Code on EV charging stations installation, maintenance, and operation

May 2025

Public Utilities Commission of Sri Lanka

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Definitions

Abbreviation	Term	Definition
BS	British Standards	Specifications and guidelines developed by the British Standards Institution (BSI) to ensure quality, safety, and consistency in products, services, and systems in the United Kingdom and internationally.
CHARdeMO	CHArge de MOve	A standard for charging electric vehicles.
Class I EVSE	Class I Electric Vehicle Supply Equipment	Equipment where protection against electric shock relies on basic insulation and a protective earth connection of accessible conductive parts. In the event of a failure in the basic insulation, the protective earthing ensures that exposed conductive parts do not reach a hazardous voltage.
Class II EVSE	Class II Electric Vehicle Supply Equipment	This equipment provides protection against electric shock through double or reinforced insulation, without relying on protective earthing. This means there is no provision for connection to a protective conductor, as safety is ensured by two layers of insulation or an equivalent single layer of reinforced insulation.
CPO	Charge Point Operator	A legal entity that constructs, owns, and operates electric vehicle charging stations, obtains the necessary power supply from a distribution licensee, and resells electricity to all types of electric vehicle owners at reasonable prices, operating under a distribution and supply exemption.
CCTV	Closed Circuit Television	A system of video cameras used to transmit signals to a specific set of monitors for surveillance and security purposes.
COP	Code of Practice	A set of guidelines and standards that outline best practices, safety measures, technical requirements, and operational procedures to ensure the efficient, safe, and user-friendly installation, operation and management of electric vehicle charging infrastructure.
CCS	Combined Charging System	A standard for charging electric vehicles.
	Commission	Public Utilities Commission of Sri Lanka incorporated under the PUCSL Act No 35 of 2002.

EV	Electric Vehicle	A vehicle powered entirely or partially by electricity, typically using energy stored in batteries or fuel cells, and driven by electric motors instead of internal combustion engines.
E-bike	Electric Bike	A bicycle equipped with an electric motor that assists propulsion, either by providing pedal assistance or full electric drive.
E-tuk tuk	Electric Tuk Tuk	A three-wheeled electric vehicle designed for passenger or cargo transport, powered by an electric motor instead of an internal combustion engine.
EVCS	Electric Vehicle Charging Station	A facility equipped with the necessary infrastructure to supply electrical energy for recharging the batteries of electric vehicles.
EVSE	Electric Vehicle Supply Equipment	The complete system that delivers electrical energy to recharge electric vehicles including all components required to safely transfer power from the electrical source to the EV battery.
Heavy EV	Heavy Electric Vehicle	An electrically powered vehicle that falls within the heavy-duty vehicle category, typically including buses, trucks, and other large commercial or industrial vehicles.
IP	Ingress Protection	A standard rating system that classifies the level of protection provided by an enclosure against the intrusion of solid objects, dust, and water.
IET	Institution of Engineering and Technology	A professional organization based in the United Kingdom that promotes engineering and technology innovation, provides industry standards, and supports education, professional development, and research globally.
IEC	International Electrotechnical Commission	A global organization that develops and publishes standards for electrical, electronic, and related technologies to ensure compatibility, safety, and performance across industries.
kWh	kilowatt hour	A unit of energy that measures the amount of electricity used or produced over one hour at a rate of one kilowatt.
LOTO	Lockout-tagout	A safety procedure used in workplaces to ensure that machines or equipment are properly shut off and not started up again while maintenance or repair work is being done, preventing accidental injuries.
NFC	Near Field Communication	A wireless technology that enables short-range communication between devices, typically within a few centimetres, for data exchange or contactless transactions.

OTP	One Time Password	A security feature that generates a unique, temporary code for a single use during authentication to enhance online security.
PPE	Personal Protective Equipment	Protective clothing, helmets, gloves, face shields, goggles, or other safety gear designed to protect individuals from health and safety risks at work or in specific environments.
PUCSL	Public Utilities Commission of Sri Lanka	Public Utilities Commission of Sri Lanka incorporated under the PUCSL Act No 35 of 2002.
QR Code	Quick Response Code	A two-dimensional barcode that can store information and is easily scanned using a smartphone or device to access data or perform actions quickly.
RFID	Radio Frequency Identification	A wireless technology that uses electromagnetic fields to identify and track tags attached to objects or devices for data exchange and authentication.
V2G	Vehicle to Grid	A technology that enables electric vehicles to transfer stored energy back to the power grid, allowing bidirectional energy flow for grid stabilization and energy management.
Wi-Fi	Wireless Fidelity	A wireless networking technology that allows devices to connect to the internet and communicate with each other using radio waves, typically within a local area.

1 PREAMBLE

This is the approved Code on EV charging stations installation, maintenance, and operation by the Commission in line with the empowerment given by the cabinet decision of 17/0613/706/041 in the year 2017 to regulate Electric Vehicle (EV) charging stations.

Further to the above, this code is issued per Condition 5 of the Certificate of Distribution and Supply or Supply Exemption granted under section 10(1) of the Sri Lanka Electricity Act 2009 (as amended).

Compliance with IEC standards is mandatory for the installation of EVSE and EV charging stations. This Code serves as a simplified and accessible version of these standards and other local regulations, ensuring that all stakeholders can easily understand and comply with its provisions.

The initial guideline issued in 2017 has been updated and structured into a Code, incorporating the latest standards and other necessary regulations, providing comprehensive guidance on the installation, operation, and maintenance of EVCS.

The Code was prepared by Dr. Eng. Lihil Uthpala Subasinghe, a consultant procured by the Sri Lanka Energy Program, the funded organization for this development.

2 ELECTRIC VEHICLE CHARGING

In an Electric Vehicle Charging Station (EVCS), the Electric Vehicle (EV) shall be connected to the Electric Vehicle Supply Equipment (EVSE) to ensure that, under normal conditions of use, the conductive energy transfer function operates safely.

This safety is generally achieved by meeting the relevant requirements specified in the **IEC 61851** and **IEC 62196** standards, with compliance verified through the prescribed tests detailed in these standards. Standard accessories used for EVSE shall be in accordance with **IEC 60309-1**, **IEC 60309-2** or **IEC 60884-1** or the national standard. Standard accessories that are intermateable with interfaces described in the **IEC 60320** series shall not be used for EVSE.

The charging equipment shall support a rated supply voltage of up to 1000 V AC or 1500 V DC. It must function correctly within a tolerance of ±6% of the nominal voltage. The rated frequency for operation is 50 Hz ± 1%.

All installations shall comply with **IEC 61439:** Low-voltage switchgear and controlgear assemblies that defines the requirements for the design, testing, and performance of electrical assemblies used in industrial, commercial, and residential applications.

An automotive-type vehicle designed for on-road use, such as passenger cars, buses, trucks, vans, electric three-wheelers, electric motorcycles, and similar vehicles, qualifies as an electric vehicle if it is primarily powered by an electric motor that draws energy from a rechargeable storage battery, supercapacitor, fuel cell, photovoltaic array, or other electric current sources. Plug-in Hybrid Electric Vehicles (PHEVs) are also considered electric vehicles.

For the purpose of the Sri Lankan standard, off-road self-propelled electric vehicles such as industrial trucks, shuttle vehicle, hoists, lifts, golf carts, airline ground support equipment, tractors, boats, and special purpose vehicles that do not require registration with the Department of Motor Traffic (DMT), Sri Lanka, are excluded from the definition of electric vehicles.

2.1 Connection between the EV and supply network

IEC 61851-1:2017 specifies 3 different connection arrangements as Case A, Case B, and Case C.

2.1.1 Case A

Connection of an EV to the supply network with a plug and cable permanently attached to the EV as shown in Figure 2.1.1. The cable assembly is part of the vehicle.

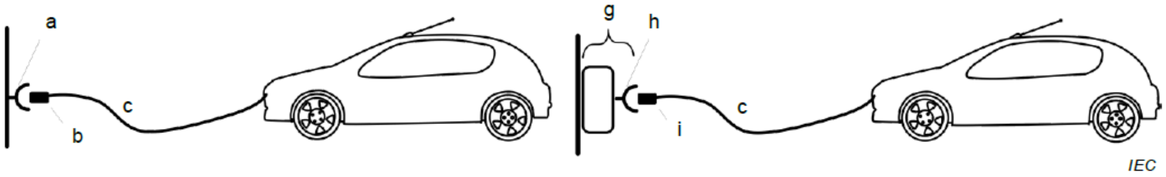

Figure 2.1.1 Case A connection

2.1.2 Case B

Connection of an EV to a supply network with a cable assembly detachable at both ends as shown in Figure 2.1.2. The detachable cable assembly is not part of the vehicle or the charging station.

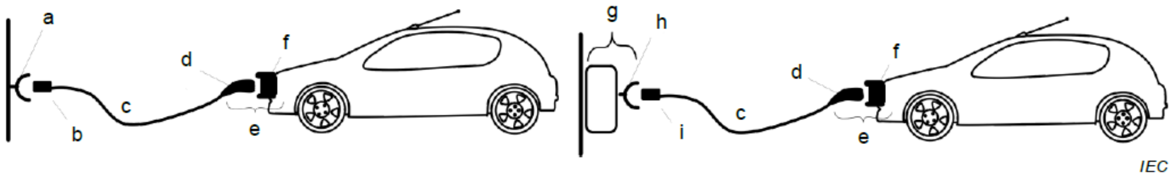

Figure 2.1.2 Case B connection

2.1.3 Case C

Connection of an EV to a supply network utilizing a cable and vehicle connector permanently attached to the EV charging station as shown in Figure 2.1.3. The cable assembly is part of the EV charging station.

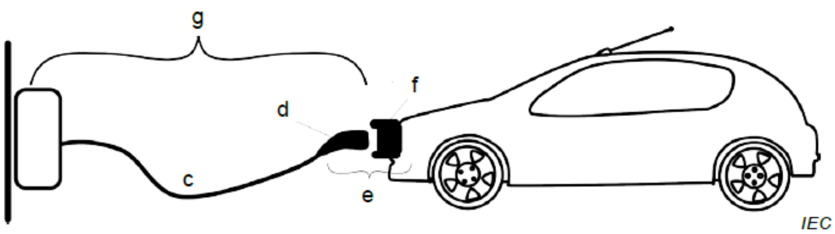

Figure 2.1.3 Case C connection

Key for, Figure 2.1.1, Figure 2.1.2, and Figure 2.1.3 are as follows.

(a) Socket-outlet (b) Plug (c) Cable (d) Vehicle connector (e) Vehicle coupler (f) Vehicle inlet (g) Charging station (h) EV socket-outlet (i) EV plug

2.1.4 Application of Accessories

IEC 62196-1:2022 depicts the application of accessories as shown in Figure 2.1.4.

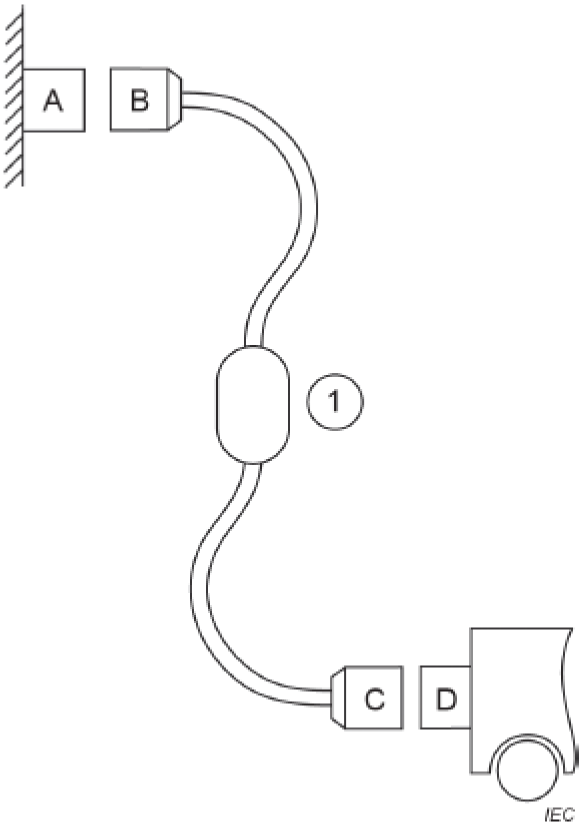

Figure 2.1.4 Diagram showing the use of the accessories.

Key for Figure 2.1.4 are as follows.

1 - In-cable control and protective device (IC-CPD)

A - Standard socket-outlet or EV socket-outlet

B - Standard plug or EV plug

C - Vehicle connector

D - Vehicle inlet

2.2 Charging modes

IEC 61851-1:2017 specifies 4 charging modes as Mode 1, Mode 2, Mode 3, and Mode 4 (see Figure 2.2.1). A Residual Current Device (RCD) with characteristics that are at least equivalent to Type A as defined in **IEC 61008-1** or **IEC 61009-1**, or **IEC/TR 60755** in conjunction with an over-current protection device shall be required for all modes of charging. However, as per **IEC 60364-7-722**, to protect against DC leakage currents, Type B RCD or a Type A RCD and appropriate equipment that ensures the disconnection of the supply in case of DC fault current above 6 mA shall be required.

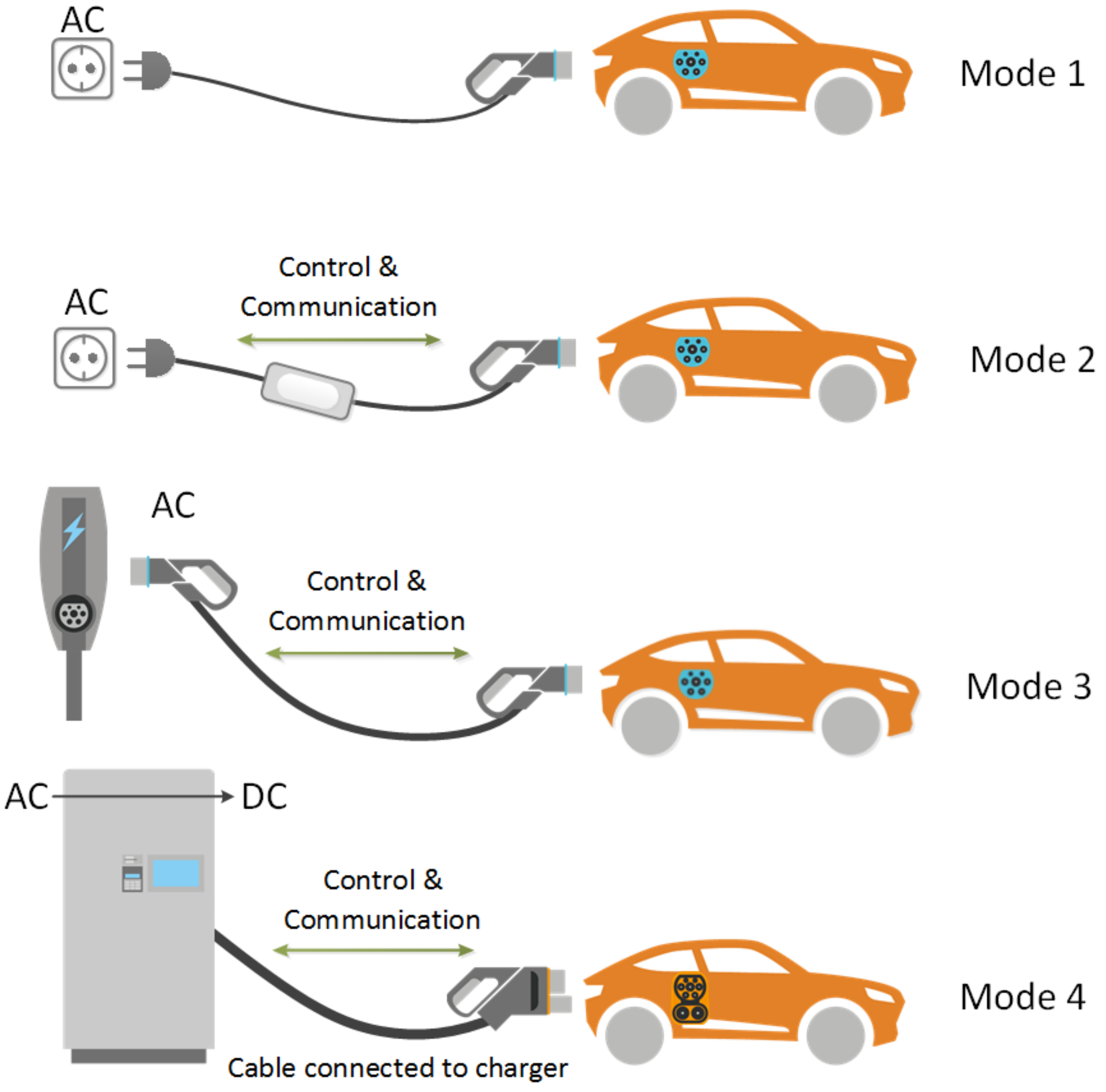

Figure 2.2.1 Charging modes

2.2.1 Mode 1

Mode 1 is a method for the connection of an EV to a standard socket outlet of an AC supply network, utilizing a cable and plug, both of which are not fitted with any supplementary pilot or auxiliary contacts.

The rated values for current and voltage shall not exceed:

- 16 A and 250 V AC, single-phase,
- 16 A and 480 V AC, three-phase.

EVSE intended for Mode 1 charging shall provide a protective earthing conductor from the standard plug to the vehicle connector.

Current limitations are also subject to the standard socket-outlet ratings.

2.2.2 Mode 2

Mode 2 is a method for the connection of an EV to a standard socket-outlet of an AC supply network utilizing an AC EVSE with a cable and plug, with a control pilot function and system for personal protection against electric shock placed between the standard plug and the EV.

The rated values for current and voltage shall not exceed:

- 32 A and 250 V AC single-phase,
- 32 A and 480 V AC three-phase.

Current limitations are also subject to the standard socket-outlet ratings.

EVSE intended for Mode 2 charging shall provide a protective earthing conductor from the standard plug to the vehicle connector.

Mode 2 equipment that is destined to be mounted on a wall but is detachable by the user, or to be used in a shock resistant enclosure shall use protection equipment as required by **IEC 62752**.

2.2.3 Mode 3

Mode 3 is a method for the connection of an EV to an AC EVSE permanently connected to an AC supply network, with a control pilot function that extends from the AC EVSE to the

EV. EVSE intended for Mode 3 charging shall provide a protective earthing conductor to the EV socket-outlet and/or to the vehicle connector.

2.2.4 Mode 4

Mode 4 is a method for the connection of an EV to an AC or DC supply network utilizing a DC EVSE, with a control pilot function that extends from the DC EVSE to the EV.

Mode 4 equipment may be either permanently connected or connected by a cable and plug to the supply network. EVSE intended for Mode 4 charging shall provide a protective earthing conductor or protective conductor to the vehicle connector.

Additional requirements for DC EVSE are given in **IEC 61851-23**.

2.2.5 Mandatory Functions provided in Mode 2, 3, and 4

The following control pilot functions shall be provided by the EVSE.

2.2.5.1 Continuous continuity checking of the protective conductor

While charging in Mode 2, the electrical continuity of the protective earthing conductor between the ICCB (in-cable control box) and the respective EV contact shall be continuously monitored by the ICCB.

Note: ICCB is a device incorporated in the Mode 2 cable assembly, which performs control functions and safety functions.

While charging in Mode 3, the electrical continuity of the protective earthing conductor between the EV charging station and the respective EV contact shall be continuously monitored by the EVSE.

While charging in Mode 4, the electrical continuity of the protective conductor between the EV charging station and the respective EV contact shall be continuously monitored by the EVSE.

The EVSE shall disconnect the supply to the EV in case of:

- loss of electrical continuity of the protective conductor (i.e. open control pilot circuit), within 100 ms.
- incapacity to verify the continuity of the protective conductor (e.g. short circuit between pilot wire and protective conductor), within 3 s.

2.2.5.2 Verification that the EV is properly connected to the EVSE

The EVSE shall be able to determine that the EV is properly connected to the EVSE.

Proper connection is assumed when the continuity of the control pilot circuit is detected.

2.2.5.3 Energization of the power supply to the EV

The EV socket-outlet or the vehicle connector shall not be energized unless the control pilot function between EVSE and EV has been established correctly with signal states allowing energization.

The presence of such states does not imply that energy will be transferred between the EVSE and the EV as this may be subject to other external conditions, e.g. energy management system.

If the EV requests ventilation, the EVSE shall only energize the system if such ventilation is provided by the installation or the premises.

2.2.5.4 De-energization of the power supply to the EV

If the control pilot signal is interrupted the power supply to the EV shall be interrupted according to 2.2.5.1.

If the control pilot signal status no longer allows energization, the power supply to the EV shall be interrupted but the control pilot signalling may remain in operation.

2.2.5.5 Maximum allowable current

A means shall be provided to inform the EV of the value of the maximum current it is allowed to draw. The value of the maximum current permitted shall be transmitted and shall not exceed any of the following:

- the rated output current of the EVSE,
- the rated current of the cable assembly.

Note: The cable assembly includes Mode 2 and Mode 3 cable assemblies.

The transmitted value may change, without exceeding the maximum allowed current, to adapt to power limitations, e.g. for load management.

The EVSE may interrupt the energy supply if the current drawn by the EV exceeds the transmitted value.

2.2.6 Optional functions for Modes 2, 3 and 4

The optional functions that are implemented shall be indicated in the manual and shall fulfil the requirements of section 2.2.6

2.2.6.1 Ventilation during supply of energy

EVSE can exchange information with installation regarding the request and presence for ventilation.

(**Note:** The EVSE can communicate with the electrical installation of the building and check for the operation of the ventilation system. If required, the EVSE can request the electrical installation to switch on the ventilation system.)

2.2.6.2 Intentional and unintentional disconnection of the vehicle connector and/or the EV plug

A mechanical or electromechanical means shall be provided to prevent intentional and unintentional disconnection under load of the vehicle connector and/or plug according to **IEC 62196-1**.

2.2.6.3 Mode 4 using the combined charging system

The combined charging system as described in Annex CC of **IEC 61851-23:2014** shall be designed so that,

- AC chargeable EVs with a basic vehicle inlet do not require any means to protect the EV against DC voltage at the inlet.
- AC EVSE does not require any means to be self-protected against DC voltage coming from the EV.

For DC charging, digital communication shall be established between the vehicle and the DC EV charging station that validates the DC energy transfer. The DC supply to the vehicle shall not be connected until such complete validation from the vehicle is achieved.

A combined interface extends the use of a basic interface for AC and DC charging.

DC charging can be achieved by using separate and additional DC power contacts to supply DC energy to the EV or by using power contacts placed at the position of the AC power contacts of a basic interface if the vehicle connector and the vehicle inlet are both suitable for DC.

The basic portion of the combined vehicle inlet can be used with a basic connector for AC charging only or with a combined connector having separate contacts for AC or DC charging.

AC and DC power transfer shall not occur through the combined interface at the same time.

The combined interface used for DC charging shall only be used with the "Combined Charging System" described in Annex CC of **IEC 61851-23**:2014.

Analysis and design of the EVSE using a basic interface for DC shall apply a risk analysis according to IEC 61508 (all parts) applying a severity level of at least S2 for the function preventing the risk of unintended DC voltage output.

Additional information has been provided in **IEC 61851** Appendix A, B, and C.

2.3 AC Charging Interfaces

AC charging interfaces that comply with the relevant provisions of the IEC 62196 series shall be deemed acceptable for use, provided they ensure interoperability, safety, and performance in accordance with applicable IEC standards.

2.3.1 Configuration Type 1

This is a 32 A, 250 V (rated) AC interface. Also known as the "Type 1 connector," which is developed based on the SAE J772 standard that supports charging in Mode 2 (section 2.2.2). It features a round housing, which has a notch on the vehicle inlet for proper orientation, with five pin-and-sleeve contacts for two AC conductors, a protective conductor and two signal pins that are used for the control pilot function (according to **IEC 61851-1** Annex A) and for proximity detection (using an auxiliary switch and no current coding, according to **IEC 61851-1 Annex B**). When inserted into the vehicle inlet, the connector is held in place by a mechanical latch, which is part of the connector.

Pin arrangement is shown in Figure 2.3.1.1 and the definitions are given in Table 2.3.1.1. Further information can be found in **IEC 62196-2**. The actual appearance of a Type 1 vehicle connector and a vehicle inlet are shown in Figure 2.3.1.2 and Figure 2.3.1.3, respectively.

