at the highest power output permitted for each level.
  - Installation requirements (circuit breaker sizing, service panel capacity)
  - Company design differences (low-power and high-power options)
  - Vehicle limitations (on-board charger limitations, battery DC voltage)
- AC Level 1
  - 1.4 kW (120 V, 12 A)
  - 5 miles of range in 1 hour of charging
- AC Level 2
  - 7.7 kW (240 V, 32 A)
  - 25 miles of range in 1 hour of charging
- DC Level 1
  - 50 kW (480 V, 105 A)
  - 100 miles of range in 0.5 hour of charging
- DC Level 2
  - 270 kW (800 V, 340 A)
  - 200 miles of range in 0.5 hour of charging

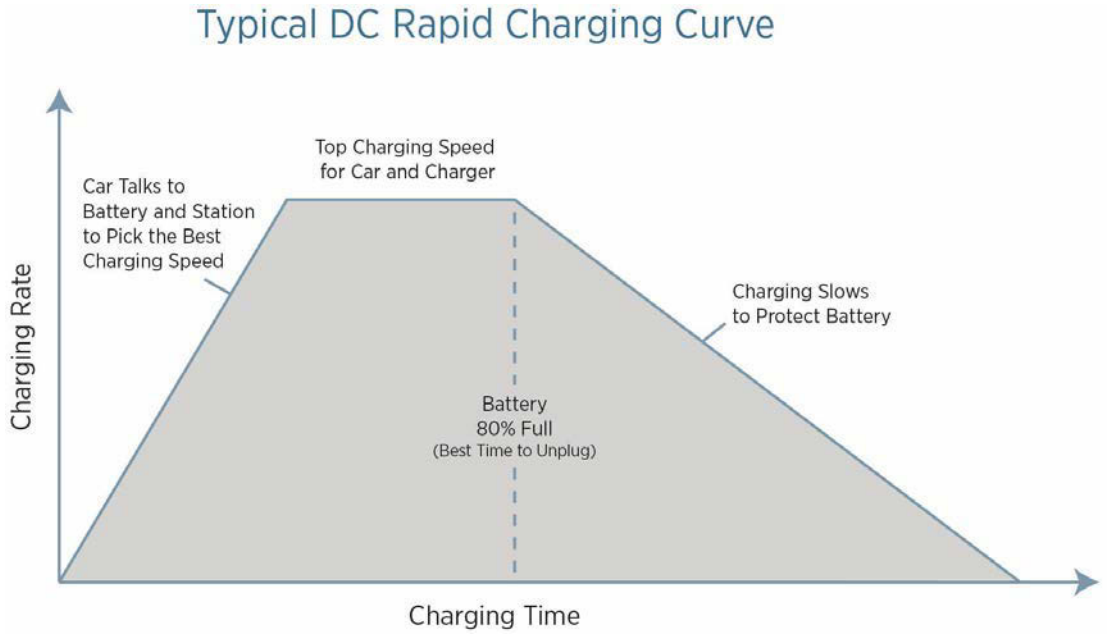


Figure: https://www.chargepoint.com/sites/default/files/inline-images/DC-Fast-Charging-Curve_2_0.jpg

What does the SAE connection look like?

SAE J-1772 provides specific requirements for charge port designs that create a consistent interface between EV and EVSE.

- Physical dimensions
  - Broad requirements for consistent designs
- Vehicle connection and pin design
  - Strict limitations for universal compatibility
  - Pin designs to facilitate charging and controls
- Environmental and durability needs
  - Temperature and moisture considerations
  - Designs intended to extend equipment life
- Safety considerations
  - Operating conditions to promote safe charging