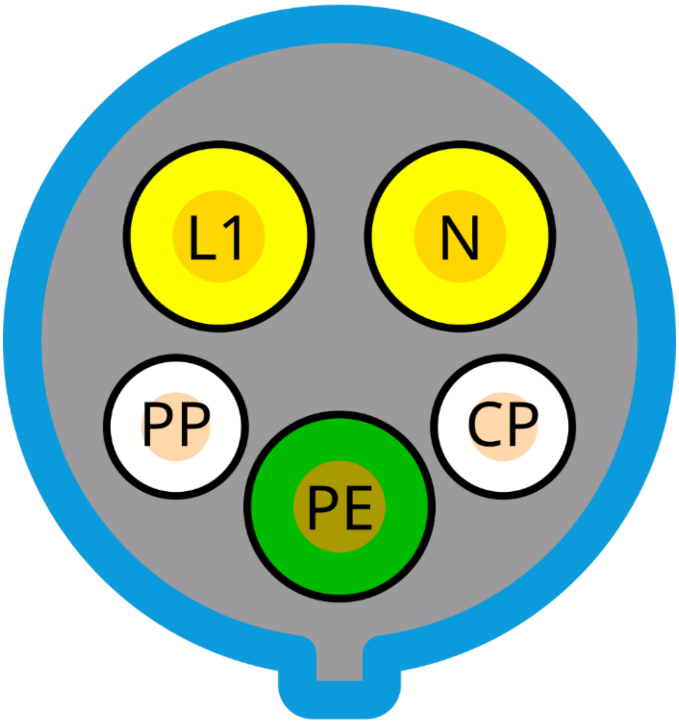

Figure 2.3.1.1 Configuration Type 1 (vehicle connector)

Table 2.3.1.1 Overview of the basic vehicle interface, configuration type 1, single phase

Pin	Definition	Maximum Voltage	Maximum Current
L1	Live 1	250 V	32 A
N/L2	Neutral/Live 2	250 V	32 A
PE	Protective Earth/Ground		Rated for fault
CP	Control pilot	30 V	2 A
PP/CS	Proximity pilot/Connection switch	30 V	2 A

Note: "Rated for fault" means "rated for the highest fault current".

Figure 2.3.1.2 Type 1 vehicle connector

Figure 2.3.1.3 Type 1 vehicle inlet

2.3.2 Configuration Type 2

This is a 63 A, 480 V (rated) three-phase or a 70 A, 250 V (rated) single-phase interface. Also known as the "Type 2 connector". This configuration consists of a plug and socket-outlet that support charging in Mode 3 (section 2.2.3), and a vehicle coupler, consisting of vehicle connector and vehicle inlet, that supports charging in Mode 2 (section 2.2.2) and Mode 3 (section 2.2.3).

It features a round housing, which is flattened on one side for proper orientation, with up to seven pin-and-sleeve contacts for up to four AC conductors, a protective conductor and two signal pins that are used for the control pilot function (according to **IEC 61851-1** Annex A) and for simultaneous proximity detection and current coding (according to IEC **61851-1** Annex B). By design, the contacts cannot be touched by the standardized test finger. Since the second edition of the standard, additional touch protection of the contacts can optionally be provided by shutters. When inserted into the inlet, the connector is held in place by the locking mechanism, which is attached to the inlet. The same concept is used by the socket-outlet to hold the plug in place.

Pin arrangement is shown in Figure 2.3.2.1 and the definitions are given in Table 2.3.2.1. Further information can be found in **IEC 62196-2**. The actual appearance of a Type 2 vehicle connector and a vehicle inlet are shown in Figure 2.3.2.2 and Figure 2.3.2.3, respectively.

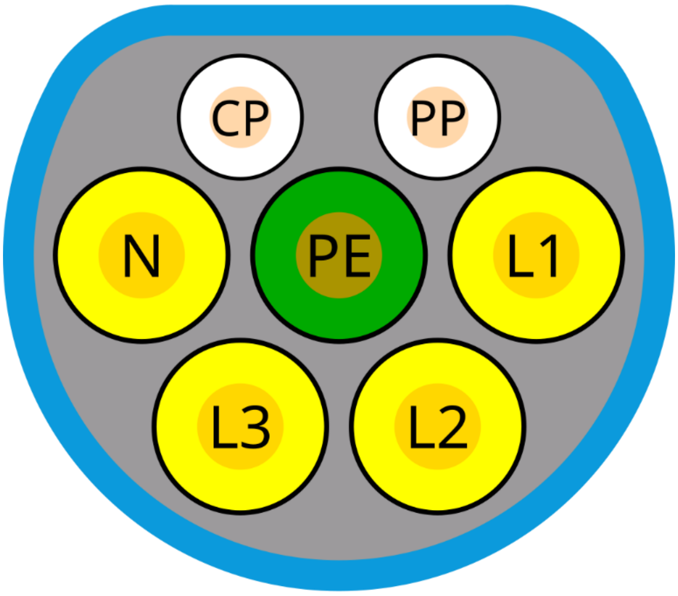

Figure 2.3.2.1 Configuration Type 2 (vehicle connector)

Table 2.3.2.1 Overview of the basic vehicle interface, configuration type 2, three phase or single phase

Pin	Definition	Maximum Voltage	Maximum Current	
			Three phase	Single phase
L1	Live 1	480 V	63 A	70 A
L2	Live 2	480 V	63 A	-
L3	Live 3	480 V	63 A	-
N	Neutral	480 V	63 A	70 A
PE	Protective Earth/Ground	—	Rated for fault	
CP	Control pilot	30 V	2 A	
PP/CS	Proximity pilot/Connection switch	30 V	2 A	

Figure 2.3.2.2 Type 2 vehicle connector

Figure 2.3.2.3 Type 2 vehicle inlet

2.4 DC Charging Interfaces

DC charging interfaces that comply with the relevant provisions of the IEC 62196 series shall be deemed acceptable for use, provided they ensure interoperability, safety, and performance in accordance with applicable IEC standards.

2.4.1 Configuration AA

This is a 1000 V DC interface that can go up to 400 A. Also known as the “CHAdeMO connector”. This coupler is intended to be used with DC charging stations that implement

System A according to **IEC 61851-23** Annex AA and CAN-communication according to **IEC 61851-24** Annex A. The coupler supports charging in Mode 4 (section 2.2.4).

Pin arrangement is shown in Figure 2.4.1.1 and the definitions are given in Table 2.4.1.1. Further information can be found in **IEC 62196-3**. The actual appearance of a Type AA vehicle connector and a vehicle inlet are shown in Figure 2.4.1.2 and Figure 2.4.1.3, respectively.

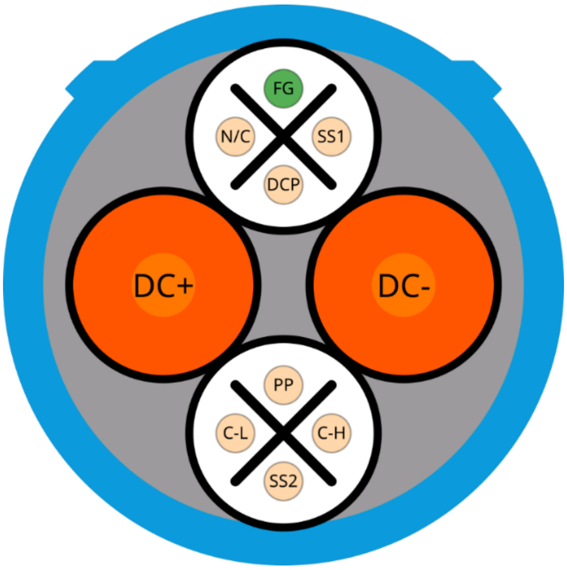

Figure 2.4.1.1 Configuration AA (vehicle connector)

Table 2.4.1.1 Overview of the basic vehicle interface, configuration AA

Pin	Definition	Maximum Voltage	Maximum Current
DC+	DC power supply (+)	1000 V	400 A
DC-	DC power supply (-)	1000 V	400 A
FG	Protective Earth/Ground	-	Rated for fault
N/C	Not connected/Reserved	-	-
SS1	Charge sequence signal (start/stop charging) 1	30 V	10 A
DCP	Control pilot / Charge Enable (Vehicle grants EVSE permission to connect power)	30 V	10 A
PP	Proximity pilot	30 V	2 A
C-L	CAN-low	30 V	2 A

C-H	CAN-high	30 V	2 A
SS2	Charge sequence signal (start/stop charging) 2	30 V	10 A

Figure 2.4.1.2 Type AA (CHAdeMO) vehicle connector

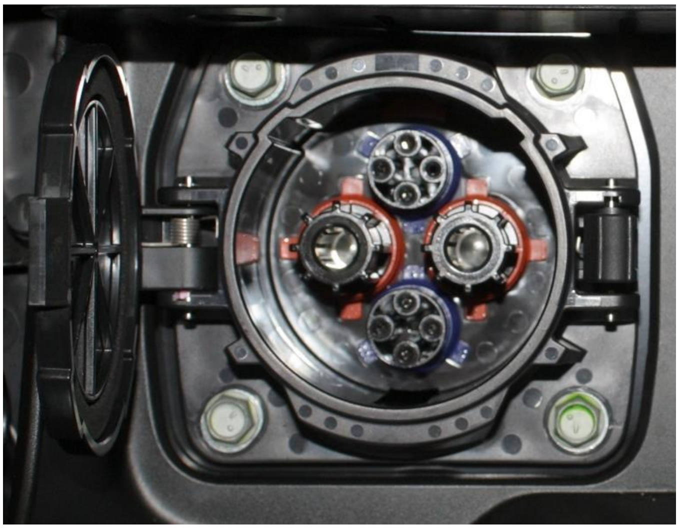

Figure 2.4.1.3 Type AA (CHAdeMO) vehicle inlet

2.4.2 Configuration EE

This is a 1000 V DC interface that can go up to 400 A. Also known as the “CCS1 connector” or “Combo1 connector”, because it is used within the Combined Charging System (CCS) and extends the Type 1 coupler. This coupler is intended to be used with DC charging stations that implement System C according to **IEC 61851-23** and PLC communication according to **IEC 61851-24** Annex C.

Pin arrangement is shown in Figure 2.4.2.1 and the definitions are given in Table 2.4.2.1. Further information can be found in **IEC 62196-3**. The actual appearance of a Type EE vehicle connector and a vehicle inlet are shown in Figure 2.4.2.2 and Figure 2.4.2.3, respectively.

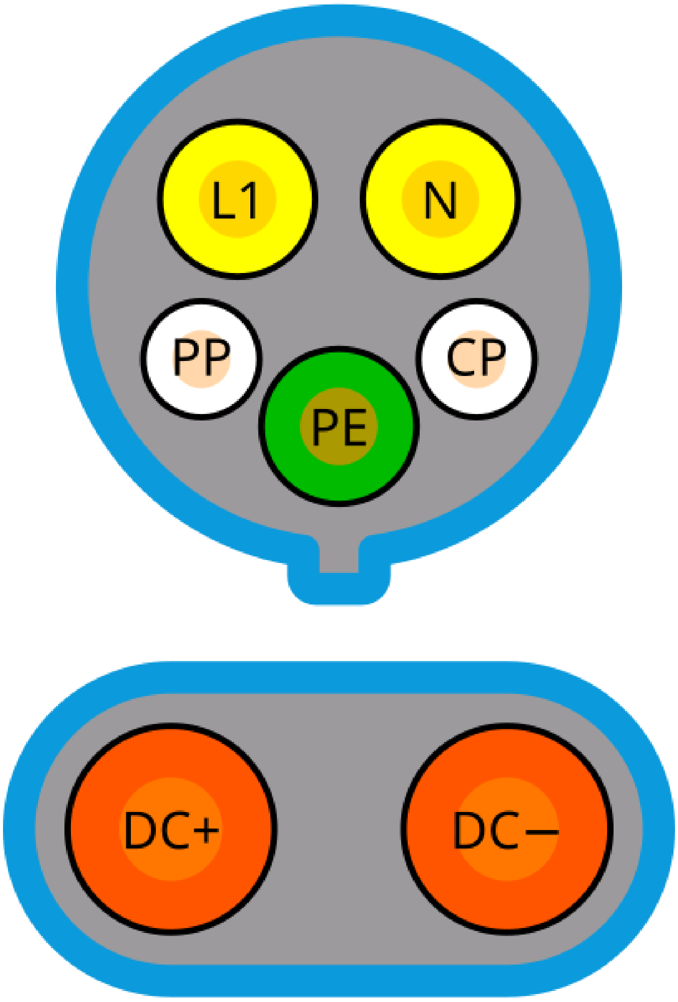

Figure 2.4.2.1 Configuration EE (vehicle connector)

Table 2.4.2.1 Overview of the basic vehicle interface, configuration EE

Pin	Definition	Maximum Voltage	Maximum Current
L1	Live 1	250 V	32 A
N/L2	Neutral/Live 2	250 V	32 A
PE	Protective Earth/Ground		Rated for fault
CP	Control pilot	30 V	2 A
PP/CS	Proximity pilot/Connection switch	30 V	2 A

DC+	DC power supply (+)	1000 V	400 A
DC-	DC power supply (-)	1000 V	400 A

Figure 2.4.2.2 Type EE (CCS1) vehicle connector

Figure 2.4.2.3 Type EE (CCS1) vehicle inlet

2.4.3 Configuration FF

This is a 1000 V DC interface that can go up to 400 A. Also known as the "CCS2 connector" or "Combo2 connector", because it is used within the Combined Charging System (CCS) and extends the Type 2 coupler. This coupler is intended to be used with DC charging stations that implement System C according to **IEC 61851-23** and PLC communication according to **IEC 61851-24** Annex C.

Pin arrangement is shown in Figure 2.4.3.1 and the definitions are given in Table 2.4.3.1. Further information can be found in **IEC 62196-3**. The actual appearance of a Type FF vehicle connector and a vehicle inlet are shown in Figure 2.4.3.2 and Figure 2.4.3.3, respectively.

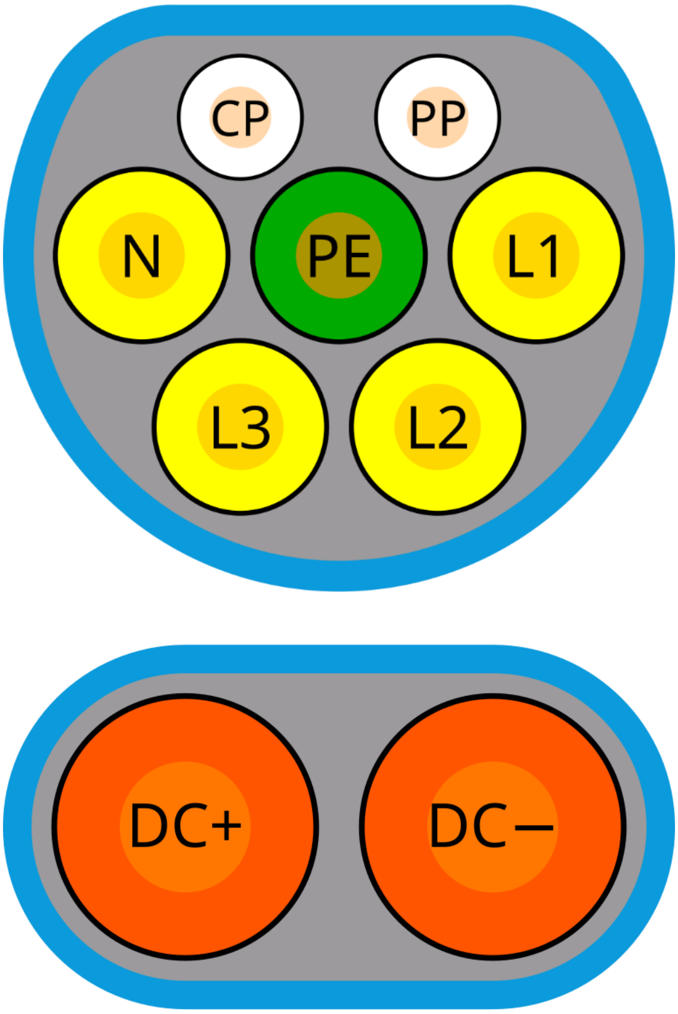

Figure 2.4.3.1 Configuration FF (vehicle connector)

Table 2.4.3.1 Overview of the basic vehicle interface, configuration FF

Pin	Definition	Maximum Voltage	Maximum Current	
			Three phase	Single phase
L1	Live 1	480 V	63 A	70 A
L2	Live 2	480 V	63 A	-

L3	Live 3	480 V	63 A	-
N	Neutral	480 V	63 A	70 A
PE	Protective Earth/Ground	—	Rated for fault	
CP	Control pilot	30 V	2 A	
PP/CS	Proximity pilot/Connection switch	30 V	2 A	
DC+	DC power supply (+)	1000 V	400 A	
DC-	DC power supply (-)	1000 V	400 A	

Figure 2.4.3.2 Type FF (CCS2) vehicle connector

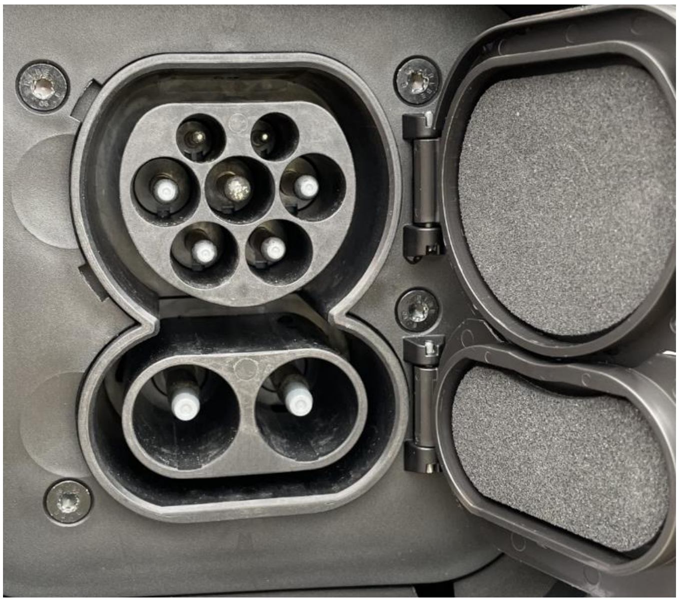

Figure 2.4.3.3 Type FF (CCS2) vehicle inlet

2.5 Communication

Digital communication is optional for Modes 1, 2 and 3. For Mode 4 the digital communication as described in **IEC 61851-24** shall be provided to allow the EV to control the EVSE.

2.6 Protection against electric shock

The means of protection against electrical shock shall be provided as described in **IEC 61851-1**.

2.7 Requirements for adaptors

Adaptors between the EV socket-outlet and the EV plug shall only be used if specifically designated and approved by the vehicle manufacturer or by the EVSE manufacturer and in accordance with national requirements.

Such adaptors shall comply with the requirements of this standard, and the other relevant standards governing either the EV plug or EV socket-outlet portions of the adaptor. The adaptors shall be marked to indicate the specific conditions of use allowed by the manufacturer.

Such adaptors shall not allow transitions from one mode to another.

2.8 Cable assembly requirements

The cable assembly requirements shall be fulfilled as described in **IEC 61851-1**.

2.9 EVSE constructional requirements and tests

The constructional requirements of EVSE shall be fulfilled, and relevant tests shall be conducted as described in **IEC 61851-1**.

2.9.1 Degrees of protection against solid foreign objects and water for the enclosures

Enclosures of the EVSE shall have an Ingress Protection (IP) degree, according to **IEC 60529** as follows.

- indoor use: at least IP41
- outdoor use: at least IP44

The minimum IP degree for socket-outlets and the vehicle connectors shall be in accordance with their appropriate standards. IPX4 may be obtained by the combination of the socket-outlet or connector and the lid or cap, EVSE enclosure or EV enclosure.

2.9.2 Degrees of protection against solid foreign objects and water for basic, universal and combined and DC interfaces

The minimum IP degrees for ingress of objects and liquids shall be as follows.

- Indoor use:
    - vehicle connector when mated with vehicle inlet: IP21
    - EV plug mated with EV socket-outlet: IP21
    - vehicle connector for case C when not mated: IP21
    - vehicle connector for case B when not mated: IP24
- Outdoor use:
    - vehicle connector when mated with vehicle inlet: IP44
    - EV plug mated with EV socket-outlet: IP44
    - vehicle connector when not mated: IP24
    - vehicle connector for case B when not mated: IP24
    - socket-outlet when not mated: IP24

IPX4 may be obtained by the combination of the socket-outlet or connector and the lid or cap, EVSE enclosure or EV enclosure.

2.10 Overload and short-circuit protection

The means of overload and short-circuit protection shall be provided as described in **IEC 61851-1**. The following is only a general description.

Where connecting points can be used simultaneously and are intended to be supplied from the same input line, they shall have individual protection incorporated in the EVSE.

If the EVSE presents more than one connecting point then such connecting points may have common overload protection means and may have common short-circuit protection means, if those protection means provide the required protection for each of the connecting points (e.g. the common protection device shall have a rating no higher than the lowest rating of the connecting points).

If the EVSE presents more than one connecting point that cannot be used simultaneously then such connecting points can have common protection means.

Such overcurrent protective devices shall comply with **IEC 60947-2**, **IEC 60947-6-2** or **IEC 61009-1** or with the relevant parts of **IEC 60898** series or **IEC 60269** series.

2.11 Marking and other relevant instructions for users

The installation manual of EV charging stations shall indicate the classification as given in Clause 5 of **IEC 61851-1**.

The EVSE manufacturer shall state the interface characteristics specified in Clause 5 of **IEC TS 61439-7**:2014 in the manual where applicable. Wiring instructions shall be provided.

If protective devices are included in the EV charging station, the manual shall indicate the characteristics of those protection devices explicitly describing the type and rating. The information may be provided in a detailed electric diagram.

If the protective devices are not in the EV charging station, the manual shall indicate all information necessary for the installation of external protection explicitly describing the type and rating of the devices to be used.

It is recommended that the installation manual be made available to relevant stakeholders and regulating bodies.

If the EV charging station has more than one connection of equipment to the AC supply network and does not have individual protection for each connecting point to the vehicles, then the installation manual shall indicate that each connection of the equipment to the AC supply network requires individual protection.

The equipment shall bear the following markings in a clear manner, as applicable.

- Name, initials, trademark or distinctive marking to identify the manufacturer
- Equipment reference
- Serial number or catalogue number
- Date of manufacture
- Rated voltage in V
- Rated frequency in Hz
- Rated current in A
- Number of phases
- IP degrees (degree of protection)
- "Indoor Use Only", or the equivalent, if intended for indoor use only
- For all Class II equipment, the symbol shall clearly appear in the markings
- All necessary information relating to the other declared classifications, characteristics and diversity factor(s)
- Minimal contact information (for example, phone number, address of contractor, installer or manufacturer)

3 MINIMUM STANDARDS FOR CHARGING MODE 1

Only the following rated power interfaces are permitted for charging Mode 1.

3.1 Power interfaces

If an EV charging station is equipped with a power supply cord featuring a plug that complies with **IEC 60083** (BS 1363), a compatible outlet must be installed. The Type I socket outlet for EV charging facilities in Sri Lanka must be a **square-pin, 13 A, 230 V** outlet conforming to **IEC 60083** Type G (BS 1363), as illustrated in Figure 3.1.1. It should be mandatory to safeguard against overcurrent and earth faults at the power supply using protective devices including miniature circuit breakers (MCBs) and residual current detectors (RCDs) designed as per the BS 7671.

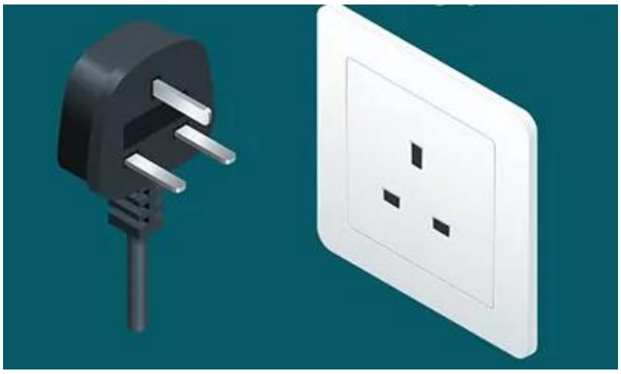

Figure 3.1.1 IEC 60083 Type G socket-outlet and a plug

The Type II socket outlet for EV charging facilities in Sri Lanka must be a **round, five-pin** industrial socket (L1, L2, L3, N, and PE), **rated at 32 A and 400 V**, compliant with **IEC 60309,** as illustrated in Figure 3.1.2. Similar to Type I outlets, it must also be protected against overcurrent and earth faults at the power supply using protective devices such as MCBs and RCDs, as per the BS 7671.