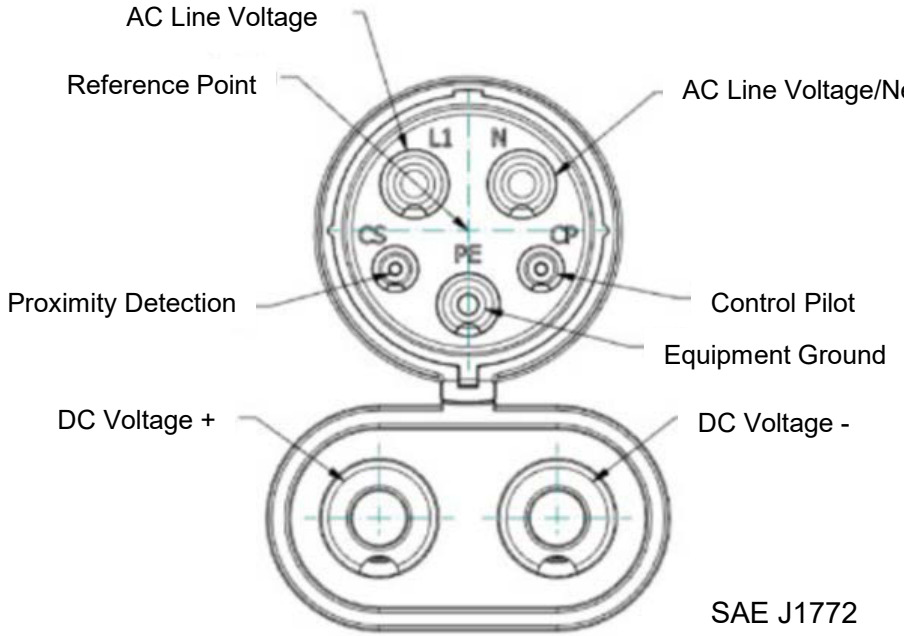


Figure and image: https://m.eet.com/media/1200054/sae-combo.jpg

How does the IEC standard compare?

- The IEC standard follows a similar structure and comparable power delivery to the SAE standard with a few exceptions.
  - Mode 1 is only for portable cord-sets and does not include the in-cable control and protective device (IC-CPD).
  - Mode 2 is only for portable cord-sets with a higher current limit than Mode 1.
  - Mode 3 is only for permanent hard-wired installations.
  - Mode 4 is the DC fast charging option with a combined charging standard (CCS) charging port that requires two additional DC pins.

Both Mode 1 and 2 are prohibited under current draft MEM regulation.

Some countries prohibit Mode 1.

Common Charging Levels	Voltage (V)	Current (A)	Power (kW)
IEC Mode 1	230	16	3.7
IEC Mode 2	230	16	3.7
IEC Mode 3	230	63	14.5
IEC Mode 4	480	105	50

Mode 1 does not have IC-CPD

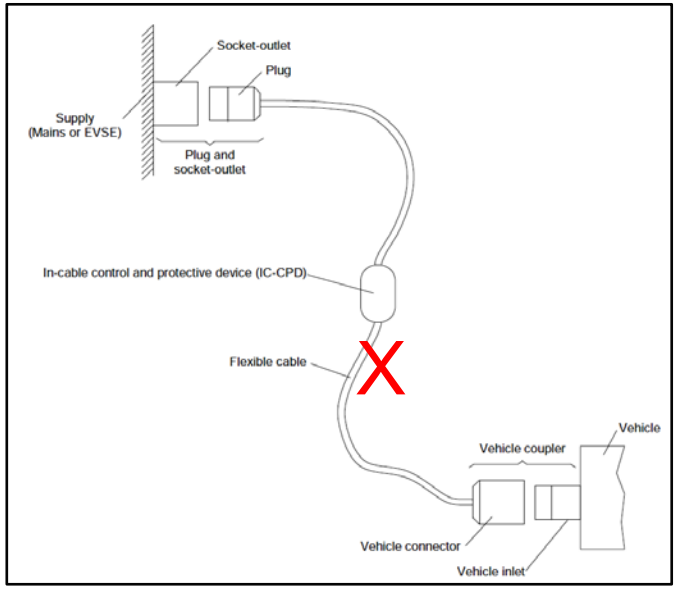


Figure and image: IEC 62196

Where does the energy go?

- AC charging power is limited by the capabilities of the vehicle's on-board charger.
- DC charging provides DC voltage directly to the vehicle's battery.