Figure 3.1.2 IEC 60309 five-pin socket-outlet and a plug

The Type III socket outlet for EV charging facilities in Sri Lanka must be a **round, three-pin** industrial socket (L N, and PE), **rated at 16 A and 230 V**, compliant with **IEC 60309,** as illustrated in Figure 3.1.3. Similar to Type I and II outlets, it must also be protected against overcurrent and earth faults at the power supply using protective devices such as MCBs and RCDs, as per the BS 7671.

Figure 3.1.3 IEC 60309 three-pin socket-outlet and a plug

Connectors intended for outdoor use must have a minimum IP rating of IP44.

The charging cable, equipped with in-cable control to support mandatory pilot functions, shall be supplied by the EV manufacturer.

3.2 Installation standards

The selection of circuit components must align with the ratings of the EV charging station as specified in **IEC 61851**. The charging station should be powered by a dedicated branch circuit, which may require installing a circuit breaker in the distribution panel. Since this equipment is classified as a continuous load, the existing service line must have sufficient capacity to handle the additional demand. If not, upgrading the panel and service line may be necessary.

Alternatively, the station can be connected to an existing branch circuit with an appropriate rating (e.g., a 20 A circuit supplying a kitchen range), provided a switching mechanism is installed to prevent simultaneous operation of both loads.

It is mandatory to provide a socket outlet along with a properly designed switch disconnector, isolator, or switching mechanism positioned before the power interface.

The conductor gauge must be selected to ensure that voltage drop and current-carrying capacity comply with the IET Wiring Regulations, 18th Edition (BS 7671).

3.3 Energy metering

All metering equipment used to measure electricity consumption must comply with **IEC 62052**. Three general approaches have been identified for metering EV load in Mode 1: single metering, submetering, and separate metering.

3.3.1 Single metering

The EV load is included as part of the total household load and is not measured separately. This approach, illustrated in Figure 3.3.1, is similar to how electricity consumption is accounted for with most other new appliances purchased by a household. It is commonly referred to as "whole-house" metering.

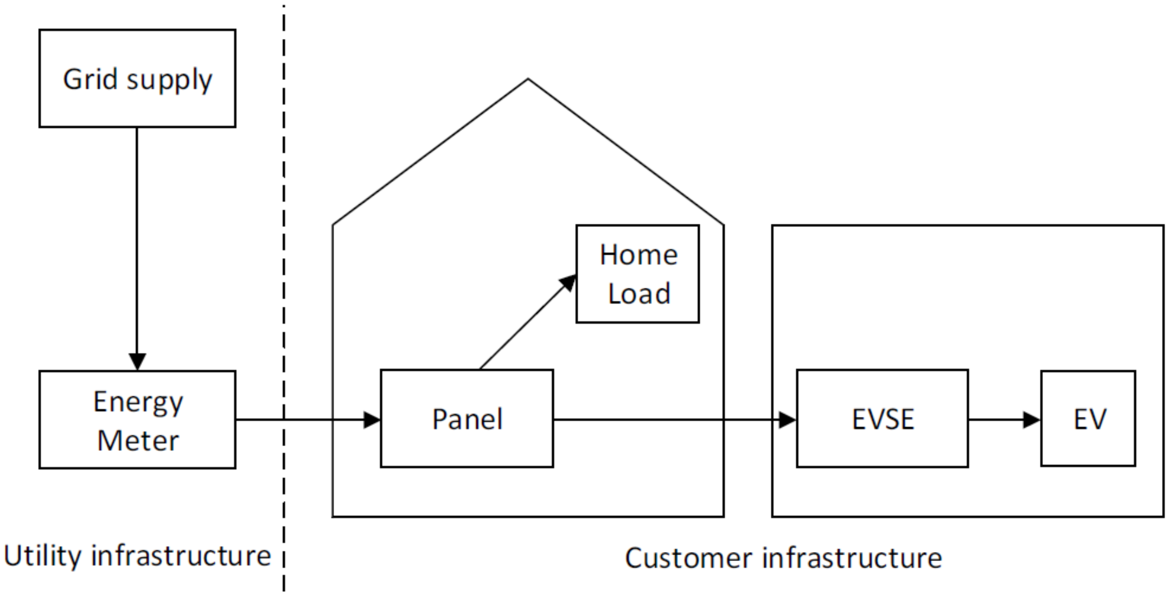

Figure 3.3.1 Single metering approach

3.3.2 Submetering approach

The EV load is measured using a meter installed between the main meter and the EVSE, functioning as a submeter specifically for the EV load. This setup allows the submeter to measure the EV load as a subset of the total load, while the main energy meter continues to measure the entire household load, as shown in Figure 3.3.2. For accurate billing, the EV load recorded by the submeter must be subtracted from the main meter's reading to prevent double-counting of EV consumption. This approach is also known as "subtractive metering" or "series metering."

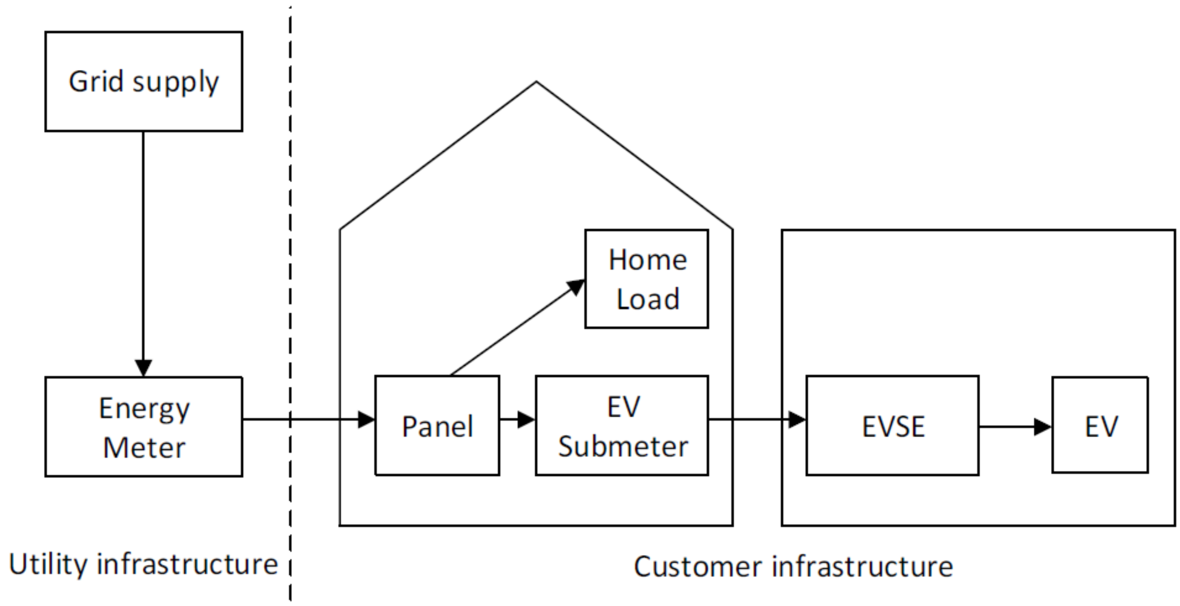

Figure 3.3.2 Submetering approach

3.3.3 Separate metering approach

The EV load is measured and billed independently of the rest of the customer's load using a dedicated revenue-grade meter. In this approach, the EV load is effectively charged to a separate account from the other household loads. However, the accounts can be combined into a single bill for convenience. This approach is also referred to as "parallel metering" and is illustrated in Figure 3.3.3.

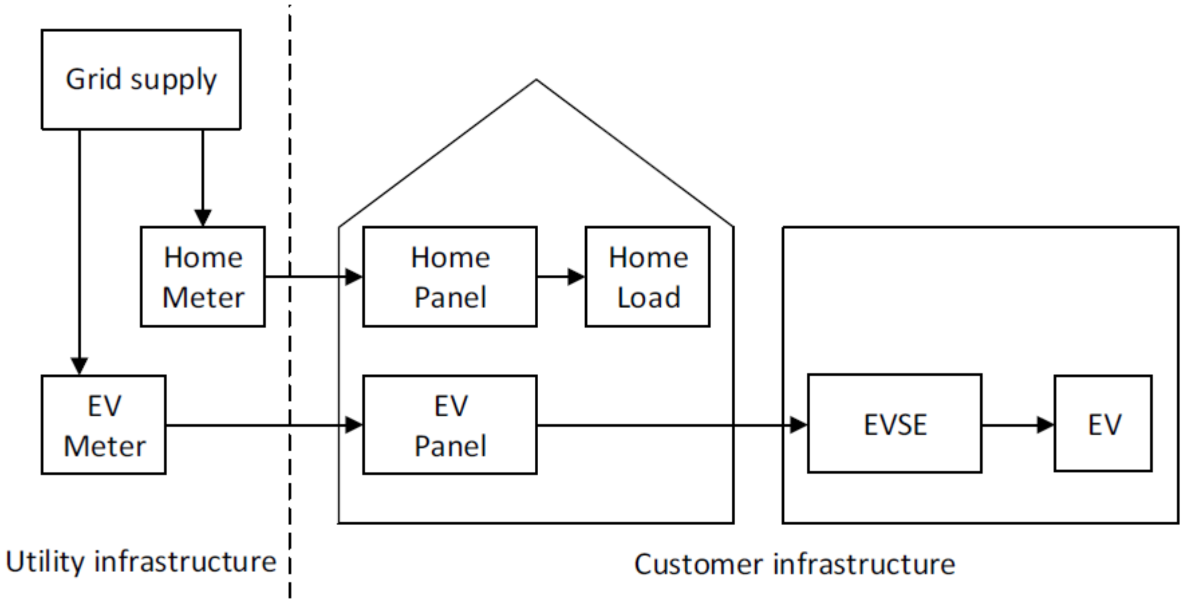

Figure 3.3.3 Separate metering approach

3.3.4 Minimum functionality requirements of energy meters

The minimum functionalities required for each metering arrangement used in charging Mode 1 are outlined in Table 3.3.4.1.

Table 3.3.4.1 Minimum functionality requirements

Functionality	Single metering	Submetering	Separate metering
EV metering accuracy	Not applicable (N/A)	Highly accurate meters are available, but the cost goes to the customer.	Require Advanced Metering Infrastructure (AMI) compatibility and the accuracy requirement for such meter.
Load data granularity	N/A	Multiple time intervals consistent with the number of intervals in the utility EV tariff structure.	Multiple time intervals consistent with the number of intervals in the utility EV tariff structure.
Communication	N/A	Daily reporting will be necessary to enable consumers to track online billing information.	Same as a meter with AMI.
Data storage	N/A	Time of use data storage.	Same as a meter with AMI.
Ownership	Energy meter should be owned by utility and the EVSE should be owned by the tariff customer.	Energy meter and EVSE should be owned by the customer.	Energy meter should be owned by utility and the EVSE should be owned by the customer.

3.4 Safety codes and standards for EV chargers

Generally, the key safety and operational requirements for onboard chargers in Mode 1 are as follows.

i. Electromagnetic compatibility (EMC), emission and immunity should comply with **IEC CISPR 11**, **IEC CISPR 22** and **IEC 61000-4**.
ii. Efficiency should be more than or equal to 96%.
iii. Total harmonic distortion (THD) of current (i_{THD}) should be less than 7% as specified in **IEC 61000-3-6**.
iv. Minimum enclosure protection should be IP54.
v. Safety in terms of breaking capacities, cables and connectors, phase fault, and earth fault conditions should comply with **IEC 62196**, **IEC 61851**, and Conformité Européene (CE) marking.

3.5 Standards for interfaces and cables

IEC 62893-1:2017(E) specifies the construction, dimensions, and testing requirements for cables with extruded insulation and sheaths, designed for flexible applications under harsh conditions. These cables have a voltage rating of up to and including 1000 V AC and are intended for use in the power supply connection between the electricity supply point of the EVCS and the EV.

Ordinary-duty cables with a rated voltage of 300/500 V are permitted only for charging Mode 1. The maximum allowable conductor temperature for these cables, as specified in **IEC 62893**, is 90°C.

4 MINIMUM STANDARDS FOR CHARGING MODE 2

4.1 Power interfaces

If an EV charging station is equipped with a power supply cord featuring a plug that complies with **IEC 60083** (BS 1363), a compatible outlet must be installed. The Type I socket outlet does not support charging Mode 2 therefore the socket must be Type II of Type III. The Type II socket outlet for EV charging facilities in Sri Lanka must be a round, five-pin industrial socket (L1, L2, L3, N, and PE), rated at 32 A and 400 V, compliant with **IEC 60309.** The Type III socket outlet for EV charging facilities in Sri Lanka must be a round, three-pin industrial socket (L, N, and PE), rated at 16 A and 230 V, compliant with **IEC 60309**. The RCD is integrated into the in-cable control and protective device supplied by the EV manufacturer. In addition to supporting the mandatory pilot functions, this device provides overcurrent detection, overtemperature detection, and protective earth (PE) detection from the socket outlet. Typical Type II and Type III socket-outlets and plugs are illustrated in Figure 3.1.2 and Figure 3.1.3.

The recommended AC charging interfaces used in charging Mode 2 are detailed in Section 2.3.

4.2 Installation standards

The selection of circuit components must align with the ratings of the EV charging station as specified in **IEC 61851**. The charging station should be powered by a dedicated branch circuit, which may require installing a circuit breaker and a Type A RCD with appropriate rating in the distribution panel. Since this equipment is classified as a continuous load, the existing service line must have sufficient capacity to handle the additional demand. If not, upgrading the panel and service line may be necessary. The conductor gauge must be chosen to ensure that voltage drops comply with the IET Wiring Regulations, 18th Edition (BS 7671).

The installation must be carried out by an electrician with qualifications and experience equivalent to Sri Lanka Qualifications Framework (SLQF) Level 4.

The electrician should adhere to the following guidelines.

- Read the manufacturer’s installation instructions carefully.
- Refer to the nameplate to ensure the apparatus is approved with recognized certification markings and confirm its ratings (e.g., 400 V, 32 A per dwelling station).

- Verify that the distribution panel can accommodate the additional load, following the guidelines of the IET Wiring Regulations, 18th Edition (BS 7671), as each station in a multi-dwelling unit (MDU) is considered as a separate continuous load.
- Install the wiring between the panel and the EVSE using the appropriate method specified in the IET Wiring Regulations, 18th Edition (BS 7671).
- Install a circuit breaker with the correct rating in the distribution panel (e.g., 40 A per dwelling station).
- Securely anchor the socket outlet to the wall.
- Complete the connections and energize the EVSE.
- Test the EVSE to ensure it operates correctly.

4.3 Energy metering

All metering equipment used to measure electricity consumption must comply with **IEC 62052**. Three general approaches can also be used for metering EV load in charging Mode 2: single metering, submetering, and separate metering. Unlike in charging Mode 1, charging Mode 2 is often adopted in industrial and commercial EVCS. In such applications, it is common to use MDUs, where separate branch circuits are required for each dwelling unit. Therefore, the most practical metering approach would be either submetering or separate metering, as illustrated in Figure 4.3.1 and Figure 4.3.2, respectively. These readings can be used for billing the customers who utilize the facility. Depending on the capacity of the grid supply and the demand of the EVCS, the utility will determine whether a separate transformer is necessary.

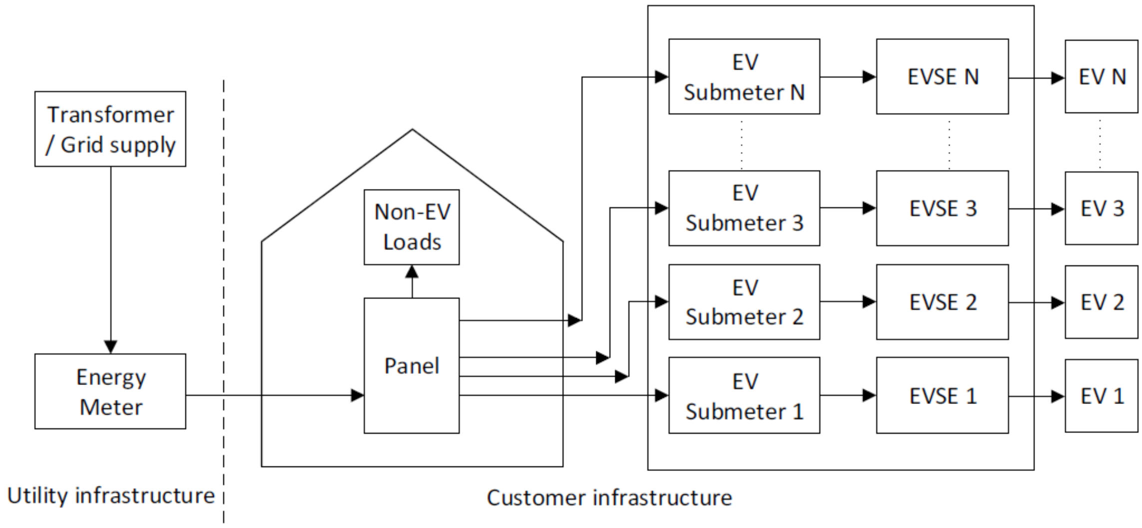

Figure 4.3.1 Submetering approach for charging Mode 2: an MDU EVCS including a Non-EV load within the customer infrastructure

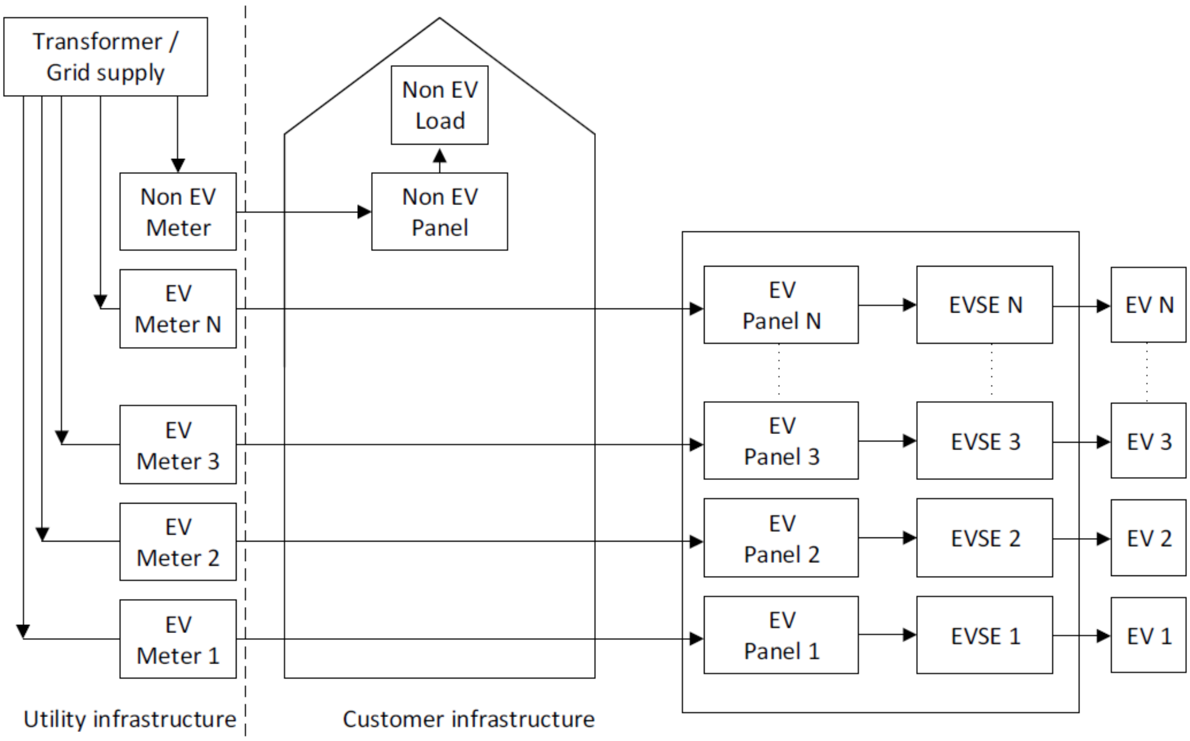

Figure 4.3.2 Separate metering approach for charging Mode 2: an MDU EVCS including a Non-EV load within the customer infrastructure

For an EVCS operating in Mode 2 with MDUs, which is not open to the public but dedicated to predefined users, such as company employees, single metering may be the preferred approach, as shown in Figure 4.3.3.

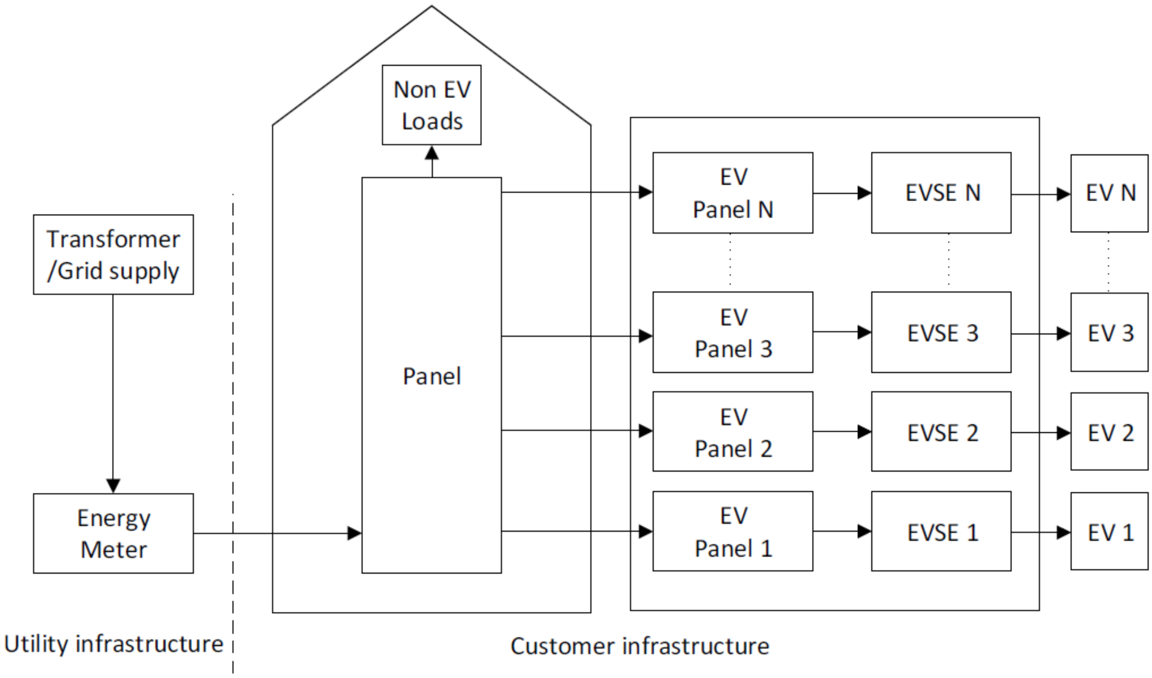

Figure 4.3.3 Single metering approach in charging Mode 2

4.4 Safety codes and standards for EV charger

The charger must adhere to various specifications mandated by the government and utility providers of Sri Lanka. Generally, the key safety and operational requirements for EV chargers in Mode 2 are as follows.

i. Electromagnetic compatibility (EMC), emission and immunity should comply with **IEC CISPR 11**, **IEC CISPR 22** and **IEC 61000-4**.
ii. Efficiency should be more than or equal to 96%.
iii. Total harmonic distortion (THD) of current (i_{THD}) should be less than 7% as specified in **IEC 61000-3-6**.
iv. Minimum enclosure protection should be IP54.
v. Safety in terms of breaking capacities, cables and connectors, phase fault, and earth fault conditions should comply with **IEC 62196**, **IEC 61851**, and Conformité Européene (CE) marking.

4.5 Standards for interfaces and cables

IEC 62893-1:2017(E) specifies the construction, dimensions, and testing requirements for cables with extruded insulation and sheaths, designed for flexible applications under harsh conditions. These cables have a voltage rating of up to and including 1000 V AC and are intended for use in the power supply connection between the electricity supply point of the EVCS and the EV.

The cables used in Mode 2 must comply with the requirements outlined in **IEC 62893-3**. The maximum conductor temperature for the cables in this part of IEC 62893 is 90 ºC.

4.6 Standards for the energy meter

The energy meter must comply with the following standards or their latest editions or latest amendments.

- General requirements, tests, and test conditions: **IEC 62052-21:2003.**
- Power consumption, voltage requirements, accuracy, and local interface: **IEC 62053-21:2003.**
- Data exchange for meter reading, tariff, and load control: **IEC 62056-21:2002.**
- Acceptance inspection: **IEC 62058-11:2010** and **IEC 62058-31:2010.**
- Degree of protection: IP51.
- Data communication: **IEC 61334** and **IEC 14908-4:2012.**
- Case: IP53, **IEC 60529.**
- Certifications: CE and RoHS, in addition to the above IEC standards.

5 MINIMUM STANDARDS FOR CHARGING MODE 3

5.1 Power interfaces

In charging Mode 3, two interface arrangements are possible:

- Case B: Featuring an EV socket-outlet and an EV plug at the EVCS end (refer to **Section 2.1.2**).
- Case C: Without an EV socket-outlet and EV plug at the EVCS end (refer to **Section 2.1.3**).

In both configurations, the AC EVSE must continuously monitor the electrical continuity of the protective conductor connected to the electric vehicle. If a loss of continuity is detected, the electrical supply circuit to the vehicle shall be immediately disconnected.

The recommended AC charging interfaces used in charging Mode 3 are detailed in Section 2.3.

5.2 Installation standards

For charging Mode 3, the AC EVSE shall incorporate the constructional requirements and tests outlined in Section 12 of **IEC 61851-1**.

5.2.1 Emergency Disconnection and Safety Measures

i. An emergency switching or disconnect device shall be installed to isolate the AC supply network from the EVSE in case of electric shock, fire, explosion, or any kind of an emergency.
ii. It shall be located within 2 meters of the EVSE, preferably mounted on a nearby wall, or on a visible pedestal, not obstructed by vehicles or equipment (BS 7671).
iii. This device shall be equipped with provisions to prevent unintentional or accidental operation.

5.2.2 Temperature Limits

The maximum permissible surface temperature of parts that are hand-grasped at the maximum rated current and an ambient temperature of 40°C shall be:

- 50°C for metallic parts
- 60°C for non-metallic parts

For parts that may be touched but not grasped under the same conditions:

- 60°C for metallic parts
- 85°C for non-metallic parts

5.2.3 Ingress Protection

When energized or not, and with the socket-outlet access trap door closed, the EVSE shall provide a minimum degree of protection of IP54, verified through testing in accordance with **IEC 60529**.

5.2.4 Cable Management and Storage

A designated storage system shall be provided for the cable assembly and vehicle connector when not in use. The EVSE shall be provided with an indicator to confirm whether the cable assembly/vehicle connector has been properly stored after disconnection from the vehicle.

5.2.5 Socket-Outlet and Connector Height Requirements

The lowest part of the socket-outlet or the storage system for the vehicle connector shall be positioned between 0.4 m and 1.5 m above ground level.

5.2.6 Prohibition of Extension Cords

The use of extension cords for connecting the EV to the AC EVSE is strictly prohibited to prevent scenarios such as direct contact with unsafe components, potential overload risks, and the absence of a protective conductor.

5.2.7 Earthing and Electrical Continuity

Under faulty conditions, all exposed conductive parts that could become live shall be connected in a way that ensures proper electrical continuity, allowing fault currents to be safely conducted to the earthed point of the AC supply network.

Compliance shall be verified by testing electrical continuity between exposed conductive parts and the earth circuit. A 16 A DC current (derived from a source with a no-load voltage not exceeding 12 V) shall be applied between any exposed conductive part and the earthing terminal of the charging station. The voltage drop between these two points shall be measured, and the calculated resistance shall not exceed 0.1 Ω.

For Class II EVSE, a lead-through protective conductor shall be provided.

5.2.8 Insulation Resistance Requirements

The insulation resistance, measured with a 500 V DC voltage applied between all interconnected inputs/outputs (including the power source) and accessible parts, shall be:

- For Class I EVSE: R > 1 MΩ
- For Class II EVSE: R > 7 MΩ

For this test, all extra low voltage (ELV) circuits shall be connected to the accessible parts during the test. The measurement of insulation resistance shall be carried out with the protective impedances disconnected, and after applying the test voltage for the duration of 1 min and immediately after the damp heat continuous test of IEC 60068-2-78, test Ca, at 40 °C ± 2 °C and 93 % relative humidity for four days.

Note: The definitions of Class I and Class II can be found in ***IEC 60364-4-41****: Protection for safety - Protection against electric shock.*

5.2.9 Electrical Supply and Circuit Requirements

The selection of circuit components must align with the ratings of the EV charging station as specified in **IEC 61851**. The charging station should be powered by a dedicated branch circuit, which may require installing a circuit breaker and a Type B RCD with an appropriate rating in the distribution panel. Since this equipment is classified as a continuous load, the existing service line must have sufficient capacity to handle the additional demand. If not, upgrading the panel and service line may be necessary. The conductor gauge must be chosen to ensure that voltage drops comply with the IET Wiring Regulations, 18th Edition (BS 7671).

5.2.10 Installation Requirements

The installation must be conducted under the supervision of a Chartered Engineer and carried out by an electrician with qualifications and experience equivalent to SLQF Level 4.

The electrician should adhere to the following guidelines:

- Read the manufacturer’s installation instructions carefully.
- Refer to the nameplate to ensure the apparatus is approved with recognized certification markings and confirm its ratings (e.g., 400 V, 32 A per dwelling station).

- Verify that the distribution panel can accommodate the additional load, following the guidelines of the IET Wiring Regulations, 18th Edition (BS 7671), as each station in a multi-dwelling unit (MDU) is considered as a separate continuous load.
- Install the wiring between the panel and the EVSE using the appropriate method specified in the IET Wiring Regulations, 18th Edition (BS 7671).
- Install a circuit breaker with the correct rating in the distribution panel (e.g., 40 A per dwelling station).
- Securely anchor the socket-outlet to the wall (Case B) or permanently connect the cable where a separate plug and socket is not applicable (Case C).
- Complete the connections and energize the EVSE.
- Test the EVSE to ensure it operates correctly.

5.3 Energy metering

Same as Section 4.3.

5.4 Safety codes and standards for EV charger

Same as Section 4.4.

5.5 Standards for interfaces and cables

Same as Section 4.5.

5.6 Standards for the energy meter

Same as Section 4.6.

6 MINIMUM STANDARDS FOR CHARGING MODE 4

Mode 4 charging refers to the connection of an EV to the power supply through a DC EVSE, such as an off-board charger, where the control pilot function extends to the DC EVSE.

Unlike AC charging, which relies on an onboard charger, DC charging utilizes a charger integrated into the charging station, allowing for significantly higher power delivery. Since the charging station supplies power directly to the EV battery, it must be capable of adjusting the charging voltage and current based on the vehicle's specific requirements.

The mandatory dc charging functions of the charger as per section 6.4 of **IEC61851-23** are as follows.

- Verification that the vehicle is properly connected
- Protective conductor continuity checking
- Energization of the system
- De-energization of the system
- DC supply for EV
- Measuring current and voltage
- Retaining / releasing coupler
- Locking of the coupler
- Compatibility assessment
- Insulation test before charging
- Protection against overvoltage at the battery
- Verification of vehicle connector voltage
- Control circuit supply integrity
- Short circuit test before charging
- User initiated shutdown
- Overload protection for parallel conductors (conditional function)
- Protection against temporary overvoltage
- Emergency shutdown

These requirements are explicitly detailed in **IEC 61851-23**.

6.1 Power interfaces

The connection of EVs using cables shall be performed in accordance with Case C: without an EV socket-outlet and EV plug at the EVCS end (refer to **Section 2.1.3**). The recommended DC charging interfaces used in charging Mode 4 are detailed in Section 2.4.

6.2 Installation standards

For charging Mode 3, the AC EVSE shall incorporate the control functions outlined in Section 8 of **IEC 61851-1**.

6.2.1 Emergency Disconnection and Safety Measures

During system installation, an emergency disconnection device must be installed to isolate the AC supply network from the DC EVSE in the event of a risk of electric shock, fire, or explosion. The disconnection device must be equipped with a mechanism to prevent accidental activation and should include a Type B RCD along with appropriate overcurrent protection measures.

6.2.2 Temperature Limits

Same as Section 5.2.2.

6.2.3 Ingress Protection

Same as Section 5.2.3.

6.2.4 Cable Management and Storage

Same as Section 5.2.4.

6.2.5 Socket-Outlet and Connector Height Requirements

Same as Section 5.2.5.

6.2.6 Prohibition of Extension Cords

Same as Section 5.2.6.

6.2.7 Earthing and Electrical Continuity

Same as Section 5.2.7.

6.2.8 Insulation Resistance Requirements

Same as Section 5.2.8.

6.2.9 Electrical Supply and Circuit Requirements

Same as Section 5.2.9.

6.2.10 Installation Requirements

The installation must be conducted under the supervision of a Chartered Engineer and carried out by an electrician with qualifications and experience equivalent to SLQF Level 4.

The electrician should adhere to the following guidelines:

- Read the manufacturer's installation instructions carefully.
- Refer to the nameplate to ensure the apparatus is approved with recognized certification markings and confirm its ratings (e.g., 400 V, 32 A per dwelling station).
- Verify that the distribution panel can accommodate the additional load, following the guidelines of the IET Wiring Regulations, 18th Edition (BS 7671), as each station in a multi-dwelling unit (MDU) is considered as a separate continuous load.
- Install the wiring between the panel and the EVSE using the appropriate method specified in the IET Wiring Regulations, 18th Edition (BS 7671).
- Install a circuit breaker with the correct rating in the distribution panel (e.g., 40 A per dwelling station).
- Complete the connections and energize the EVSE.
- Test the EVSE to ensure it operates correctly.

6.3 Energy metering

The AC side metering is the same as Section 4.3.

6.4 Safety codes and standards for EV charger

Same as Section 4.4.

6.5 Standards for interfaces and cables

Same as Section 4.5.

6.6 Standards for the energy meter

Same as Section 4.6.

6.7 DC charging systems

In IEC 61851-23, three systems namely System A, System B, and System C are defined for EVSE, each with distinct characteristics as follows.

6.7.1 System A

System A is a regulated DC charging system that utilizes a dedicated CAN communication circuit for digital communication between the DC charging station and the EV, ensuring precise control of the charging process. The vehicle coupler Configuration AA, as specified in **IEC 62196-3**, is applicable to System A.

The specific digital communication requirements, along with detailed communication actions and parameters for System A, are defined in Annex A of **IEC 61851-24**. The rated DC output voltage for a System A station is limited to 500 V DC, making it suitable for passenger vehicles and light trucks.

The schematic block diagram of system A is given in Figure 6.7.1.1. The interface circuit between the station and the vehicle for charging control is shown in Figure 6.7.1.2. CAN-bus circuit is provided for digital communication with the vehicle. The definition and description of symbols and terms in Figure 6.7.1.1 and Figure 6.7.1.2 are given in Table 6.7.1.1. The values of the parameters for the interface circuit are given in Table 6.7.1.2. Detailed information can be found in **IEC 61851-23**.

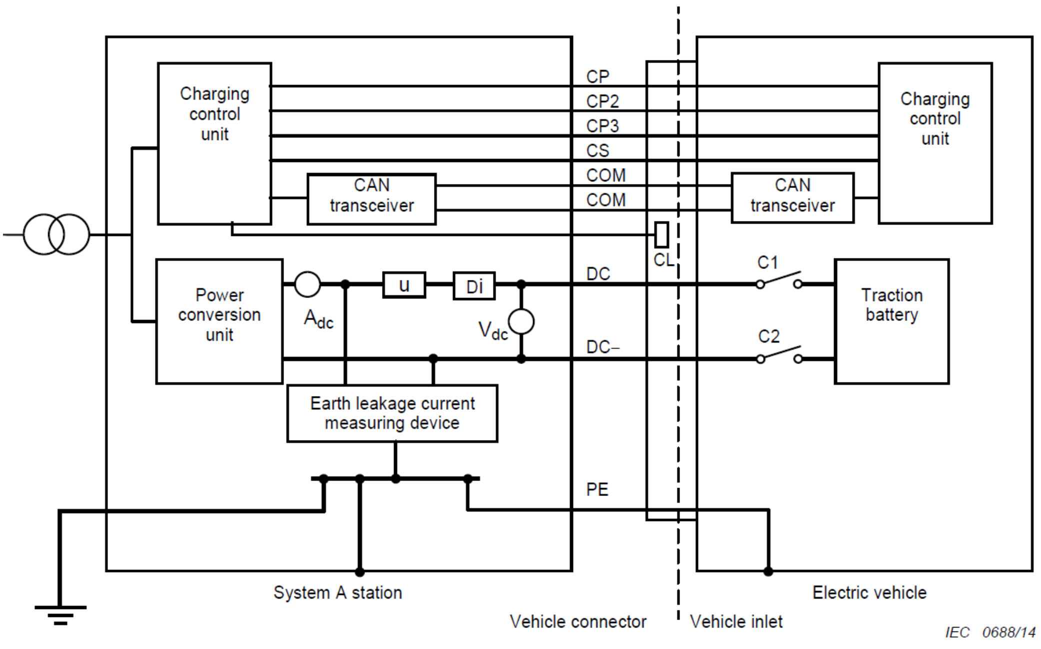

Figure 6.7.1.1 Overall schematic of system A station and EV

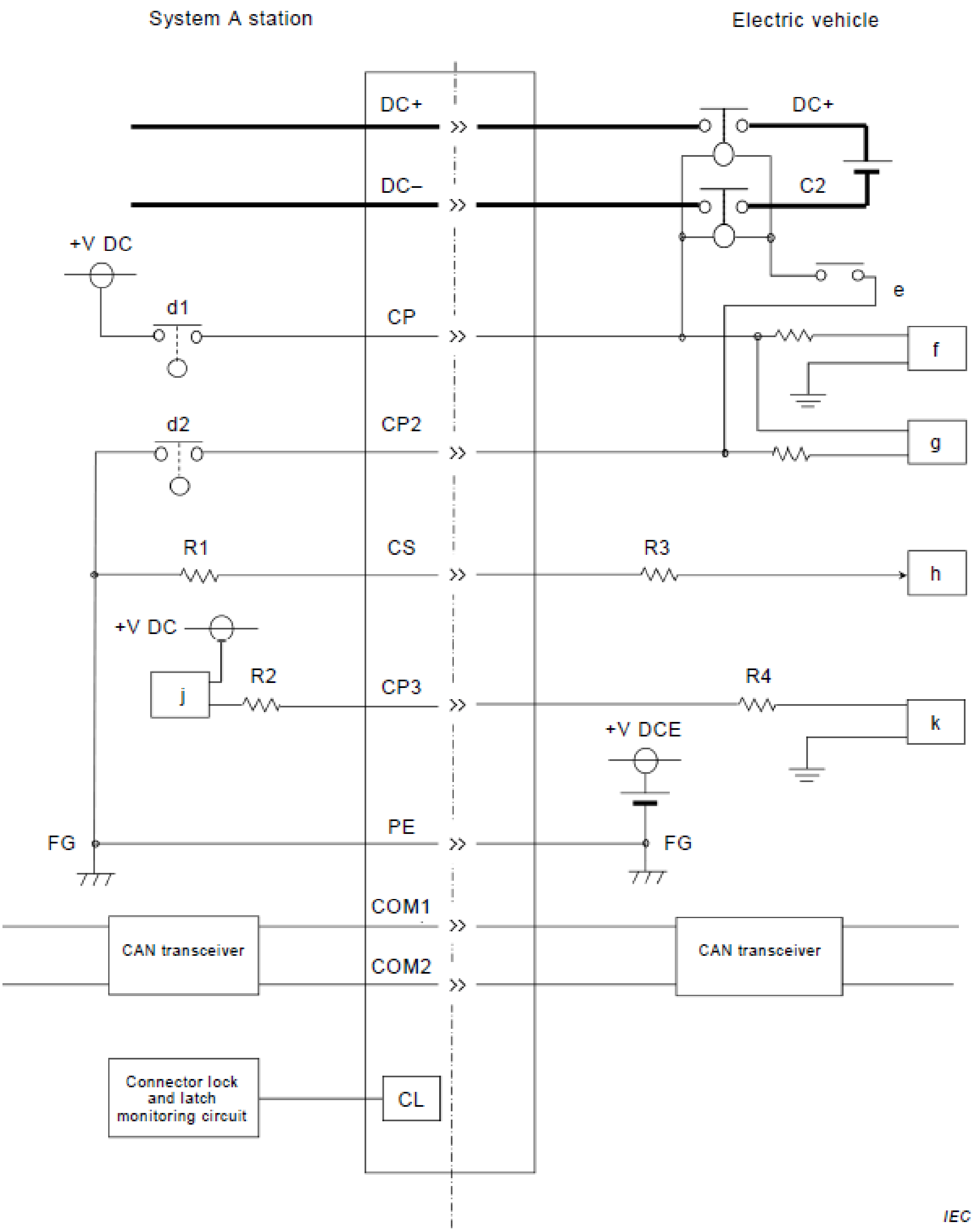

Figure 6.7.1.2 Interface circuit for charging control of system A station

Table 6.7.1.1 Definition of symbols of system A station

	Symbols	Definitions
System A station	Di	Reverse-current-prevention device (e.g. diode: cathode on the vehicle side, anode on the station side)
	d1	Switch on CP for controlling the charging start/stop signals from the station to the vehicle
	d2	Switch on CP for controlling the charging start/stop signals from the station to the vehicle
	j	Signal sensing device to detect vehicle ready/not ready to accept energy
	V_{dc}	Voltage measurement device
	A_{dc}	Current measurement device
	u	Short-circuit protection device (e.g. current limiting fuse)
	R1	Resistor
	R2	Resistor
	+V DC	DC power supply to EV contactors
Electric vehicle	C1,C2	Disconnection switch for d.c. power lines (EV contactors)
	e	Relay for turning on EV contactors
	f	Signal sensing device to detect the status of d1
	g	Signal sensing device to detect the status of d2
	h	Signal sensing device to detect connection / disconnection of vehicle coupler
	k	Switch to give the go ahead / stop to charge
	R3	Resistor
	R4	Resistor
	+V DCE	DC power supply in the vehicle
Terminal and wire	DC+	DC power supply (positive)
	DC-	DC power supply (negative)
	CP	Control pilot which indicates the start/stop status of station
	CP2	Control pilot which indicates the start/stop status of station
	CS	Pilot wire which indicates the status of vehicle coupler connection
	CP3	Control pilot which confirms that the vehicle is ready for charging
	COM1 COM2	Signal line pair for digital communication
	PE	Protective conductor between the station and EV for detecting the first d.c. earth fault
Vehicle connector	CL	Connector latching and locking mechanism

Table 6.7.1.2 Parameters and values for interface circuit of system A station

System A station					
Terminal/ Wire	Parameters	Minimum value	Typical value	Maximum value	Unit
CP	+V DC	10,8	12,0	13,2	V
CS	Resistor R1	190	200	210	Ω
CP3	Resistor R2	950	1 000	1 050	Ω
CP	Load current of switch d1	2		2 000	mA
CP2	Load current of switch d2	2		2 000	mA
Electric vehicle					
CP	Load current (when d1 and d2 closing)	10		2 000	mA
CP2	Load current (when d1 and d2 closing)	10		2 000	mA
CS	Resistor R3	950	1 000	1 050	Ω
	+V DCE	8	12	16	V
CP3	Resistor R4	190	200	210	Ω

6.7.2 System B

The following shows the specification of a DC EV charging station of system B using dedicated DC vehicle coupler of Configuration BB as specified in **IEC 62196-3**.

Figure 6.7.2.1 shows DC charging System B for charging Mode 4, including DC charger control unit, resistors R1, R2, R3, R4 and R5, switch S, AC supply circuit contactor K0, isolating transformer T, AC/DC inverter, DC supply circuit contactors K1 and K2, low voltage auxiliary supply circuit contactors K3 and K4, charging circuit contactors K5 and K6, reverse-current-prevention device including the diode, K7 and R6, electrical interlock, and vehicle control unit. Vehicle control unit can be integrated in the Battery Management System (BMS). The R2 and R3 resistors are installed on the vehicle connector, and the R4 resistor is installed in the vehicle inlet. Switch S is the inner switch of vehicle connector, and it will close when the vehicle connector and vehicle inlet are properly connected. During the whole charging process, DC charger control unit should detect and control the states of K1, K2, K3 and K4, while the vehicle control unit detects and controls K5 and K6. During the charging procedure, if the Insulation Monitoring Device (IMD) detects that the insulation resistance drops below the setting value, appropriate protective measures shall be activated. The setting value shall be no less than 100 Ω/V multiplied by the maximum output voltage rating of the DC EVCS. Detailed information can be found in **IEC 61851-23**.

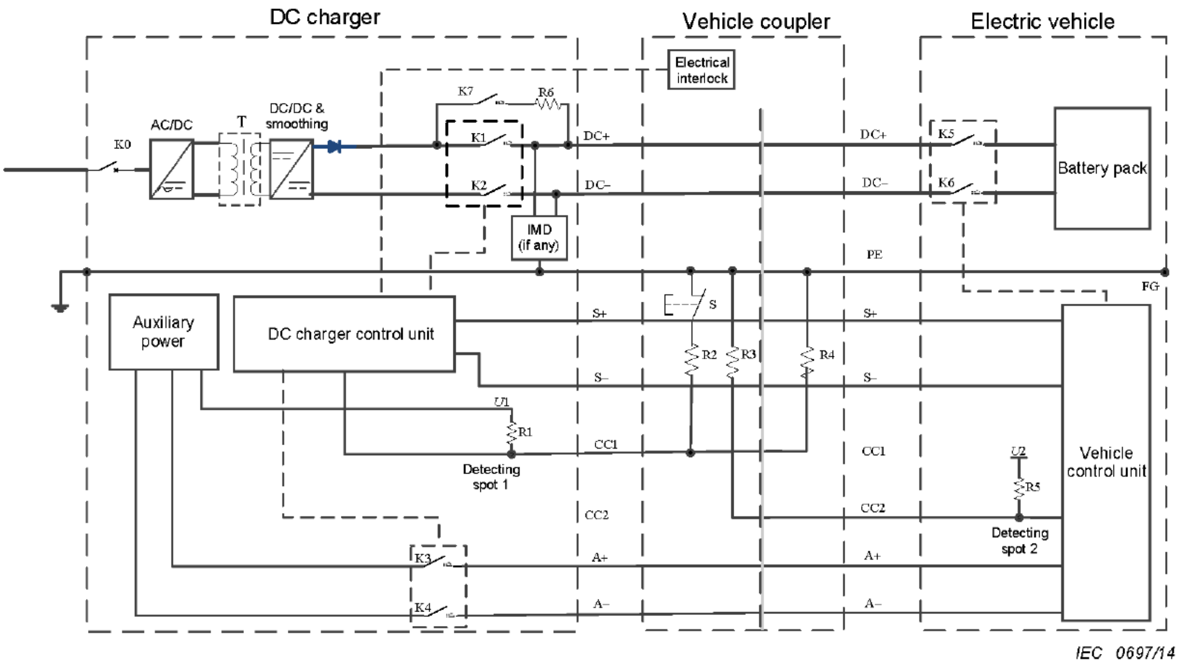

Figure 6.7.2.1 Overall schematic of system B station and EV

6.7.3 System C

System C specifies the requirements for DC EVCS designed for use with the Combined Charging System (CCS). Schematics of CCS for DC supply is given in Figure 6.7.3.1, as well the definition and description of symbols and terms in Table 6.7.3.1.

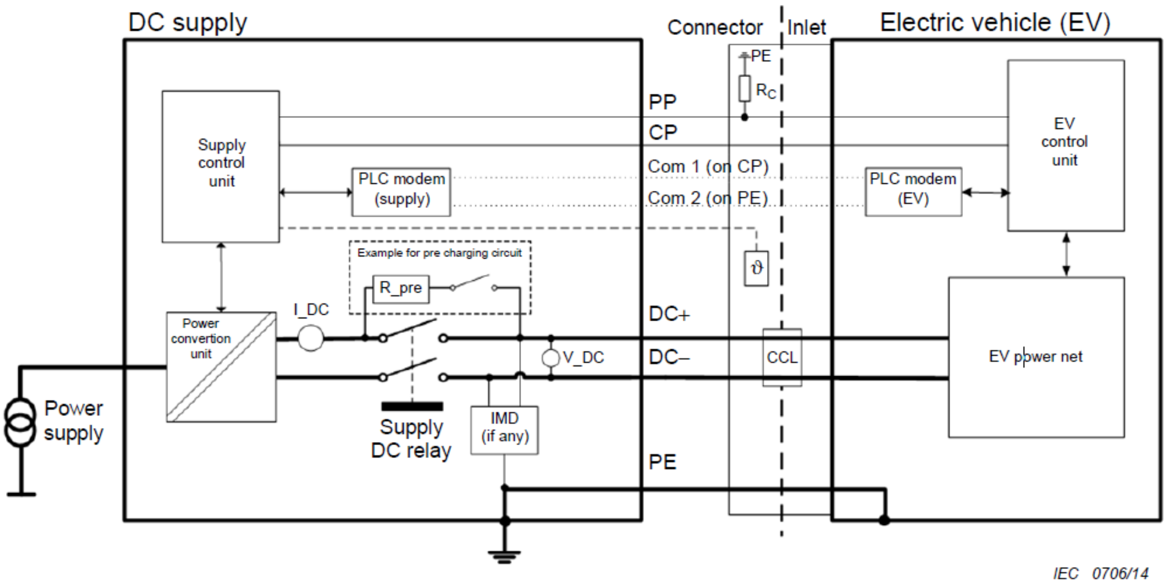

Figure 6.7.3.1 Overall schematic of system C station and EV

Note: PP line from vehicle connector to DC supply is mandatory for Configuration EE and optional for Configuration FF couplers.