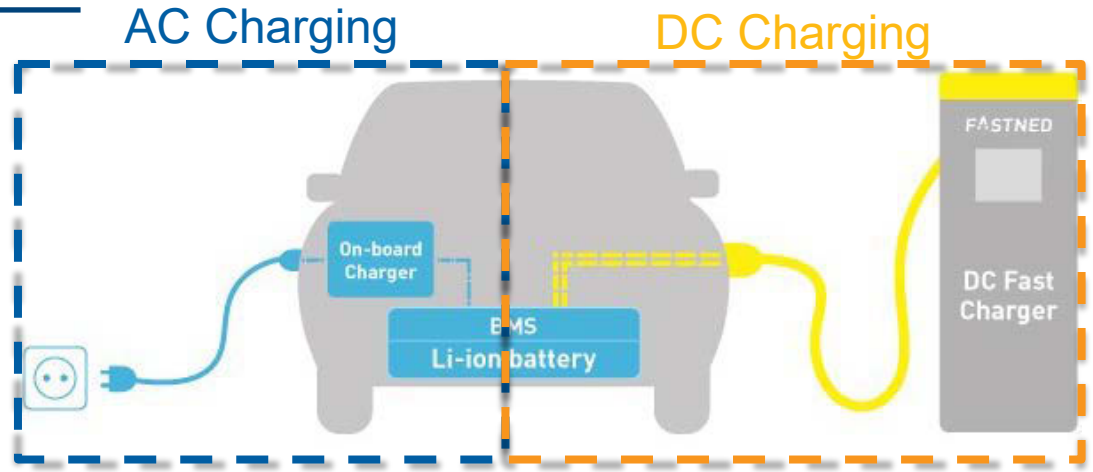


Figure: http://www.olino.org/blog/us/articles/2016/07/18/22857/comment-page-1

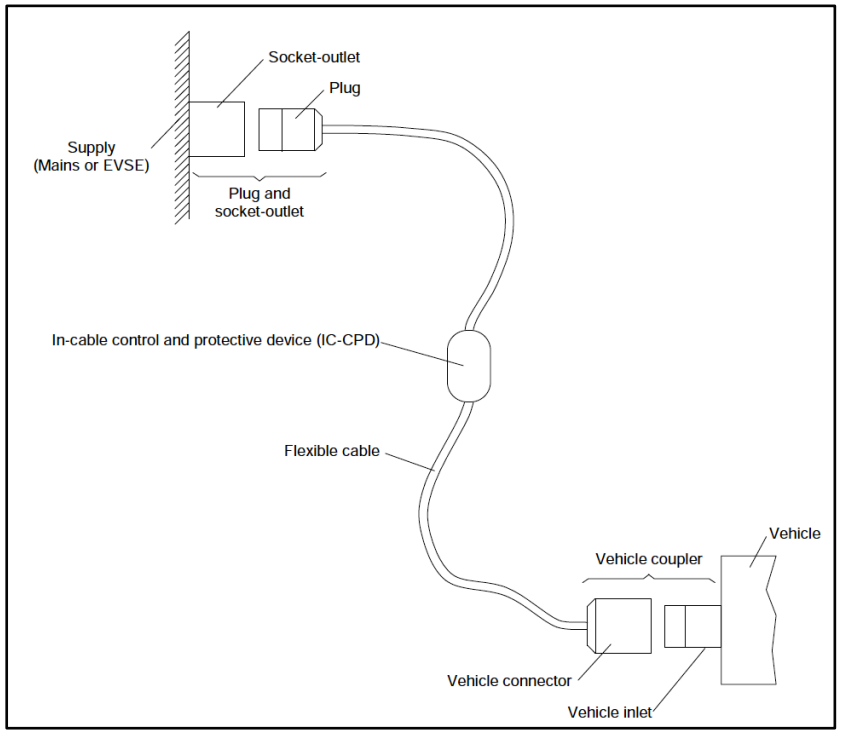


Figure: IEC 62196

- All AC charging (SAE and IEC), except IEC Mode 1, use an IC-CPD.
- This device communicates with the vehicle and controls the charging session.
  - Proximity detection
  - Ground fault indicator
  - EV and EVSE "handshake"
    - Battery level, electric grid conditions, continuity