Table 6.7.3.1 Definitions and descriptions of symbols and terms of system C station

DC supply		Electric Vehicle (EV)		Interface Circuit	
Symbols/ terms	Definitions	Symbols/ terms	Definitions	Symbols / terms	Definitions
V_DC	Voltage measurement at output of d.c. supply	PLC modem (EV)	EV communication interface between PLC and internal EV communication	PE	Protective conductor
I_DC	Current measurement (on DC+ or DC- or both)	EV control unit	Unit for communicating from EV to the d.c. supply and verifying safety procedure	DC+	DC power supply (positive)
Power conversion unit	Galvanically isolated power stage for converting mains power supply into regulated d.c. power for EV supplying	EV power net	Subsystem within the EV related to be supplied with energy from the d.c. supply.	DC-	DC power supply (negative)
Supply d.c. relay	All-line-relay to connect and disconnect d.c. output of d.c. supply to power conversion unit [a]			Com1	(Positive) line for PLC [c]
PLC modem (supply)	Supply communication interface between PLC and internal supply communication			Com2	(Negative) line for PLC
Supply control unit	Unit for control of supply process within d.c. supply and communicating with EV			PP (proximity)	General functions according to IEC 61851-1 with definition of values in table CC.2 for configurations DD and FF and SAE J1772™ with +5 V PP voltage inside EV for d.c. supply with configurations CC and EE.
R_pre	Resistor for pre-charging circuit [b]			CP (control pilot)	Function acc. to IEC 61851-1 Also used for emergency shutdown of d.c. supply by EV going into state B or interruption of control pilot for CP lost shutdown.
IMD	Insulation monitoring device			R_C	Proximity-resistor used for coding of cable current capability in case of AC supply acc. values in IEC 61851-1.
				CCL (correct contact& locking)	Feedback of correct contact and locking of d.c. vehicle connector
				ϑ	Temperature monitoring of vehicle connector by d.c. supply

[a] The supply DC-relay may be substituted by a diode.
[b] Switch and resistor are recommended for implementation of mandatory pre-charging function.
[c] Refer to Table CC.1 for different connectors.

Detailed information can be found in **IEC 61851-23**.

7 STANDARDS FOR INSTALLING EVCS AT DIFFERENT LOCATIONS

7.1 Installation of EVCS at domestic premises

This section specifies the special requirements for installation of EVCS at domestic premisses such as houses. All relevant standards outlined in previous sections shall apply to this section, except where otherwise specified in this section.

7.1.1 Electrical Supply and Load Capacity

i) Assess the household electrical supply to ensure it can support the additional load of an EVCS.
ii) A dedicated circuit should be used for the EVCS to avoid overloading existing household circuits.
iii) Ensure the main service panel has sufficient capacity; if not, an upgrade may be required.
iv) Voltage levels should be compatible with the local grid (i.e. 230 V for single-phase or 400 V for three-phase).

7.1.2 Charging Mode and Equipment Compliance

Charging Mode 1, 2, and 3 are recommended for this application.

7.1.3 Protection and Safety Requirements

7.1.3.1 Overcurrent Protection

Use an appropriately rated MCB to prevent overcurrent damage. The breaker should match the rated current of the EVSE (e.g., 32 A for a 7.4 kW charger).

7.1.3.2 Residual Current Protection

i) The selection and installation of the RCD shall comply with **IEC 60364-7-722**.
ii) The connecting point of the EV supply equipment shall be protected by an RCD having a rated residual operating current not exceeding 30 mA.
iii) For AC leakage protection, use Type A RCD.
iv) For DC leakage protection, use
   - Type B RCD or

- Type A RCD and appropriate equipment that ensures the disconnection of the supply in case of DC fault current above 6 mA.

7.1.3.3 Surge Protection

i) The selection and installation of the surge protection devices (SPD) shall comply with **IEC 60364-4-44**.

ii) An SPD is required to protect the EVSE from transient overvoltage (e.g., lightning).

7.1.3.4 Earthing and Bonding

i) Earthing and bonding shall comply with **IEC 60364-4-41**.

ii) Ensure the EVSE is properly earthed to prevent electric shock hazards.

iii) Bonding of exposed conductive parts must comply with IEC protection against electric shock regulations depicted in **IEC 61140**.

7.1.4 Inspection and Compliance Verification

Installation should be conducted by a SLQF Level 4-certified electrician to ensure compliance with national wiring regulations. A schematic of a sample wiring diagram of an EVSE installation in a domestic premise is shown in Figure 7.1.4.1.

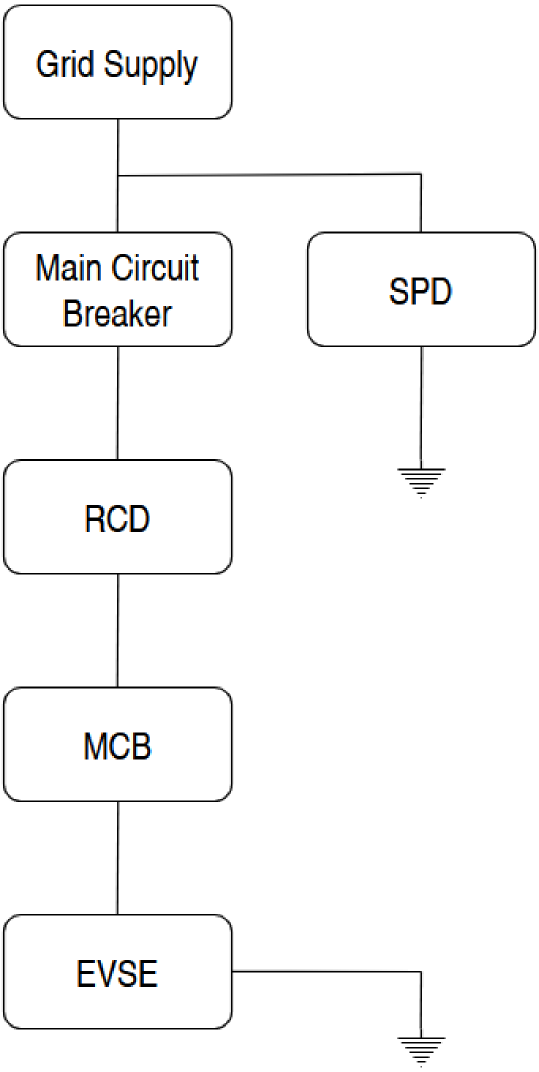

Figure 7.1.4.1 Sample single line diagram of an EVSE installation at a domestic premise

7.2 Installation of EVCS at fuelling stations

7.2.1 Electrical Supply and Load Capacity

i) Ensure that the fuelling station's electrical infrastructure can support the EVCS, considering both the continuous load and the potential simultaneous charging of multiple vehicles.

ii) EVCS installations should have dedicated branch circuits to avoid interference with other electrical systems.

iii) Implement load management systems to distribute power efficiently, especially when multiple EVCS units are in operation.

7.2.2 Charging Mode and Equipment Compliance

Charging Mode 3 and 4 are recommended for this application.

7.2.3 Protection and Safety Requirements

7.2.3.1 Overcurrent Protection

Same as Section 7.1.3.1.

7.2.3.2 Residual Current Protection

Same as Section 7.1.3.2.

7.2.3.3 Surge Protection

Same as Section 7.1.3.3.

7.2.3.4 Earthing and Bonding

Same as Section 7.1.3.4.

7.2.3.5 Emergency Disconnection

A dedicated emergency disconnection device should be installed to isolate the EVSE from the power supply in the event of faults, fire, or explosion risks.

7.2.3.6 Hazardous Area Safety

i) When the EVSE is near fuel dispensing areas and underground fuel tank vents, adherence to **IEC 60079** is crucial to prevent ignition sources and ensure the equipment is rated for explosive atmospheres.

ii) The installation must be based on a detailed risk assessment and the hazardous area classification as outlined in **IEC 60079**.

   a. Risk Assessment and Zoning: The installation should consider the likelihood of flammable vapours and the classification of hazardous zones around fuel dispensing areas and underground fuel tank vents.

iii) It is recommended to maintain a minimum separation of 10 meters between the fuel dispenser or underground fuel tank vent and the EVSE to reduce ignition risks. However, the exact distance may vary based on site-specific conditions.

iv) It is recommended to install a heat or smoke detector near the charging area.

An EVCS installed closer to a fuelling station is shown in Figure 7.2.3.6.1.

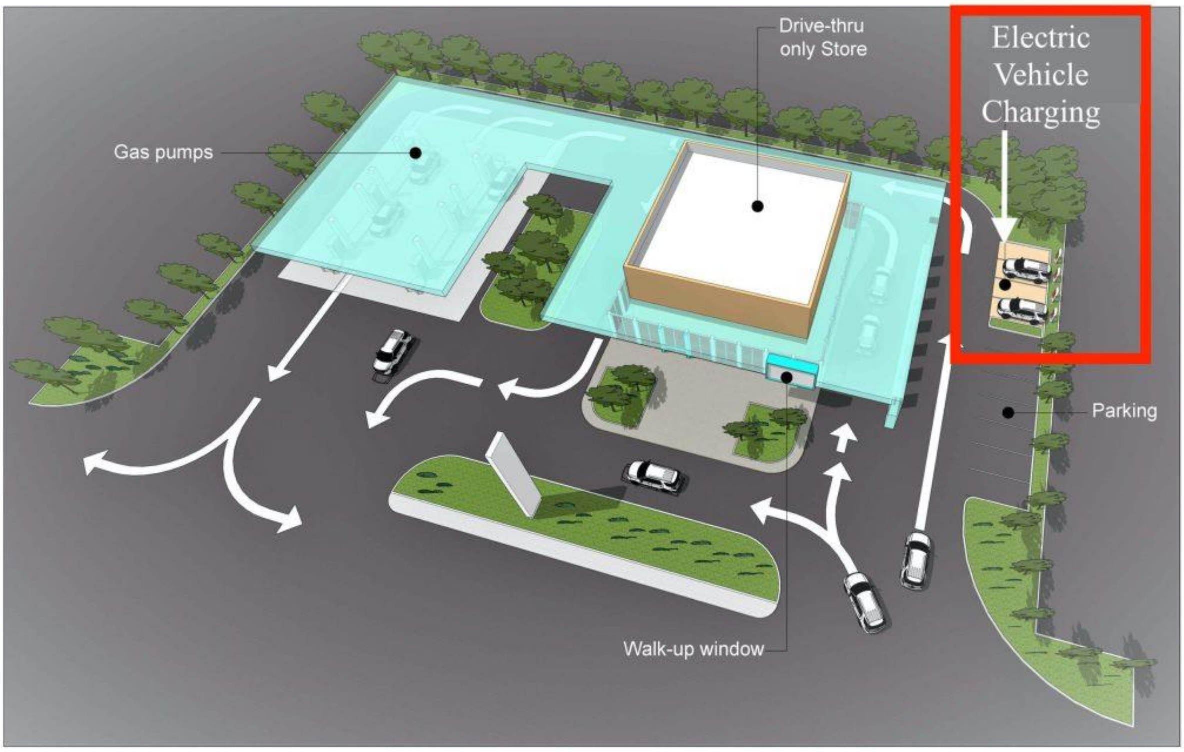

Figure 7.2.3.6.1 An EVCS with a fuelling station (gas pumps) nearby

7.2.3.7 Environmental considerations

i) The EVSE must have adequate ingress protection (typically IP44 or higher) for outdoor installations, safeguarding against moisture, dust, and other environmental factors.

ii) Use weather-resistant, durable enclosures and ensure proper ventilation to manage heat dissipation, particularly for DC chargers used in charging Mode 4.

7.2.4 Inspection and Compliance Verification

Installation should be inspected and verified by a Chartered Engineer to ensure compliance with relevant IEC standards and national wiring regulations. A schematic of a sample wiring diagram of a EVSE installation at a fuelling station is shown in Figure 7.2.4.1.

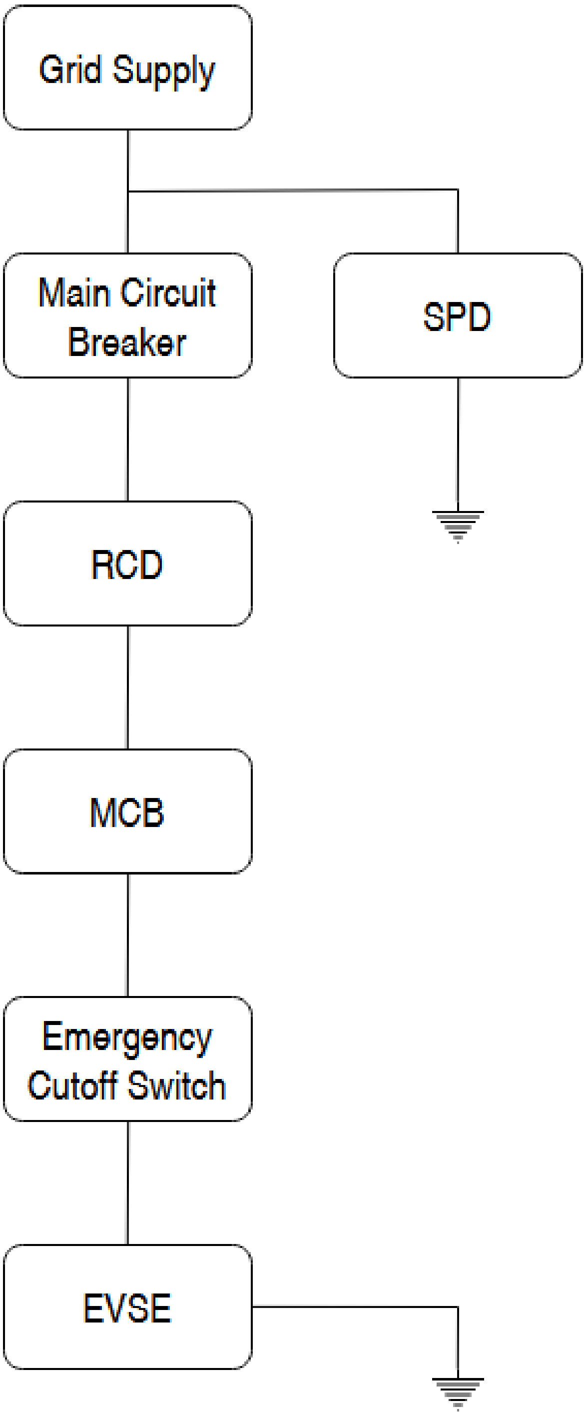

Figure 7.2.4.1 Sample single line diagram of an EVSE installation at a fuelling station

7.3 Installation of EVCS at Enclosed Parking Lots

Enclosed parking lots are typically found in:

- Residential Complexes: Many apartment buildings and housing developments include multistorey or underground parking structures.

- Commercial Buildings: Office complexes, shopping centres, and mixed-use developments often feature enclosed parking to protect vehicles from weather.
- Transportation Hubs: Airports, train stations, and transit centres may incorporate enclosed parking for security and climate control.
- Institutional Facilities: Hospitals, universities, and government buildings often provide enclosed parking to ensure safe, year-round vehicle storage.

A picture of a modern indoor EVCS is shown in Figure 7.3.1 and Figure 7.3.2.

Figure 7.3.1 EVs getting charged in an enclosed EVCS

Figure 7.3.2 An enclosed EVCS

A sample layout plan for an EVCS integrated into a parking lot is shown in Figure 7.3.3. The green colour dots represent the EVSE for e-bikes and the red colour dots represent the EVSE for four-wheeled EVs. The 3 m wide pathway can be used for e-tuk tuks as well.

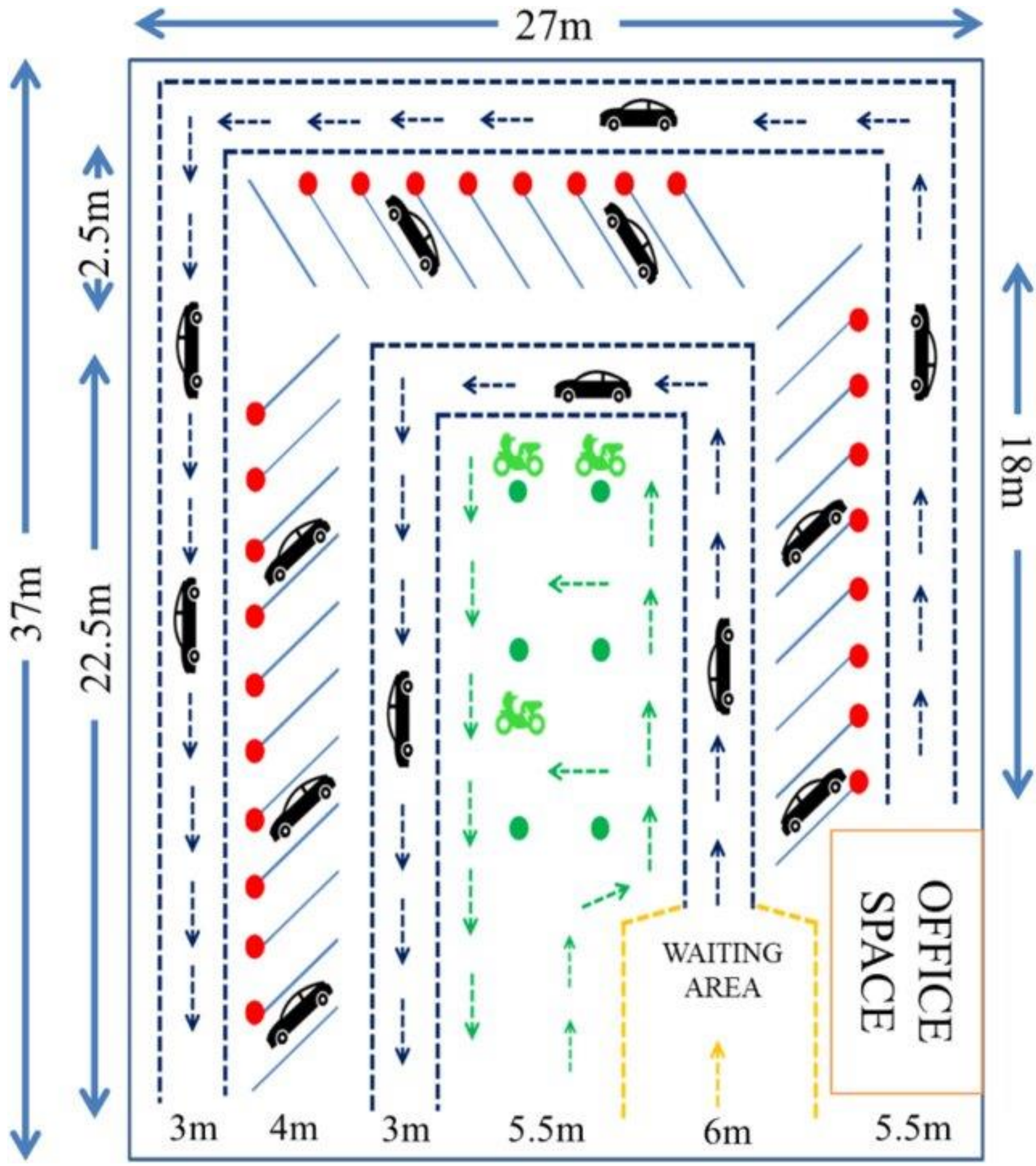

Figure 7.3.3 Sample Layout plan for an EVCS in an enclosed parking lot

7.3.1 Electrical Supply and Load Capacity

i) Ensure that the building's electrical system can handle the additional load from EVCS installations without compromising other services.

ii) Each EVCS should have its own dedicated branch circuit with appropriate overcurrent protection devices, such as MCBs.

iii) For multiple charging stations, implement load management systems to distribute power efficiently and prevent overloads on the main service panel.

7.3.2 Charging Mode and Equipment Compliance

Charging Mode 3 and 4 are recommended for this application.

7.3.3 Protection and Safety Requirements

7.3.3.1 Overcurrent Protection

Same as Section 7.1.3.1.

7.3.3.2 Residual Current Protection

Same as Section 7.1.3.2.

7.3.3.3 Surge Protection

Same as Section 7.1.3.3.

7.3.3.4 Earthing and Bonding

Same as Section 7.1.3.4.

7.3.3.5 Emergency Disconnection

Same as Section 7.2.3.5.

7.3.3.6 Hazardous Area Safety

i) Implement fire detection and suppression systems to comply with **IEC 60079**.

ii) A risk assessment shall be conducted to ascertain whether any segment of the installation is required to comply with the explosive atmosphere standards (**IEC 60079**), particularly in instances where flammable vapours such as those emitted from exhaust gases or present in fuel tanks, are present.

iii) Ensure the installation area is well-lit and that emergency access routes remain unobstructed.

iv) It is recommended to install a heat or smoke detector near the charging area.

7.3.3.7 Environmental considerations

i) Enclosed parking lots require adequate ventilation to prevent the buildup of exhaust fumes and to manage heat generated by both vehicles and charging equipment.

ii) Ensure that the EVSE operates within its specified temperature range. Additional cooling or heat dissipation measures may be necessary in poorly ventilated areas.

iii) The EVSE must have adequate ingress protection (typically IP44 or higher) for enclosed parking lots, safeguarding against moisture, dust, and other environmental factors.

iv) Use durable enclosures and ensure proper ventilation to manage heat dissipation, particularly for DC chargers used in charging Mode 4.

7.3.4 Inspection and Compliance Verification

Installation should be inspected and verified by a Chartered Engineer to ensure compliance with relevant IEC standards and national wiring regulations. A schematic of a sample wiring diagram of an EVSE installation in an enclosed parking lot is similar to the diagram shown in Figure 7.2.4.1.

7.4 Installation of EVCS at Open Parking Lots

Open parking lots are typically found in:

- Retail Centres, Supermarkets, and Shopping Malls: Often situated adjacent to or within large commercial complexes.
- Airports and Transit Hubs: Common for vehicle parking areas serving travellers.
- Urban and Suburban Areas: Street parking or surface lots provided by municipalities.
- Educational and Institutional Campuses: Outdoor parking spaces for students and staff.
- Recreational Facilities: Stadiums, parks, and sports complexes usually feature open parking areas.

Sample layouts of an open parking lot with EVCS are illustrated in Figure 7.4.1 and Figure 7.4.2.

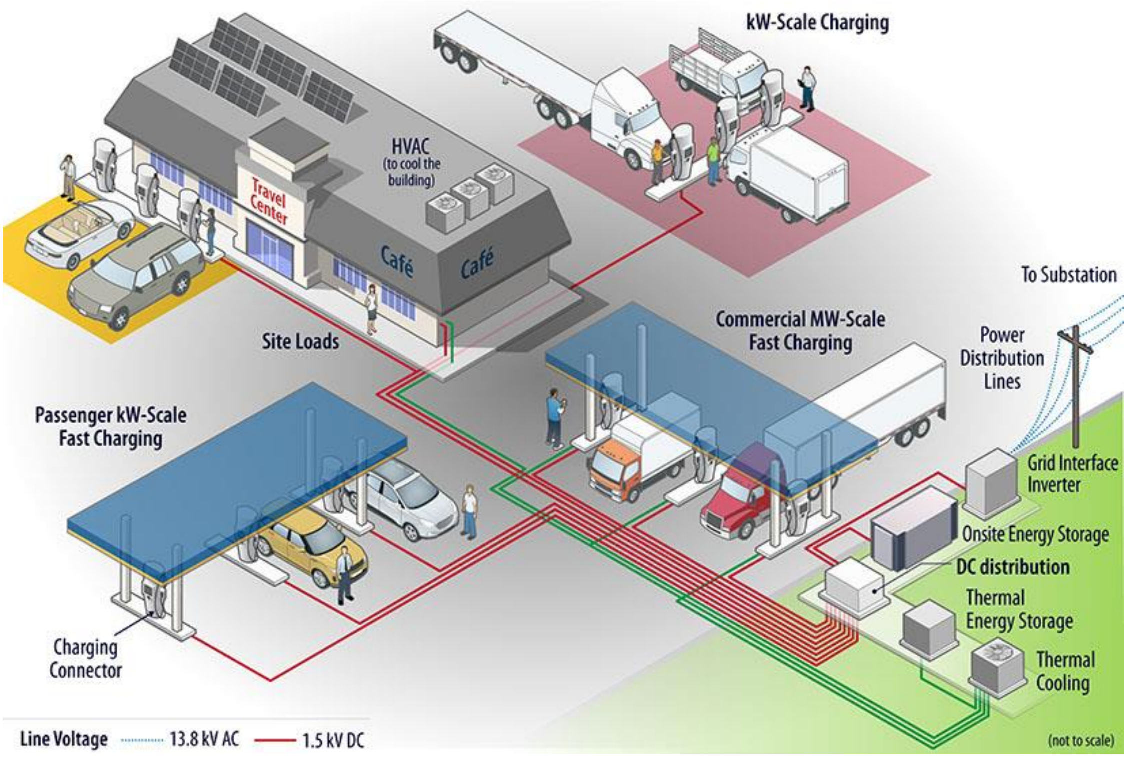

Figure 7.4.1 An EVCS at an open parking lot - Example 1

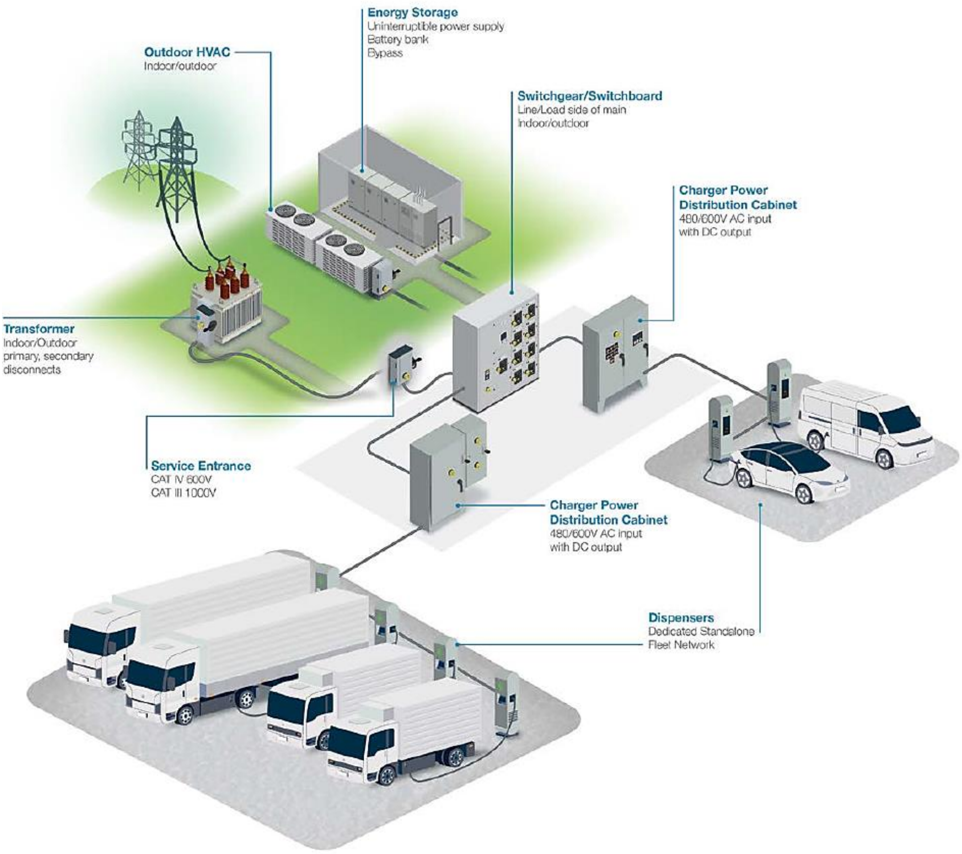

Figure 7.4.2 An EVCS at an open parking lot - Example 2

7.4.1 Electrical Supply and Load Capacity

Similar to Section 7.3.1.

7.4.2 Charging Mode and Equipment Compliance

Charging Mode 3 and 4 are recommended for this application.

7.4.3 Protection and Safety Requirements

7.4.3.1 Overcurrent Protection

Same as Section 7.1.3.1.

7.4.3.2 Residual Current Protection

Same as Section 7.1.3.2.

7.4.3.3 Surge Protection

Same as Section 7.1.3.3.

7.4.3.4 Earthing and Bonding

Same as Section 7.1.3.4.

7.4.3.5 Emergency Disconnection

Same as Section 7.2.3.5.

7.4.3.6 Hazardous Area Safety

i) Implement fire detection and suppression systems to comply with **IEC 60079**.

ii) Adequate lighting for security and safety, along with clear signage, ensures that the charging area is easily identifiable and safe to use.

iii) The EVSE should be designed with durable, vandal-resistant enclosures, as open parking lots can be more susceptible to vandalism or accidental damage.

iv) Ensure cables are securely routed and stored to prevent trip hazards and damage from environmental exposure or interference.

v) It is recommended to install a heat or smoke detector near the charging area.

7.4.3.7 Environmental considerations

i) Since the EVSE will be exposed to the elements, the enclosure should be designed to withstand direct exposure to dust, rain, and UV radiation.

ii) Typically, an IP rating of IP65 (or higher) is recommended for fully outdoor installations, ensuring the equipment is dust-tight and protected against water jets. If the unit is sheltered (e.g., under a canopy), a slightly lower rating (such as IP54) shall be acceptable.
iii) The EVSE must have adequate ingress protection (typically IP44 or higher) for enclosed parking lots, safeguarding against moisture, dust, and other environmental factors.
iv) Ensure that the EVSE operates within its specified temperature range. Additional cooling or heat dissipation measures may be necessary, especially when the EVSE is in direct sunlight.

7.4.4 Inspection and Compliance Verification

Installation should be inspected and verified by a Chartered Engineer to ensure compliance with relevant IEC standards and national wiring regulations. A schematic of a sample wiring diagram of an EVSE installation in an open parking lot is similar to the diagram shown in Figure 7.2.4.1.

8 INSTALLATION OF EVCS INTEGRATED WITH RENEWABLE ENERGY AND BATTERY ENERGY STORAGE SYSTEMS

The following are few examples of EVCS integrated with renewable energy and energy storage systems.

- Solar-Powered Charging Stations: EVCS that incorporate solar panels mounted on canopies or rooftops. These systems capture solar energy during daylight hours and, when combined with battery storage, can provide charging services even during periods of low sunlight or peak demand (see Figure 8.1 and Figure 8.2).
- Hybrid Renewable Systems: Integrated solutions that combine multiple renewable sources such as solar and wind with battery storage. These systems can optimize energy generation throughout the day and across different weather conditions, ensuring a more reliable power supply for EV charging.
- Microgrid-Integrated EVCS: EV charging stations connected to a local microgrid that includes renewable energy generation (e.g., solar arrays, wind turbines) and energy storage systems. These microgrids can operate independently from the main grid, providing sustainable charging options, especially in remote or off-grid areas.
- Grid-Tied Systems with V2G Capability: EVCS integrated with renewable energy sources and battery storage that also support vehicle-to-grid (V2G) functionality. In this configuration, electric vehicles can feed energy back into the grid during peak demand, enhancing grid stability and maximizing the use of renewable energy (see Figure 8.3).

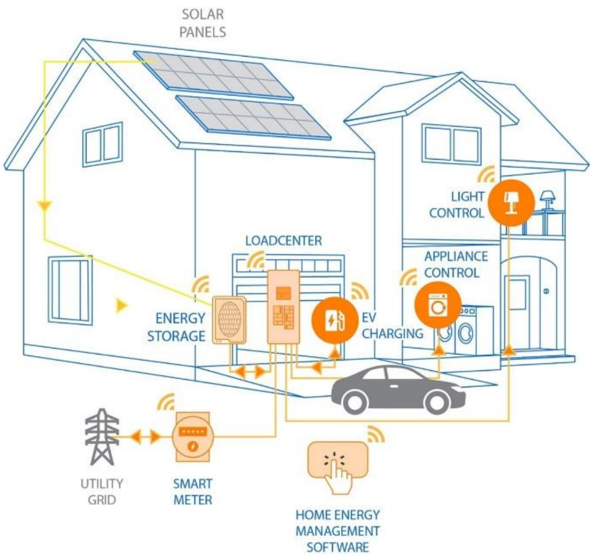

Figure 8.1 A domestic EVCS integrated with Solar PV and Energy Storage System

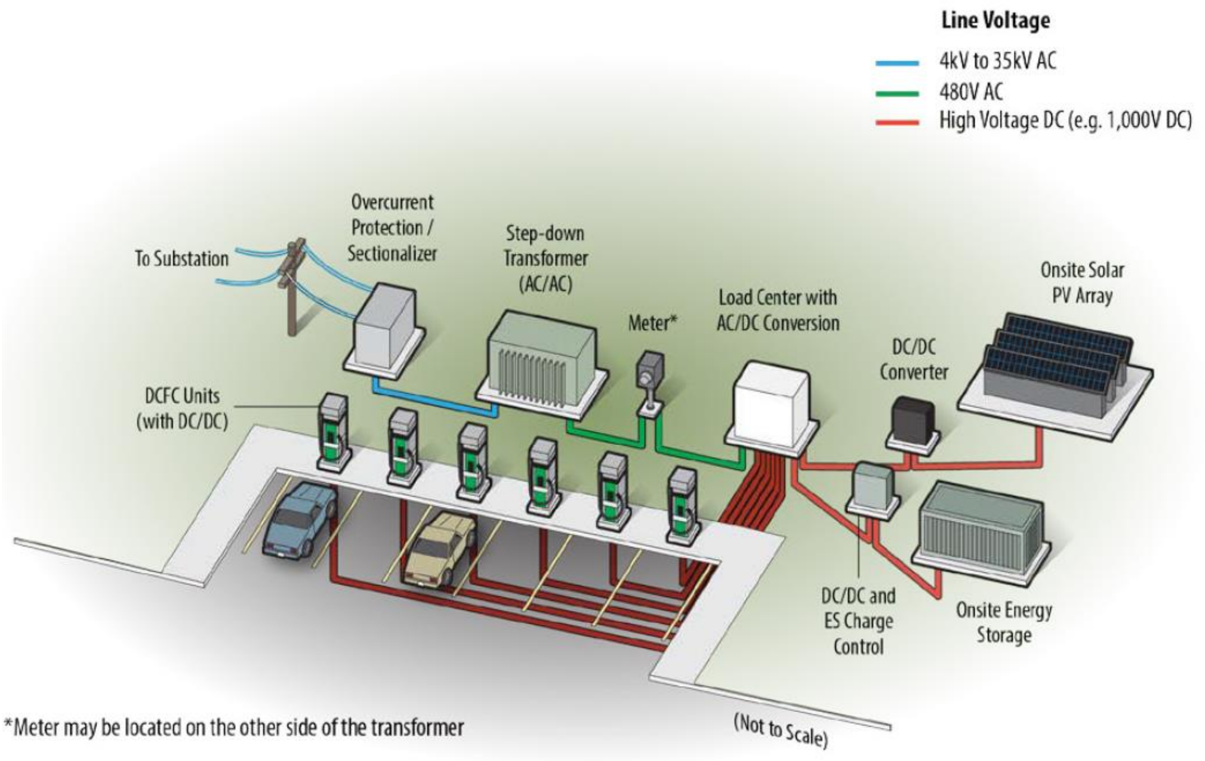

Figure 8.2 A conventional EVCS powered by the Grid, an Onsite Solar PV array, and an Onsite Energy Storage

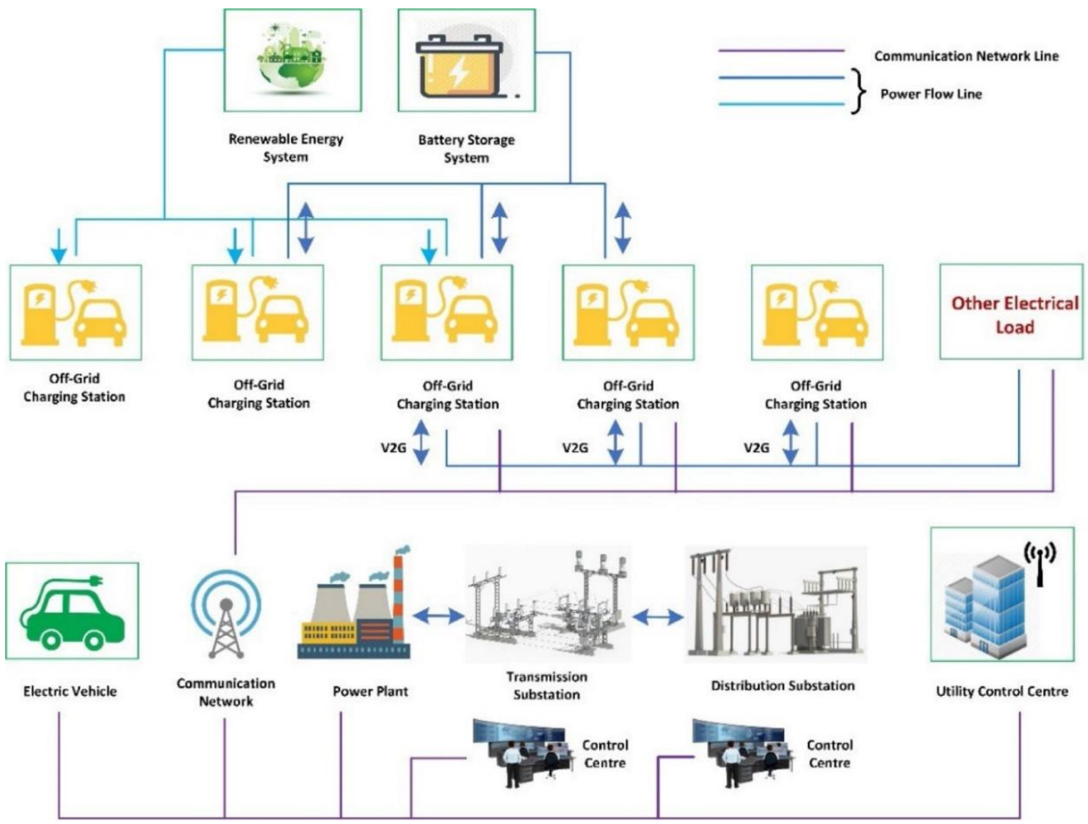

Figure 8.3 A V2G-enabled EVCS powered by the Grid, a Renewable Energy System and a BSS

8.1 System Design and Integration

i) Interconnection Architecture: Design a seamless integration of the EVCS, renewable energy generation (solar panels, wind turbines), and energy storage, ensuring efficient energy flow and load management.

ii) Smart Energy Management: Implement an intelligent control system that balances energy from renewables, the grid, and the storage system, supports smart charging features, and facilitates demand response or V2G functionalities.

iii) Grid Interconnection: For grid-tied systems, ensure compliance with local grid codes and standards, including anti-islanding and synchronization requirements (e.g., **IEC 61727** for grid-connected PV systems).

8.2 Electrical Infrastructure and Protection

Adhere to **IEC 60364** for electrical installations, ensuring proper wiring, grounding, and protection in the overall system.

8.3 Renewable Energy and Inverter Standards

i) Photovoltaic (PV) Systems: Use PV modules and inverters certified to **IEC 61215** (design qualification) and **IEC 61730** (safety) and ensure inverter safety in line with **IEC 62109**.

ii) All PV installations should comply with the “Guidelines on Rooftop Solar PV Installation for Solar Service Providers” published by the PUCSL.

iii) Wind Energy Systems: Follow relevant IEC standards for wind turbine safety and grid integration (e.g., **IEC 61400** series), if wind energy is part of the renewable mix.

8.4 Battery Energy Storage System Standards

When the EVCS is integrated with a Battery Energy Storage System (BESS) consist of Li-ion cells, the system shall comply with the following standards.

i) **IEC 62619:2017** Safety requirements for secondary lithium cells and batteries for use in industrial applications: This standard addresses safety aspects for Li-ion batteries intended for stationary or industrial use.

ii) **IEC 62933 Series**: This series covers the safety, performance, and testing requirements for electrical energy storage systems (EES), including those that utilize Li-ion battery technology in stationary applications.

iii) **IEC 62485-5**: This standard covers requirements on safety aspects associated with the installation, use, inspection, and maintenance and disposal of lithium-ion batteries.

iv) **IEC 63056**: Covers safety for secondary lithium-ion batteries in stationary energy storage systems.

v) Battery enclosures should be weatherproof (**IEC 60529** – minimum IP54 rating) if installed outdoors.

8.5 Fire Protection and Thermal Management

i) Implement fire-resistant enclosures (per **IEC 60332** for fire-resistant materials).

ii) Install automatic fire suppression systems (e.g., gas-based or water mist systems per NFPA 855 and **IEC 62305** for lightning protection).

iii) Maintain adequate ventilation to dissipate heat and prevent thermal runaway.

iv) Use battery thermal management systems (BTMS) to control cell temperatures and prevent overheating.

8.6 Electrical Safety and Protection Systems

i) Use BMS to monitor state of charge (SOC), state of health (SOH), temperature, and voltage balancing of the BESS.

ii) Implement overcurrent and short-circuit protection (as per **IEC 60364-4-43**).

iii) Use isolation monitoring devices to detect insulation faults (as per **IEC 61557-8**).

iv) The selection and installation of the RCD shall comply with **IEC 60364-7-722**.

v) The connecting point of the EV supply equipment shall be protected by an RCD having a rated residual operating current not exceeding 30 mA.

vi) For AC leakage protection, use Type A RCD.

vii) For DC leakage protection, use

- Type B RCD or
- Type A RCD and appropriate equipment that ensures the disconnection of the supply in case of DC fault current above 6 mA.

viii) Ensure proper earthing and bonding as per **IEC 60364-5-54**.

ix) Protect against lightning and power surges as per **IEC 62305**.

x) Include emergency isolation mechanisms to disconnect the EVSE in the event of a fault, fire, or other hazards.

8.7 Explosion and Hazardous Environment Considerations

i) If installed near fuel dispensers or in enclosed areas, conduct risk assessments as per **IEC 60079** (Explosive Atmospheres).

ii) Enclosures should meet IP54 or higher (as per **IEC 60529**) for dust and water protection.

8.8 Emergency Shutdown and Maintenance Provisions

i) Install an Emergency Disconnection System to isolate the battery in case of faults (as per **IEC 60364-4-482**).

ii) Provide manual and remote disconnect options for maintenance and emergency situations.

iii) Ensure safe access for maintenance personnel, including lockout/tagout (LOTO) provisions.

9 INSTALLATION OF BATTERY SWAP STATIONS

A Battery Swap Station (BSS) allows the replacement of a discharged battery pack in an electric vehicle with a fully charged battery pack, using an automated or manual process, ensuring electrical and mechanical safety and compatibility with the vehicle's energy management system. A sample layout of a modern BSS is illustrated in Figure 9.1.1.

The purpose of the battery swap system is to provide energy partly or in total to EVs through fast replacement of their swappable battery system (SBS). While charging, the EV typically takes a relatively long time, the battery swap process takes only a few minutes to complete. Thus, it will reduce range anxiety and will facilitate travel for longer distances.

As there is a possibility to charge the batteries after their removal from the vehicle in various ways, the impact of this process on the critical infrastructure of the electrical grid is minimized.

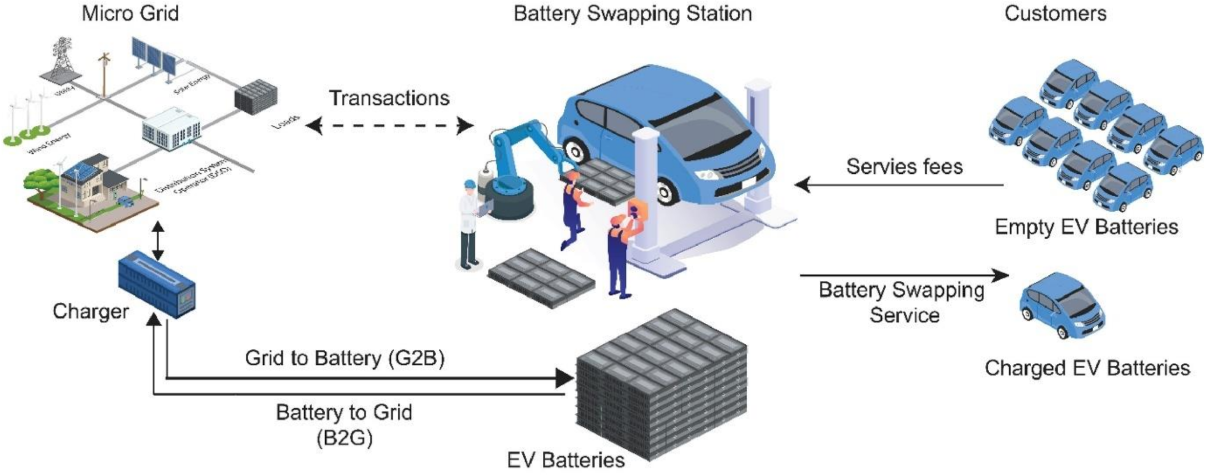

Figure 9.1 Battery swap station

Battery swap stations mainly include one or more of the following functions.

i) Swap of EV SBS
ii) Storage of EV SBS
iii) Charging and cooling of EV SBS
iv) Testing, maintenance and safety management of EV SBS

All the BSS shall comply with the following IEC standards.

i) **IEC 62840-1**: General and guidance
ii) **IEC 62840-2**: Safety requirements

9.1 System overview

Figure 9.1.1 shows the composition of the EV battery swap system and the relationships between the various systems.

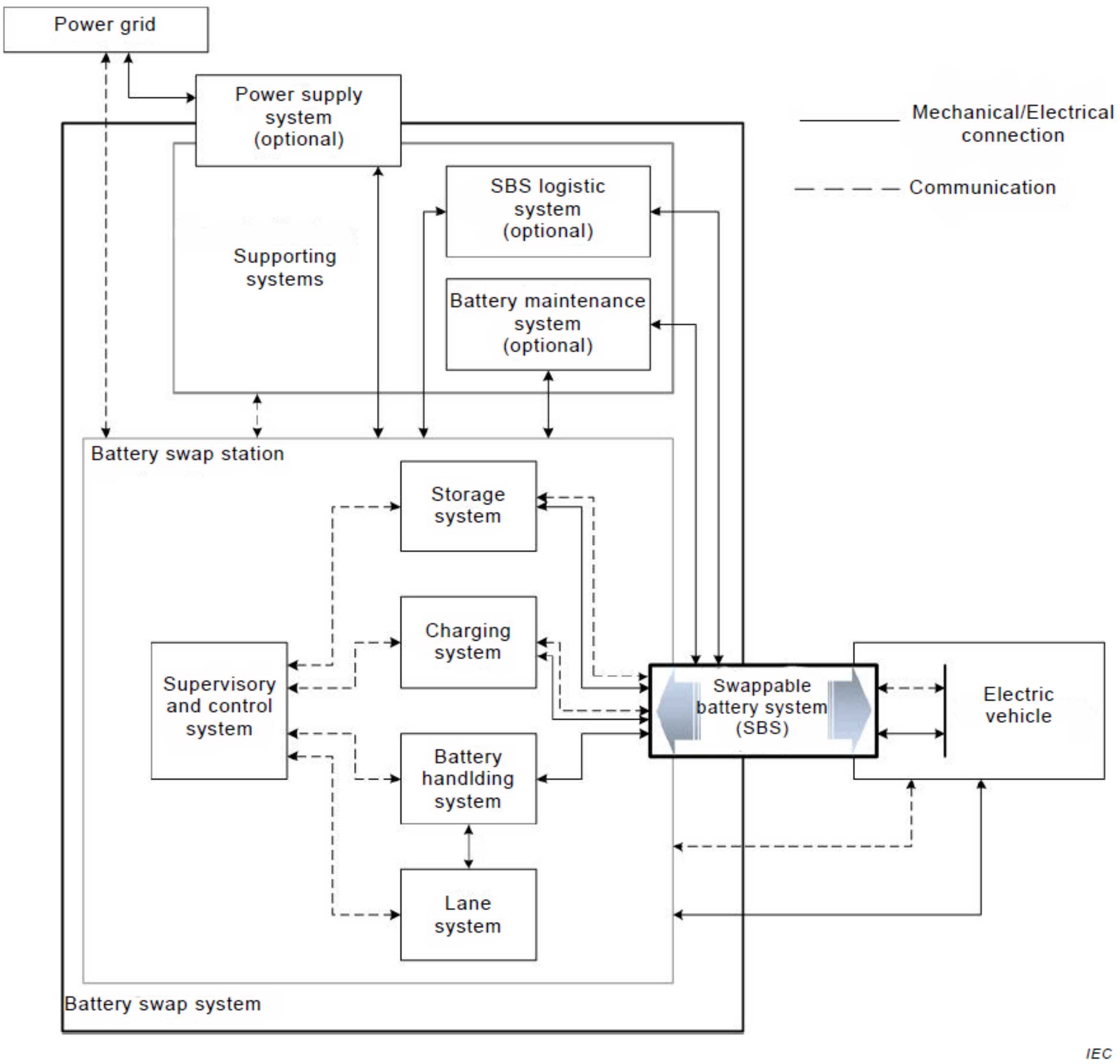

Figure 9.1.1 EV battery swap system

A BSS may include the following.