Safety precautions included in Mode 2, 3, and 4

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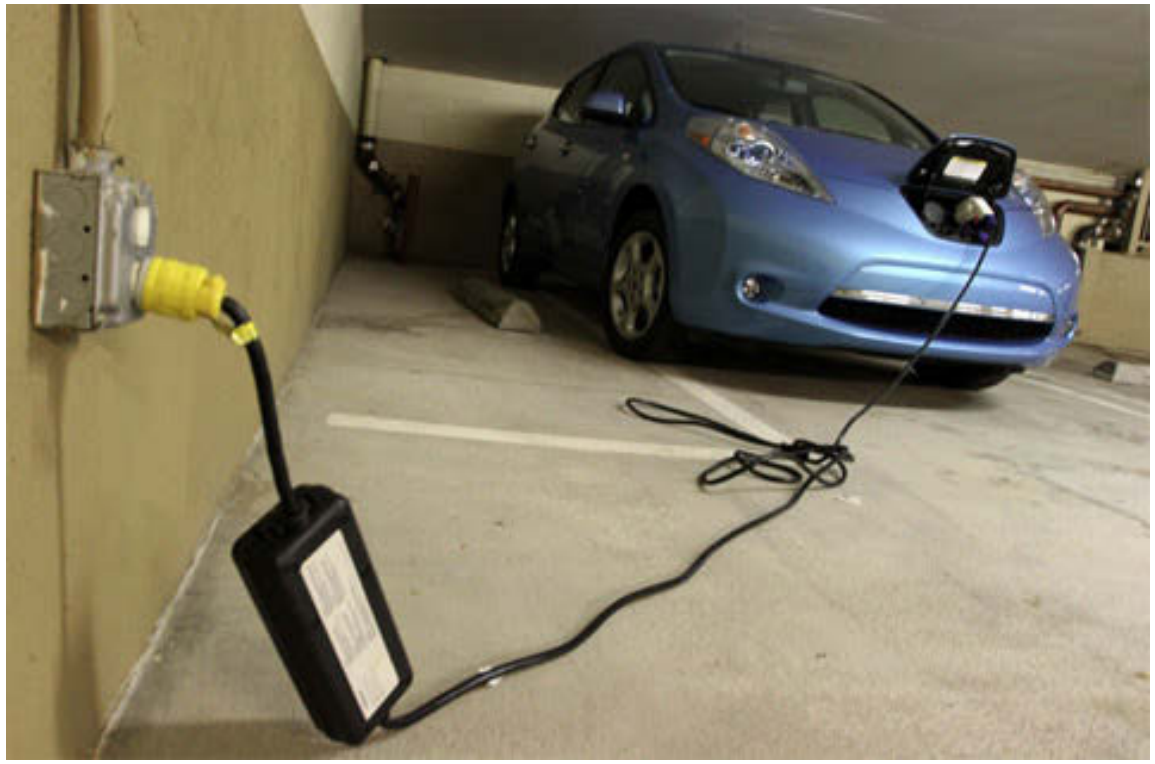
Example EVSE



- Portable AC powered EVSE with IC-CPD
  - SAE Level 1
  - IEC Mode 2

Image:
https://www.greenenergyconsumers.org/sites/default/files/images/nissan_leaf_110charging%20from%20evworld.jpg

- Permanently Installed AC powered EVSE
  - SAE Level 2
  - IEC Mode 3

Image:
https://cdn.shopify.com/s/files/1/0011/4102/products/717lfh0vPAL._SL1000__1_large.jpg?v=1510338934

Group Discussion:

1. Does the draft EVSE regulation capture all possible standards in the current and future EV market?
   - Most common vehicle types