- A lane system.
- A battery handling system.
- A storage system.
- A charging system.
- A supervisory and control system.

9.1.1 Lane system

The lane system is used to transfer and/or position the EV to the designated location to get ready for battery handling. EVs leave safely through the lane system after SBS are exchanged. The lane system may provide functions such as,

i) EV verification,
ii) EV validation,
iii) EV cleaning,
iv) EV positioning, and
v) EV locking and unlocking.

The lane may include a cleaning station for the purposes of cleaning EV/battery parts before the swap process starts.

9.1.2 Battery handling system

The battery handling system consists of swap equipment and transferring equipment. The system may provide functions such as,

i) locking/unlocking,
ii) mounting/un-mounting, and
iii) transferring.

9.1.3 Storage system

The storage system is used to store the SBS safely. It shall monitor the status of the SBS and the ambient circumstances during storage. This system consists of a storage rack and equipment to communicate with supervisory and control system.

9.1.4 Charging system

The charging system is used to charge the SBS safely. It shall carry the SBS in the charging rack, communicate with the battery control unit (BCU) during the charging procedure, and control the charging procedure and its safe operation.

This system consists of,

i) SBS charger(s),
ii) charging racks, and
iii) equipment to communicate with supervisory and control system.

9.1.5 Supervisory and control system

The supervisory and control system contains

i) communication units,
ii) a data process module,
iii) data acquisition units,
iv) a data storage module,
v) a remote-control module, and
vi) a human machine interface (HMI).

The supervisory and control system monitors and controls all battery swap system processes. This system may have communication with the power grid as well.

9.2 Safety requirements

IEC 62840-2 provides the safety requirements for a battery swap system, for the purposes of swapping swappable battery system (SBS) of electric vehicles. The battery swap system is intended to be connected to the supply network. The power supply is up to 1 000 V AC or up to 1 500 V DC in accordance with **IEC 60038**.

Aspects covered under this section are,

- safety requirements of the battery swap system and/or its systems;
- security requirements for communication;
- electromagnetic compatibility (EMC);
- signs and instructions;
- protection against electric shock and other hazards.

9.2.1 Safety requirements of the battery swap system and/or its systems

The battery swap system for electrical vehicles shall be in accordance with **IEC 60204-1**, **IEC 61511-1** and ISO 13849-1.

9.2.1.1 Lane system

At the entrance to the lane, the EV information shall be identified and fed into the supervisor and control system in order to use the right parameters and components for this vehicle.

The lane may include a cleaning station for the purposes of cleaning EV/battery parts before the swap process starts. All lane system components shall be able to resist the effect of automotive solvents and fluids.

Drivers and passengers may be allowed to stay on-board during the battery swap process. The lane system shall be built in such a manner that humans and EVs are not at risk as a result of movement of mechanical parts or as a result of open underground cavities.

During each phase of the battery swap process, the driver (if on board) and system operators should have immediate access to emergency stop buttons to stop all automation motions in case of emergency.

The lane shall be equipped with suitable escape routes and emergency exits allowing people (if on board), including disabled persons, children and infants to evacuate from the lane area in case of fire or any other emergency.

All marking, routing and geometry of escape routes and exits should be done according to local regulations.

9.2.1.2 Battery handling system

In automatic BSS, a door or a sensor system shall be installed to prevent an unauthorized person gaining access to the battery swap zone:

- if a door or access is opened, the system has to stop.
- the system can only operate if all accesses are closed.
- a door can be opened from outside only if the system stops.
- a door, if one exists, shall be able to open from inside in any case.
- a restart can only be performed if all accesses are closed, and no person is inside the zone.

In the event of a grid power outage (loss of electrical power), the battery handling system shall have a function that prevents the battery handling system from releasing unsafely.

The battery handling system of either automatic mode or semi-automatic mode shall have emergency operation mode and manual operation mode.

*Note: The definitions of automatic, semi-automatic, and manual modes are given in **IEC62840-2**.*

An emergency stop device shall be provided, so that the operator can stop the battery handling system immediately in case of emergency.

Detecting and warning devices or relevant protection measures are recommended in case of a human or an animal having unexpected proximity to the system.

9.2.1.3 Battery storage

The storage condition provided by the battery storage system shall comply with the specific requirements of SBS. Structural elements carrying SBS in battery storage system shall be rigid and precise enough to prevent a risk of a SBS falling down from a storage compartment.

Structural elements supporting SBS in the storage system shall be secured to the ground or to the wall in such a manner that the structure shall not collapse under SBS weight or as the result of impact or vibration, such as failure in undesired motion of automatic devices against battery storage.

If SBS is not fully sealed, each SBS shall be separated by coverage from other SBS stored in the same rack by at least IP4x.

If SBS is not fully sealed, each SBS shall be protected by coverage to avoid liquid drops from other SBS stored in the same rack by at least IPx2.

The storage system shall be designed and constructed in accordance with local construction regulations. The storage rack shall be equipped with locking device to prevent unintended motion of SBS and provide locking state information to the supervisor and control system.

Safety critical parameters shall be monitored as long as the SBS is stored in the storage rack. If there are no other local regulations or system requirements, the following parameters shall be monitored.

- Temperature of critical components
- Electrical malfunctions
- Locking state

If any of these parameters are out of specific level, necessary actions shall be activated by the supervisory and control system.

Rapid isolation or transfer of the battery in case of emergency shall be ensured, including the following equipment:

- Fire detection and extinguishing equipment in the battery storage/bin area. The fire detection system should be connected to the supervisory and control system of the BSS.
- Isolated observation facility, such as fire bunker, in order to isolate abnormal batteries.
- It is recommended to install a heat or smoke detector near the BSS.

9.2.1.4 Charging system

i) Charging parameters of the charger shall meet the inherent parameters of the battery which are specified by the battery manufacturer.

ii) The SBS charger shall supply a DC current or voltage to the battery in accordance with a charging control function request. Functions provided in DC charging shall comply with 6.4.1 and 6.4.2 of **IEC 61851-23**.

iii) The SBS charger shall connect to SBS on the charging rack through both power connections and communication connections, for the purpose of battery charging.

iv) An emergency means shall be installed to isolate the AC supply network (mains) from the SBS charger in case of risk of electric shock, fire or explosion.

v) The SBS charger shall be equipped with a protective device against the uncontrolled reverse power flow from the SBS.

vi) Specific requirements for isolated systems shall comply with 101.2 of **IEC 61851-23**.

vii) The charger shall have an unambiguous signal and indicator during the charging procedure, so as to avoid an incorrect operation.

viii) Chargers shall be installed according to manufacturers' instructions. This applies to requirements regarding installation, cooling, ventilation and further requirements.

ix) The battery charge process should be enabled only if the SBS coupler between the charging rack and the SBS is reliably connected as well as the locking device is reliably locked. The charger shall cease its output, if any abnormal connection or condition between the charger and SBS is detected.

x) As long as the SBS is stored in the charging rack, the requirement of storage system shall be applied.

xi) The battery charge process shall be based on a real time handshake between the charger controller and BCU. Parameters, such as:

   a. temperature of critical components,
   b. voltage,
   c. SOH,
   d. SOC, and
   e. maximum allowed charging current,

shall be provided by BCU to the charger controller.

xii) The charger controller shall have a communication interface with the supervisory and control system to transmit charging data to the supervisory and control system.

9.2.2 Battery Maintenance

The battery maintenance system shall have the functions of periodic inspection and maintenance of SBS to ensure safety and to extend the life cycle of SBS.

The battery maintenance system shall have a function that checks and tests the following of the SBS.

- Appearance
- Insulation
- Mechanical condition of the wearing parts
- Reliability of connections between cables and key parts, such as connectors and fuse.

The battery maintenance system shall have the following functions.

- Forecast and maintain the cells' electrical quantity and life cycle.
- Check and test the consistency of assembled battery cells.
- Store and analyse the data during the process of SBS maintenance.
- Communicate with the supervisory and control system.

9.2.3 Data Security and Transmission Safety

i) Any communication between two or more systems within the BSS as well as with external communication entities shall avoid unauthorized access and ensure the data integrity.

ii) Where the functional safety is affected, the communication between systems and inside systems shall follow the requirements of **IEC 61784-3**.

9.2.4 Environmental considerations

i) The IP degrees for enclosures that provide protection against access to hazardous parts shall be at least IPXXC (Protection Against Tool Access).

ii) The minimum IP degrees for the enclosures shall be,

  a. for indoor use: IP21

  b. for outdoor use: IP44

iii) Live parts shall be located inside enclosures regarding protection against direct contact of at least IP2X or IPXXB (Protection Against Finger Contact) in conformance to **IEC 60529**.

iv) Where the top surfaces of the enclosure are readily accessible, the minimum degree of protection against direct contact provided by the top surfaces shall be IP4X or IPXXD (Protection Against Wire Access).

v) The IP degrees for couplers located outside enclosures which enclose hazardous live parts shall provide protection by at least IPXXB.

vi) The minimum IP degrees for the coupler shall be,

  a. for indoor use: IP21

  b. for outdoor use: IP44

Detailed information can be found in **IEC 62840-2**.

10 INSTALLATION OF CHARGING FACILITIES FOR E-BIKES AND E-TUK TUKS

When installing an EVCS for E-bikes and E-tuk tuks, several technical, safety, and regulatory aspects must be considered.

10.1 Charging Mode and Equipment Compliance

All 4 charging modes are applicable for E-bikes and E-tuk tuks.

i) AC Charging (Mode 1, 2, and 3): Typically, single-phase 230V, with power ratings of 1-3 kW (e-bikes) and 3-7 kW (e-tuk tuks).

ii) DC Charging (Mode 4): Some e-tuk tuks may support higher power DC charging that complies with **IEC 61851-23**.

iii) If swapping stations are used, compliance with **IEC 62840** is required.

10.2 Connector Types

The vehicle connector, vehicle coupler, and vehicle inlet shall comply with the charging interfaces mentioned in Sections 2.3 and 2.4.

10.3 Safety and Protection Measures

i)

ii) Circuit breakers must comply with **IEC 60898-1**.

iii) For DC systems, IEC 61557-8 ensures insulation resistance monitoring.

iv) IP Rating Requirements (**IEC 60529**)

a. Outdoor chargers: Minimum IP54

b. Indoor chargers: Minimum IP44

v) EVCS shall meet **IEC 61140** for electrical shock protection.

vi) EVCS shall meet **IEC 62262** (IK ratings for impact resistance).

vii) EVCS shall meet **IEC 60068-2** for extreme climate conditions.

viii) EVCS shall meet **IEC 60332** (fire resistance of cables) and **IEC 60695** (flammability of enclosures).

ix) It is recommended to install a heat or smoke detector near the charging area.

11 INSTALLATION OF CHARGING FACILITIES FOR HEAVY EVs

When installing an EVCS for Heavy EVs such as busses and trucks, several technical, safety, and regulatory aspects must be considered.

11.1 Charging Mode and Equipment Compliance

i) Heavy EV charging typically requires Mode 4 (DC fast charging) with high output power ranging from 150 kW to 600 kW or more however, Modes 2 and 3 (AC charging) may also be applicable. Mode 1 is prohibited for Heavy EVs.

ii) If swapping stations are used, compliance with **IEC 62840** is required.

11.2 Connector Types

i) The vehicle connector, vehicle coupler, and vehicle inlet shall comply with the charging interfaces mentioned in Sections 2.3 and 2.4.

ii) The system shall comply with **IEC 61851-23**, **IEC 61851-24,** and **ISO 15118** if a pantograph-based overhead charging system is used.

11.3 Safety and Protection Measures

i. The selection and installation of the RCD shall comply with **IEC 60364-7-722**.

ii. The connecting point of the EV supply equipment shall be protected by an RCD having a rated residual operating current not exceeding 30 mA.

iii. For AC leakage protection, use Type A RCD.

iv. For DC leakage protection, use
   - Type B RCD or
   - Type A RCD and appropriate equipment that ensures the disconnection of the supply in case of DC fault current above 6 mA.
   - If the load current is more than 125 A, use an external Type B RCD relay plus a matching contactor or breaker as per **IEC 62423.**

v. Use SPDs as per **IEC 61643** and MCBs compliant with **IEC 60947-2**.

vi. Proper earthing per **IEC 60364-5-54** is essential for large metal-bodied vehicles.

vii. Use weatherproof and rugged outdoor-compatible equipment with a minimum IP rating of IP54 (**IEC 60529**).

viii. Ensure sufficient airflow if installed indoors or in enclosed depots (as per **IEC 61851-1** and **IEC 60068** for environmental conditions).

ix. Install fire detection and suppression systems in accordance with **IEC 60364-4-42**.
x. EVCS shall meet **IEC 61140** for electrical shock protection.
xi. EVCS shall meet **IEC 62262** (IK ratings for impact resistance).
xii. EVCS shall meet **IEC 60068-2** for extreme climate conditions.
xiii. EVCS shall meet **IEC 60332** (fire resistance of cables) and **IEC 60695** (flammability of enclosures).
xiv. EVCS shall be designed for larger turning radii, parking bays, and overhead clearance.

11.4 Special Considerations for Pantograph-based Charing Stations

11.4.1 Mechanical Design and Structural Integration

i. The pantograph assembly shall be structurally supported to withstand mechanical loading due to wind, vibration, and vehicle-induced movement.
ii. The design shall ensure accurate vertical and lateral alignment with the vehicle contact rails, accommodating standard tolerances defined in **IEC 61851-23** and **IEC 61980**.
iii. The supporting infrastructure (e.g., gantries, overhead masts) shall be constructed using corrosion-resistant materials and comply with applicable civil engineering codes for public installations.
iv. Vehicle access to the charging point shall be unobstructed, and the layout shall ensure safe and repeatable docking for consistent pantograph connection.

11.4.2 Site Design and Spatial Requirements

i. The site layout shall accommodate the turning radius, height, and length of the intended Heavy EVs, ensuring safe manoeuvring to and from the pantograph charging point.
ii. The charging point design shall include standardized markings, curbing, and vehicle guidance features to enable consistent alignment beneath the pantograph.
iii. Minimum overhead clearance shall comply with local traffic and safety regulations of the Department of Motor Traffic (DMT) and shall be sufficient to avoid obstruction by other infrastructure or vehicles.

iv. The charging station footprint, including the pantograph assembly and control enclosure, shall be designed to withstand outdoor environmental conditions and maintain accessibility for service and maintenance personnel.

11.4.3 Safety and Protective Measures

i. The pantograph system shall include automatic disconnection functionality in the event of system malfunction, communication loss, electrical fault, or activation of an emergency stop.
ii. All exposed conductive parts shall be physically protected against accidental contact in accordance with **IEC 61851-1** and **IEC 60529** and insulated where appropriate to prevent electrical hazards.
iii. Adequate electrical clearance and creepage distances shall be maintained to prevent arcing or flashover, particularly under high-voltage DC operation.
iv. Safety interlocks shall be employed to prevent energization of the pantograph unless full mechanical engagement is verified.
v. Visual indicators and audible alerts shall be provided to signal charging status and fault conditions to personnel in the vicinity.

11.4.4 Communication

i. The pantograph charging system shall incorporate a digital communication interface compliant with **IEC 61851-24**, enabling real-time data exchange between the electric vehicle and the supply equipment.
ii. The system shall support automated positioning, connection control, and verification processes to ensure correct alignment and electrical engagement.
iii. All automated communication functions shall include redundant safety protocols to prevent unintended connection or disconnection events.
iv. The charging system shall be compatible with vehicle and fleet management systems via **ISO 15118** to facilitate smart charging and diagnostics.

12 COMMUNICATION AND IT-RELATED ASPECTS

When setting up an EVCS, communication and IT-related aspects are crucial for interoperability, monitoring, billing, security, and remote management. A schematic of a communication network for an EVCS that connects EV, EVSE, and Grid together is illustrated in Figure 12.1.

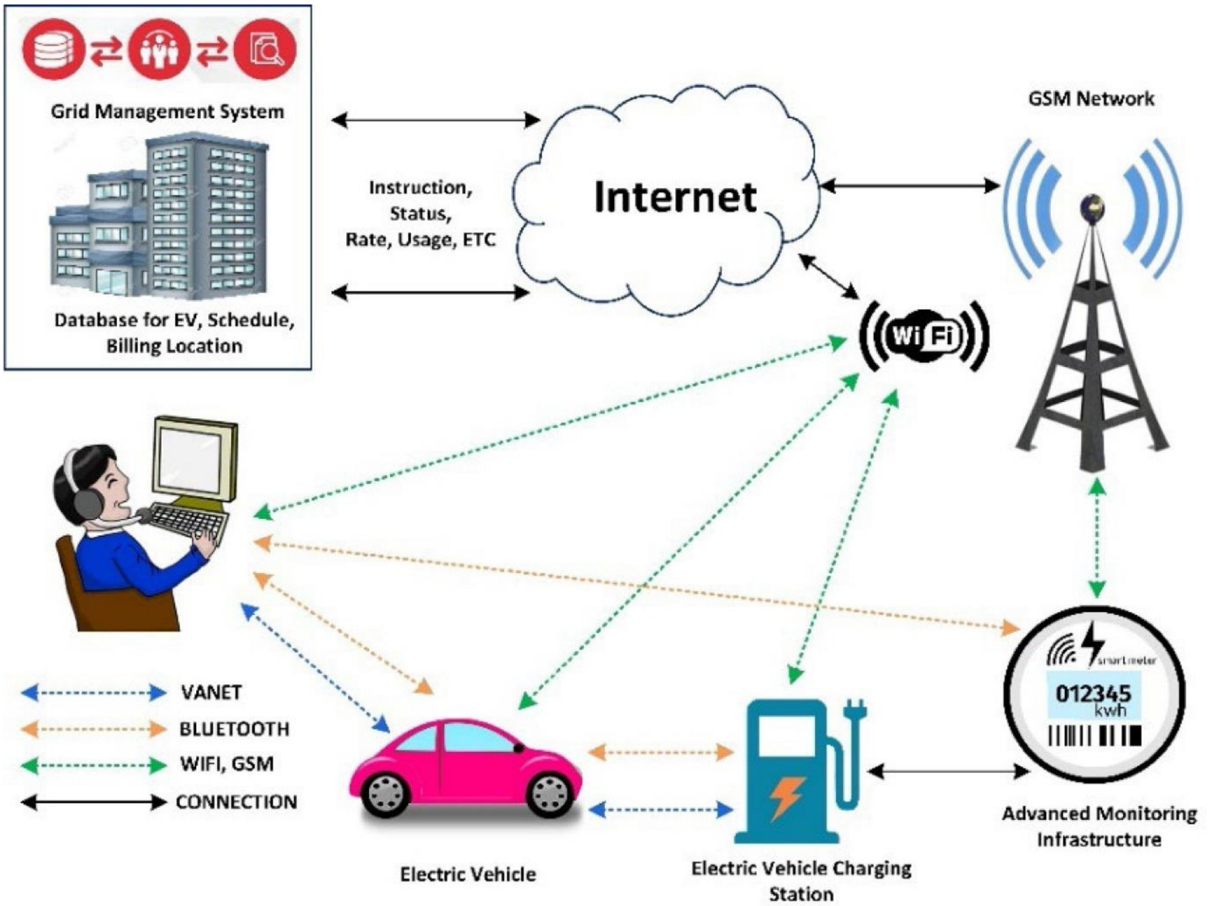

Figure 12.1 A schematic of a communication network for an EVCS that connects EV, EVSE, and Grid together

12.1 Communication Protocols for EVCS

The EVCS shall comply with the following communication protocols.

i) **IEC 61850**: Communication networks and systems for power utility automation, applicable for smart grid integration.

ii) **IEC 61851-1**: Defines control and communication requirements between the EV and charging equipment.

iii) **IEC 61851-24**: Specifies digital communication protocols for DC charging stations.

iv) **IEC/ISO 15118**: Vehicle-to-grid (V2G) communication protocol for automated authentication and billing.

v) **IEC 63584**: Open Charge Point Protocol (OCPP) – Open standard for communication between charging stations and central management systems.

12.2 Cybersecurity and Data Protection

The EVCS shall comply with the following standards relevant to cybersecurity and data protection.

i) **IEC 62443**: Industrial cybersecurity standard for protecting charging infrastructure from cyber threats.

ii) **IEC/ISO 27001**: Information security management system (ISMS) for data protection.

iii) **ISO 15118-20**: Enhances security features in V2G communication.

iv) **IEC 62351**: TLS (Transport Layer Security) - Encryption for secure data transmission between the EVCS and backend systems.

12.3 Smart Grid and Energy Management

The EVCS shall comply with the following standards relevant to smart grid and energy management.

i) **IEC 63110**: Protocol for managing EV charging infrastructure, energy distribution, and grid integration.

ii) **IEC 61850-7-420**: Defines interactions between Distributed Energy Resources (DER) and charging stations.

iii) **IEC 60870-5-104**: Communication protocols for smart energy monitoring.

13 OPERATING PROCEDURES

13.1 Pre-Operation Checks

i) Ensure the charging station is powered and the display is operational.
ii) Check that the charger’s cables and connectors are free from visible damage.
iii) Verify the emergency stop button is functional and accessible.
iv) Confirm the charger’s indicator light shows it is ready for use.

13.2 Charging Process

i) User Authentication: Authenticate via RFID card, mobile app, OTP, QR code, Barcode, NFC, Biometric etc.
ii) Connect to Vehicle:
   a. Plug the charging connector into the EV inlet securely.
   b. Ensure a firm connection and wait for the vehicle to communicate with the charger.
iii) Charging Initiation:
   a. Follow on-screen instructions to start charging.
   b. The charging session begins once authentication is successful.
iv) Monitoring Charging:
   a. Observe the charger’s display for charging status and energy consumption.
   b. Monitor the state of charge (SoC) via the app or display.

13.3 Charging Completion and Disconnection

i) Charging will stop automatically or manually via the app or the display of the EVSE.
ii) Disconnect the charging cable and store it properly.
iii) Ensure the EVSE returns to standby mode.

14 MAINTENANCE PROCEDURES

14.1 Daily Checks

i) Visually inspect the charger for any physical damage.
ii) Check for any error messages or alerts on the display panel.
iii) Ensure proper cable management and check for wear or fraying.

Note: If the EVCS is an unmanned station, these daily checked shall be performed monthly by the Charge Point Operator (CPO) and empower the EV user to perform these checks on daily basis before plugging the EV to the charger.

14.2 Monthly Checks

i) Inspect and clean the charging connectors and ports.
ii) Ensure ventilation systems are clear of obstructions.
iii) Check the indicator lights and display functionality.
iv) Confirm that safety labels and user instructions are intact and legible.
v) Verify the charger is operational by performing a test charge.
vi) Test emergency stop function to ensure proper operation.

14.3 Quarterly Checks

i) Perform insulation resistance tests as per **IEC 61851**.
ii) Inspect and test the proper functioning of SPDs.
iii) Verify all communication and networking connections.
iv) Ensure that the circuit breakers and RCDs operate correctly.
v) Perform software/firmware updates if applicable.

14.4 Annual Checks

i) Conduct a full electrical system inspection by a SLQF Level 4-certified electrician.
ii) Verify grounding and bonding as per **IEC 60364**.
iii) Perform thermal imaging on electrical connections to detect overheating.
iv) Inspect enclosure integrity, ensuring compliance with IP rating requirements.
v) Calibrate metering and billing components to ensure accuracy.
vi) Clean and lubricate mechanical components as required.

14.5 Emergency Maintenance

i) If an error or fault occurs, follow the troubleshooting guide provided by the EVSE manufacturer.

ii) If a surge or electrical fault is detected, inspect and replace damaged components as necessary.

iii) In case of overheating or fire risk, shut down the system and investigate the cause before reactivating.

14.6 Safety Precautions

i) Always wear appropriate personal protective equipment (PPE) during maintenance.

ii) Follow LOTO procedures before servicing electrical components.

iii) Ensure all tools and equipment used are certified and in good condition.

14.7 Record Keeping

i) Maintain logs of all maintenance activities, including date, observations, and corrective actions taken.

ii) Store reports for audit and compliance purposes.

iii) Ensure digital records are backed up and accessible for review.

15 BASIC TROUBLESHOOTING STEPS FOR EVCS

15.1 Power Supply Issues

- Check the circuit breakers, MCBs, and RCDs: Ensure the main breaker, MCB, and RCD have not tripped. Reset if necessary.
- Check the SPD indicator colour (should be green) to confirm that no electrical surge has occurred.
- Inspect wiring connections: Loose or damaged wiring should be checked and corrected by a qualified electrician.
- Verify grid supply: Ensure that the home's electrical system is providing sufficient power as per **IEC 60364-7-722**.

15.2 Charging Cable and Connector Issues

- Inspect for damage: Look for visible wear or damage on the cable, plug, and charging socket.
- Check connection status: Ensure the EV is properly connected and locked into place.
- Verify the connector type: Use only connectors compliant with **IEC 62196**, **IEC 60083**, or **IEC 60309**.

15.3 Communication Errors

- Restart the charger: Power cycle the EVCS by turning it off and on.
- Check error messages: Many modern chargers have LED indicators or display screens showing error codes.
- Verify EV compatibility: Ensure the vehicle supports the selected charging mode (Mode 2, 3, or 4 as per **IEC 61851**).

15.4 Abrupt stop during a charging session

- Check the ambient temperature: Charging may stop due to overheating protection.
- Check if the load management system is limiting power.
- Inspect for tripped breakers: If overload is suspected, reduce other electrical loads.

15.5 Electrical Shock or Fire Risk

- Immediately disconnect power: Use an emergency disconnect switch (mandatory as per **IEC 61851-1**).

- Use a suitable fire extinguisher.
  - For a Class E (electrical) fire: Dry Powder (Blue colour label or tank) or CO_2 (Black colour label or tank).
  - See Figure 15.1 and Figure 15.2.

Figure 15.1 Dry Powder Fire Extinguisher

Figure 15.2 CO_2 Fire Extinguisher

- Follow the PASS technique to operate the fire extinguisher as illustrated in Figure 15.3.
  - P: Pull the safety pin to release the extinguisher mechanism.
  - A: Aim the nozzle directly at the base of the fire, not the flames.
  - S: Squeeze the handle to discharge the extinguishing agent.

- S: Sweep the nozzle back and forth or sideways across the base of the fire until it is extinguished

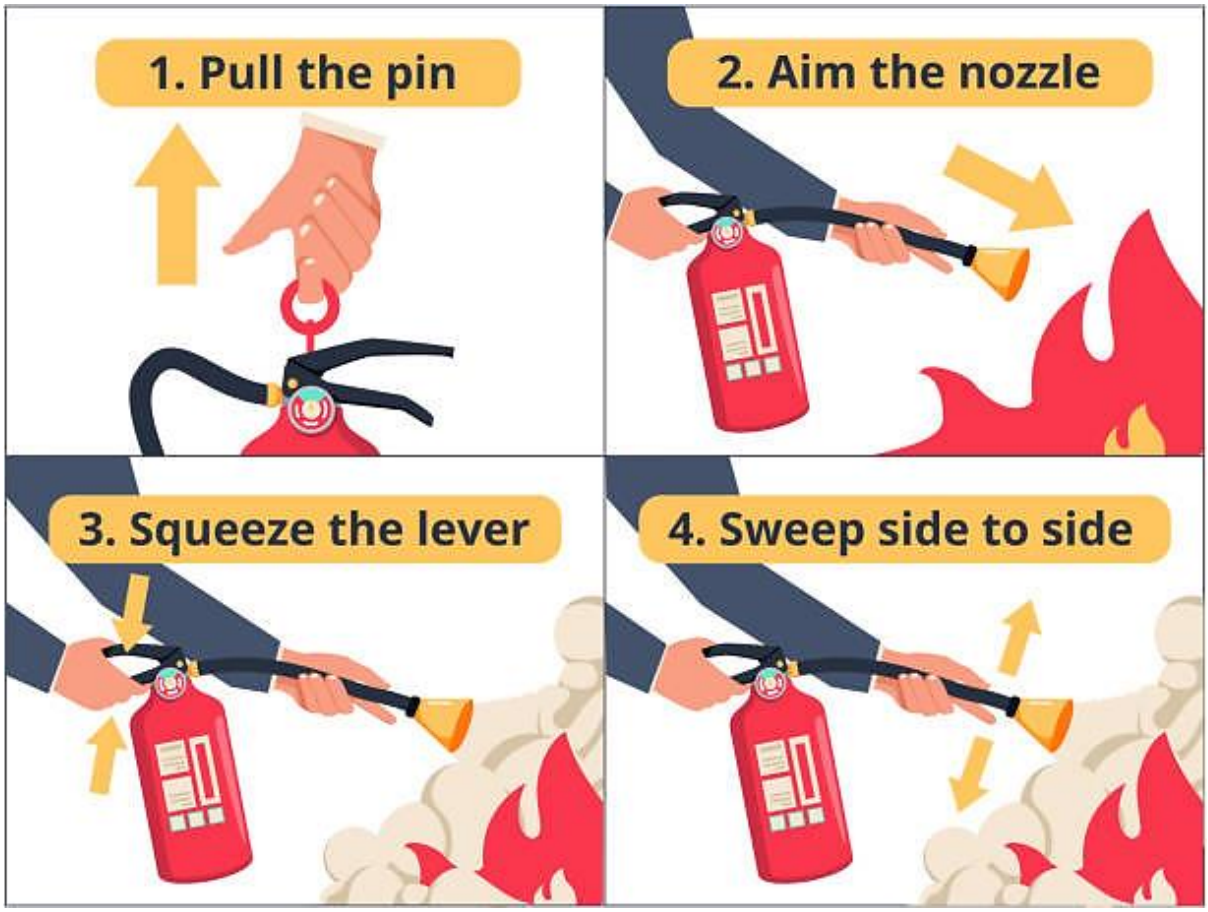

Figure 15.3 PASS Technique

- Ensure that the nearest exit is always behind you and the fire is in front of you.
- If the fire cannot be controlled, leave the premises and call emergency services.
  - Fire and Rescue: Call 110
  - Sri Lanka Police Emergency Service: Call 119
  - Suwa Seriya Ambulance Service: Call 1990

15.6 Overheating of the Charging Station

- Stop charging immediately: Overheating could indicate internal component failure.
- Check ventilation: EVCS should be installed in well-ventilated areas per I**EC 60364-7-722**.
- Contact a professional: If persistent overheating occurs, a SLQF Level 4-certified electrician should inspect the unit.

15.7 Grounding or Earthing Failure

- Perform an earth test: Use an earth resistivity tester to check compliance with **IEC 60364** grounding requirements.
- Check the earthing conductor: Loose or corroded connections should be fixed immediately.

15.8 Frequent RCD Tripping

- Identify the cause: RCD trips may indicate leakage currents above permissible limits (**IEC 60364-7-722**).
- Inspect the insulation resistance: If below 1 MΩ (in Class I) or 7 MΩ (in Class II) per **IEC 61851**, repair is required.

16 REFERENCES

16.1 Standards

No	Name	Link
1	IEC 14908-4	https://webstore.iec.ch/en/publication/10213
2	IEC 27001	https://www.iso.org/standard/27001
3	IEC 60068-2	https://webstore.iec.ch/en/publication/62437
4	IEC 60079-0	https://webstore.iec.ch/en/publication/32878
5	IEC 60204-1	https://webstore.iec.ch/en/publication/26037
6	IEC 60269-1	https://webstore.iec.ch/en/publication/66096
7	IEC 60309	https://webstore.iec.ch/en/publication/59916
8	IEC 60320	https://webstore.iec.ch/en/publication/64901
9	IEC 60332	https://webstore.iec.ch/en/publication/62423
10	IEC 60364-1	https://webstore.iec.ch/en/publication/1865
11	IEC 60364-4-41	https://webstore.iec.ch/en/publication/1867
12	IEC 60364-4-43	https://webstore.iec.ch/en/publication/28432
13	IEC 60364-4-44	https://webstore.iec.ch/en/publication/32355
14	IEC 60364-4-482	https://webstore.iec.ch/en/publication/15757
15	IEC 60364-5-54	https://webstore.iec.ch/en/publication/1882
16	IEC 60364-7-722	https://webstore.iec.ch/en/publication/29958
17	IEC 60529	https://webstore.iec.ch/en/publication/64427
18	IEC 60695-2-11	https://webstore.iec.ch/en/publication/63552
19	IEC 60755	https://webstore.iec.ch/en/publication/33927
20	IEC 60870-5-104	https://webstore.iec.ch/en/publication/3746
21	IEC 60898-1	https://webstore.iec.ch/en/publication/66619
22	IEC 60947-1	https://webstore.iec.ch/en/publication/26973
23	IEC 61000-4-20	https://webstore.iec.ch/en/publication/34378
24	IEC 61008	https://webstore.iec.ch/en/publication/67980
25	IEC 61009	https://webstore.iec.ch/en/publication/4270
26	IEC 61140	https://webstore.iec.ch/en/publication/23997
27	IEC 61215-1	https://webstore.iec.ch/en/publication/61345
28	IEC 61334-4-41	https://webstore.iec.ch/en/publication/5303
29	IEC 61400-12-1	https://webstore.iec.ch/en/publication/68499
30	IEC 61439	https://webstore.iec.ch/en/publication/32338
31	IEC 61511-1	https://webstore.iec.ch/en/publication/24241
32	IEC 61557-8	https://webstore.iec.ch/en/publication/5582
33	IEC 61727	https://webstore.iec.ch/en/publication/5736
34	IEC 61730-1	https://webstore.iec.ch/en/publication/59803
35	IEC 61850-7-420	https://webstore.iec.ch/en/publication/34384
36	IEC 61851	https://webstore.iec.ch/en/publication/33644
37	IEC 61980	https://webstore.iec.ch/en/publication/31657
38	IEC 62052-11	https://webstore.iec.ch/en/publication/28212

39	IEC 62053-21	https://webstore.iec.ch/en/publication/6382
40	IEC 62056-21	https://webstore.iec.ch/en/publication/6398
41	IEC 62058-11	https://webstore.iec.ch/en/publication/6414
42	IEC 62058-31	https://webstore.iec.ch/en/publication/6416
43	IEC 62109-1	https://webstore.iec.ch/en/publication/6470
44	IEC 62196	https://webstore.iec.ch/en/publication/59922
45	IEC 62262	https://webstore.iec.ch/en/publication/6673
46	IEC 62305	https://webstore.iec.ch/en/publication/6797
47	IEC 62423	https://webstore.iec.ch/en/publication/6998
48	IEC 62443	https://www.isa.org/standards-and-publications/isa-standards/isa-iec-62443-series-of-standards
49	IEC 62485-5	https://webstore.iec.ch/en/publication/29086
50	IEC 62619	https://webstore.iec.ch/en/publication/28895
51	IEC 62752	https://webstore.iec.ch/en/publication/66220
52	IEC 62840-2	https://webstore.iec.ch/en/publication/25983
53	IEC 62893-1	https://webstore.iec.ch/en/publication/30590
54	IEC 62933-1	https://webstore.iec.ch/en/publication/64642
55	IEC 63056	https://webstore.iec.ch/en/publication/29224
56	IEC 63110-1	https://webstore.iec.ch/en/publication/60000
57	IEC 63584	https://webstore.iec.ch/en/publication/95734
58	IEC TR 60083	https://webstore.iec.ch/en/publication/23628
59	IEC TR 61850-1	https://webstore.iec.ch/en/publication/6007
60	IEC TS 61400-30	https://webstore.iec.ch/en/publication/31267
61	IEC TS 62351-100-4	https://webstore.iec.ch/en/publication/63323
62	IEC TS 62840-1	https://webstore.iec.ch/en/publication/25398
63	ISO 13849-1:2023	https://www.iso.org/standard/73481.html
64	ISO 15118-20	https://webstore.iec.ch/en/publication/26347
65	ISO 15118-4	https://webstore.iec.ch/en/publication/32348
66	CISPR 11	https://webstore.iec.ch/en/publication/66118
67	CISPR 22	https://webstore.iec.ch/en/publication/72
68	NFPA 855	https://www.nfpa.org/codes-and-standards/nfpa-855-standard-development/855

16.2 Other references

[1] BS 7671 - 18th Edition: The IET Wiring Regulations https://electrical.theiet.org/bs-7671/

[2] EV Plugs, socket-outlets, vehicle connectors and vehicle inlets https://en.wikipedia.org/wiki/IEC_62196

[3] Guidelines on Rooftop Solar PV Installation for Solar Service Providers https://www.pucsl.gov.lk/wp-content/uploads/2022/10/Guidelines-on-Rooftop-Solar-PV-installation-for-Utility-Providers_Revision-01.pdf

[4] Battery swapping stations https://www.sciencedirect.com/topics/engineering/battery-swapping-station

[5] An in-depth analysis of electric vehicle charging station infrastructure, policy implications, and future trends https://www.sciencedirect.com/science/article/pii/S2352484722017346

[6] Electric Vehicle Public Charging Station Host's Handbook by Iowa Economic Development Authority https://publications.iowa.gov/38022/1/ev-infrastructureguide2019.pdf

[7] New Retail Layouts With EV Charging Deliver a High-Value Customer Experience https://evadvisors.com/new-retail-layouts-with-ev-charging-deliver-a-high-value-customer-experience/

[8] Dumb Or Brilliant? Electrify America Opens An Indoor Charging Station https://www.youtube.com/watch?v=W0hK5mphkGA

[9] This Massive Indoor EV Hub Is the Nicest Charging Station I've Visited https://www.cnet.com/home/electric-vehicles/this-massive-indoor-ev-hub-is-the-nicest-charging-station-ive-visited/

[10] Feasibility analysis of a solar-assisted electric vehicle charging station model considering differential pricing https://onlinelibrary.wiley.com/doi/10.1002/est2.237

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17 APPENDIX

17.1 Annexure A: Cross Reference Standards

International Standards	Corresponding Sri Lanka Standards
IEC 61851 Electric Vehicle Conductive Charging System Part 1: 2017 COR-2023 General Requirements	**SLS 1801** Electric Vehicle Conductive Charging System Part 1: 2024 COR-2023 General Requirements
IEC 61851 Electric Vehicle Conductive Charging System Part 1-1: 2023 Specific requirements for electric vehicle conductive charging system using type 4 vehicle coupler	**SLS 1801** Electric Vehicle Conductive Charging System Part 1-1: 2024 Specific requirements for electric vehicle conductive charging system using type 4 vehicle coupler
IEC 61851 Electric Vehicle Conductive Charging System Part 21-1: 2017 Electric vehicle on-board charger EMC requirements for conductive connection to an AC/DC supply	**SLS 1801** Electric Vehicle Conductive Charging System Part 21-1: 2024 Electric vehicle on-board charger EMC requirements for conductive connection to an AC/DC supply
IEC 61851 Electric Vehicle Conductive Charging System Part 21-2: 2018 Electric vehicle requirements for conductive connection to an AC/DC supply	**SLS 1801** Electric Vehicle Conductive Charging System Part 21-2: 2024 Electric vehicle requirements for conductive connection to an AC/DC supply
IEC 61851 Electric Vehicle Conductive Charging System Part 23: 2014 DC electric vehicle charging station	**SLS 1801** Electric Vehicle Conductive Charging System Part 23: 2024 DC electric vehicle charging station
IEC 61851 Electric Vehicle Conductive Charging System Part 24: 2014 Digital communication between a DC EV charging station and an electric vehicle for control of DC charging	**SLS 1801** Electric Vehicle Conductive Charging System Part 24: 2024 Digital communication between a DC EV charging station and an electric vehicle for control of DC charging

IEC 61851 Electric Vehicle Conductive Charging System Part 25: 2020 DC EV supply equipment where protection relies on electrical separation	**SLS 1801** Electric Vehicle Conductive Charging System Part 25: 2024 DC EV supply equipment where protection relies on electrical separation
IEC 62196 Plugs, socket-outlets, vehicle connectors and vehicle inlets Part 1: 2022 General Requirements	**SLS 1802** Plugs, socket-outlets, vehicle connectors and vehicle inlets Part 1: 2024 General Requirements
IEC 62196 Plugs, socket-outlets, vehicle connectors and vehicle inlets Part 2: 2022 Dimensional compatibility requirements for AC pin and contact-tube accessories	**SLS 1802** Plugs, socket-outlets, vehicle connectors and vehicle inlets Part 2: 2024 Dimensional compatibility requirements for AC pin and contact-tube accessories
IEC 62196 Plugs, socket-outlets, vehicle connectors and vehicle inlets Part 3: 2022 Dimensional compatibility requirements for DC and AC/DC pin and contact-tube vehicle couplers	**SLS 1802** Plugs, socket-outlets, vehicle connectors and vehicle inlets Part 3: 2024 Dimensional compatibility requirements for DC and AC/DC pin and contact-tube vehicle couplers
IEC 62196 Plugs, socket-outlets, vehicle connectors and vehicle inlets Part 3-1: 2020 Vehicle connector, vehicle inlet and cable assembly for DC charging intended to be used with a thermal management system	**SLS 1802** Plugs, socket-outlets, vehicle connectors and vehicle inlets Part 3-1: 2024 Vehicle connector, vehicle inlet and cable assembly for DC charging intended to be used with a thermal management system
IEC 62196 Plugs, socket-outlets, vehicle connectors and vehicle inlets Part 4: 2022 Dimensional compatibility and interchangeability requirements for DC pin and contact-tube accessories for Class II or Class III applications	**SLS 1802** Plugs, socket-outlets, vehicle connectors and vehicle inlets Part 4: 2024 Dimensional compatibility and interchangeability requirements for DC pin and contact-tube accessories for Class II or Class III applications

IEC 62196 Plugs, socket-outlets, vehicle connectors and vehicle inlets Part 6: 2022 Dimensional compatibility requirements for DC pin and contact-tube vehicle couplers intended to be used for DC EV supply equipment where protection relies on electrical separation	**SLS 1802** Plugs, socket-outlets, vehicle connectors and vehicle inlets Part 6: 2024 Dimensional compatibility requirements for DC pin and contact-tube vehicle couplers intended to be used for DC EV supply equipment where protection relies on electrical separation
IEC 61980 Electric Vehicle Wireless Power Transfer (WPT) systems Part 1: 2020 General Requirements	**SLS 1806** Electric Vehicle Wireless Power Transfer (WPT) systems Part 1: 2024 General Requirements
IEC 61980 Electric Vehicle Wireless Power Transfer (WPT) systems Part 2: 2023 Specific requirements for communication between electric road vehicle (EV) and infrastructure	**SLS 1806** Electric Vehicle Wireless Power Transfer (WPT) systems Part 2: 2024 Specific requirements for communication between electric road vehicle (EV) and infrastructure
IEC 61980 Electric Vehicle Wireless Power Transfer (WPT) systems Part 3: 2022 Specific requirements for the magnetic field wireless power transfer systems	**SLS 1806** Electric Vehicle Wireless Power Transfer (WPT) systems Part 3: 2024 Specific requirements for the magnetic field wireless power transfer systems
IEC 62576: 2018 - Electric double-layer capacitors for use in hybrid electric vehicles - Test methods for electrical characteristics	**SLS 1807**: 2024 - Electric double-layer capacitors for use in hybrid electric vehicles - Test methods for electrical characteristics
IEC 62840 Electric vehicle battery swap system Part 1: 2016 General and Guidance	**SLS 1808** Electric vehicle battery swap system Part 1: 2024 General and Guidance
IEC 62840 Electric vehicle battery swap system Part 2: 2016 Safety Requirements	**SLS 1808** Electric vehicle battery swap system Part 2: 2024 Safety Requirements
IEC 62840 Electric vehicle battery swap system Part 3: 2021 Particular safety and interoperability requirements for battery swap systems operating with removable RESS/battery systems	**SLS 1808** Electric vehicle battery swap system Part 3: 2024 Particular safety and interoperability requirements for battery swap systems operating with removable RESS/battery systems

IEC 62893 Charging cables for electric vehicles for rated voltages up to and including 0.6/1 kV Part 1: 2017 + AMD 2020General Requirements	**SLS 1809** Charging cables for electric vehicles for rated voltages up to and including 0.6/1 kV Part 1: 2024 + AMD 2020 General Requirements
IEC 62893 Charging cables for electric vehicles for rated voltages up to and including 0.6/1 kV Part 2: 2017 Test Methods	**SLS 1809** Charging cables for electric vehicles for rated voltages up to and including 0.6/1 kV Part 2: 2024 Test Methods
IEC 62893 Charging cables for electric vehicles for rated voltages up to and including 0.6/1 kV Part 3: 2017 Cables for AC charging according to modes 1, 2 and 3 of IEC 61851-1 of rated voltages up to and including 450/750 V	**SLS 1809** Charging cables for electric vehicles for rated voltages up to and including 0.6/1 kV Part 3: 2024 Cables for AC charging according to modes 1, 2 and 3 of IEC 61851-1 of rated voltages up to and including 450/750 V
IEC 62893 Charging cables for electric vehicles for rated voltages up to and including 0.6/1 kV Part 4-1: 2020 Cables for DC charging according to mode 4 of IEC 61851-1 - DC charging without use of a thermal management system	**SLS 1809** Charging cables for electric vehicles for rated voltages up to and including 0.6/1 kV Part 4-1: 2024 Cables for DC charging according to mode 4 of IEC 61851-1 - DC charging without use of a thermal management system
IEC 62893 Charging cables for electric vehicles for rated voltages up to and including 0.6/1 kV Part 4-2: 2021 Cables for DC charging according to mode 4 of IEC 61851-1 - Cables intended to be used with a thermal management system	**SLS 1809** Charging cables for electric vehicles for rated voltages up to and including 0.6/1 kV Part 4-2: 2024 Cables for DC charging according to mode 4 of IEC 61851-1 - Cables intended to be used with a thermal management system
IEC 63110 Protocol for management of electric vehicles charging and discharging infrastructures Part 1: 2022 Basic definitions, use cases and architectures	**SLS IEC 63110** Protocol for management of electric vehicles charging and discharging infrastructures Part 1: 2024 Basic definitions, use cases and architectures
IEC 63119 Information exchange for electric vehicle charging roaming service Part 1: 2019 General	**SLS IEC 63119** IEC 63119 Information exchange for electric vehicle charging roaming service Part 1: 2024 General

IEC 63119 Information exchange for electric vehicle charging roaming service Part 2: 2022 Use Cases	**SLS IEC 63119** Information exchange for electric vehicle charging roaming service Part 2: 2024 Use Cases
IEC PAS 63454: 2022 Conductive charging of electric vehicles – DC vehicle coupler configuration GG	**SLS 1811**: 2024 Conductive charging of electric vehicles – DC vehicle coupler configuration GG
ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 1: 2019 General Information and use case definition	SLS ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 1: 2024 General Information and use case definition
ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 2: 2014 Network and application protocol requirements	SLS ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 2: 2024 Network and application protocol requirements
ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 3: 2015 Physical and data link layer requirements	SLS ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 3: 2024 Physical and data link layer requirements
ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 4: 2018 Network and application protocol conformance test	SLS ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 4: 2024 Network and application protocol conformance test
ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 5: 2018 Physical and data link layer conformance test	SLS ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 5: 2024 Physical and data link layer conformance test
ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 8: 2020 Physical and data link layer requirements for wireless communication	SLS ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 8: 2024 Physical and data link layer requirements for wireless communication

ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 9: 2022 Physical and data link layer conformance test for wireless communication	SLS ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 9: 2024 Physical and data link layer conformance test for wireless communication
ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 20: 2022 2nd Generation network layer and application layer requirements	SLS ISO 15118 Road Vehicles - Vehicle to grid communication interface Part 20: 2024 2nd Generation network layer and application layer requirements