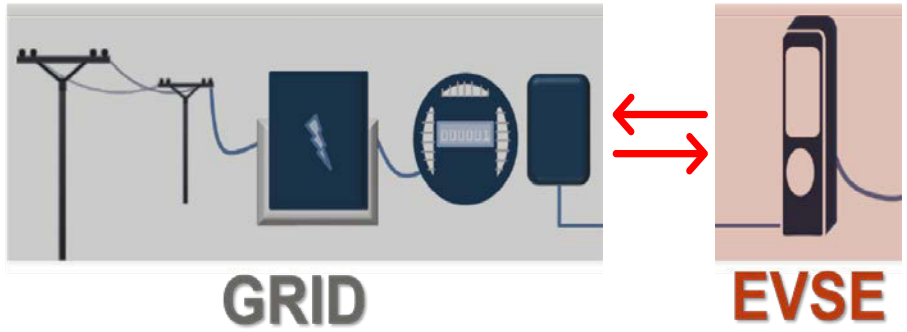
2. Could the regulation include provisions for both portable and permanent EVSE installation?
   - Mode 2 is a portable option that has a protection device, unlike Mode 1.

Please break into small groups (3-5 people per group) to discuss and then report back to the group in 10 minutes.

EVSE to Grid Connections

How is this power supplied to the EVSE?

- The NEC lists specific requirements for the installation of electricity circuits and electrical equipment in homes and commercial buildings.
- NEC Section 625 covers specific requirements for the installation of EVSE.



  - Branch circuits: Each EVSE permanently installed must be supplied by an individual branch circuit.
  - Overcurrent protection: Circuit breakers must be sized for 125% of the maximum EVSE load.
  - Conductor gauge and length: Supply cord and cable must meet specific requirements for each power level, generally #8 wire gauge and less than 25 feet.
  - Loss of primary service: If the electric grid loses power, the EVSE must not back-feed the grid, unless part of an interactive micro-grid system.

Cable sizing and maximum cable length are important to avoid voltage drop.

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Figure: Adapted from MJ Bradley & Associates

How does the NEC impact EVSE installs?

- Installation practices are strongly influenced by the NEC and common electrical equipment ratings.
- Many portable AC Level 1 units supply 1.4 kW (120 V, 12 A) or less.
  - Portable units are typically plugged in alongside other devices in a circuit and commonly have a lower rating.
  - Permanent Level 1 units are sometimes the full rating of 1.9 kW (120 V, 16 A) but require a 20 A circuit breaker.

Portable units provide convenience but are typically lower power to avoid overloading circuits.

The maximum power of Level 1 is designed for a standard 20 A circuit breaker (16 X 1.25 = 20).

EVSE	Service	Positions	Voltage	Connection
Level 1	120/240, 1Φ, 3W	1 (20 A)	120 V, 1Φ, L-N	A-N or (-A)-N
Level 1	208Y/120, 3Φ, 4W	1 (20 A)	120 V, 1Φ, L-N	A-N, B-N, or C-N
Level 2	120/240, 1Φ, 3W	2 (40 A)	240 V, 1Φ, L-L	A-(-A)
Level 2	208Y/120, 3Φ, 4W	2 (40 A)	208 V, 1Φ, L-L	A-B, B-C, or C-A

How does the NEC impact EVSE installs?

- Many permanent AC Level 2 units supply 6.7 kW (208 V, 32 A) for commercial buildings and 7.7 kW (240 V, 32 A) for residential homes.
  - A common 2-pole circuit breaker rating is 40 A (32 X 1.25 = 40).
  - Typical commercial buildings are supplied 208Y/120 V, 3-phase, 4-wire services.
  - Typical residential homes are supplied 120/240 V, 1-phase, 3-wire services.

DC fast charging options may be served by either AC or DC voltage.

DC voltage services may become valuable in the future when DC fast chargers become more popular.

EVSE	Service	Positions	Voltage	Connection
Level 1	120/240, 1Φ, 3W	1 (20 A)	120 V, 1Φ, L-N	A-N or (-A)-N
Level 1	208Y/120, 3Φ, 4W	1 (20 A)	120 V, 1Φ, L-N	A-N, B-N, or C-N
Level 2	120/240, 1Φ, 3W	2 (40 A)	240 V, 1Φ, L-L	A-(-A)
Level 2	208Y/120, 3Φ, 4W	2 (40 A)	208 V, 1Φ, L-L	A-B, B-C, or C-A

Thank You!

Questions?

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