Technical Guideline

CHARGING INFRASTRUCTURE ELECTROMOBILITY

Version 4

DKE VDE DIN · VDE FNN · bdew Energie. Wasser. Leben. · ZVEH · ZVEI: Die Elektroindustrie · VDA Verband der Automobilindustrie

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01 Technical Guideline Charging Infrastructure

1.1. Motivation for Version 4

This present revision of the technical guideline on charging infrastructure takes into account the technological progress and ongoing developments in the field of electromobility.

Since the publication of the last edition, among other things charging technology has continued to develop, but also the issuance of new application rules and guidelines as well as further development of norms and standards make it necessary to adapt the guide.

Particularly relevant is the Charging Column Ordinance (LSV) issued by the German Federal Ministry of Economics and Technology (BMWi) in 2016, which was last updated in 2021. It sets out standardized legal requirements for the technology and positioning of charging stations in public spaces, as well as minimum requirements for the payment system used.

The updated requirements are supplemented by the VDE application rule VDE-AR-E 2532-100, the aim of which is, to ensure that the minimum standards applicable from July 2023 can be met with the highest possible level of safety. For this purpose, the application rule specifies uniform standards for the handling authentication and billing processes at charging stations and defines the minimum requirements for reliable and data-protection-compliant systems for recognizing and authorization at charging stations.

In line with the changed technical as well as legal framework conditions, the application examples for public and private charging infrastructures have been adapted and expanded. The German government's draft for a Building Electric Mobility Infrastructure Law (GEIG) also comes into play here. This implements a requirement of the EU Buildings Directive for the construction of charging and line infrastructure for electromobility in buildings and stipulates the installation of protective pipes from a certain number of parking spaces.

The technical developments in the field of inductive charging are also considered in the revised Technical Guide. The outlook also includes for the first time the solutions currently being developed for charging heavy electric commercial vehicles.

A userfriendly, safe, comprehensive and efficient charging infrastructure has a considerable influence on the reliable charging of electric vehicles and represents one of the basic prerequisites for the greater acceptance of electric mobility.

1.2. Target groups

This guideline is primarily aimed at the following target groups:

- Home owners and real estate owners
- Property managers and parking garage operators
- Architects and urban planners
- Public administration employees
- Network operators and energy suppliers
- Electrical planners and installers

The latter two assume a service provider role in relation to the other target groups. Investors, urban planners and operators, for example, request services, while network operators and energy suppliers, as well as electrical planners and installers, can fulfill these requirements.

This guideline shows what is necessary for the expert planning, construction and operation of a charging infrastructure and advises on how to avoid dangers or costly misinvestments. It provides an overview of important standards and regulations to be observed, but only serves as a recommendation and does not replace the support of qualified personnel (e.g. electrically skilled personnel)

Information for end users can be found in the HEA guidelines "Ladeninfrastruktur in Wohngebäuden" (Charging infrastructure in residential buildings)

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(only available in German)

1.3. Standards and their impact

Norms, guidelines and standards open the market for electromobility and pave the way for its rapid further development towards a mobility concept suitable for mass use for the foreseeable future. The standards form the basis for the implementation of future innovations in the field of electromobility.

Standards offer investors a high degree of security for their investments in electric vehicles and especially in charging infrastructure. The standards create a framework within which solutions for important future topics can be established. Additionally, they promote and accelerate development processes and strengthen innovation.

Standardization lays the foundation for the end-to-end interoperability of the different trades involved in electromobility. From the user's point of view, this ensures unrestricted, convenient and safe access to the technologies - no matter where they want to charge their electric vehicle.

Last but not least, standards ensure a consistently high level of quality and, in the long term, ensure reductions in production costs due to economies of scale.

The figure below contains an overview of relevant norms and standards in the field of charging of electric vehicles.

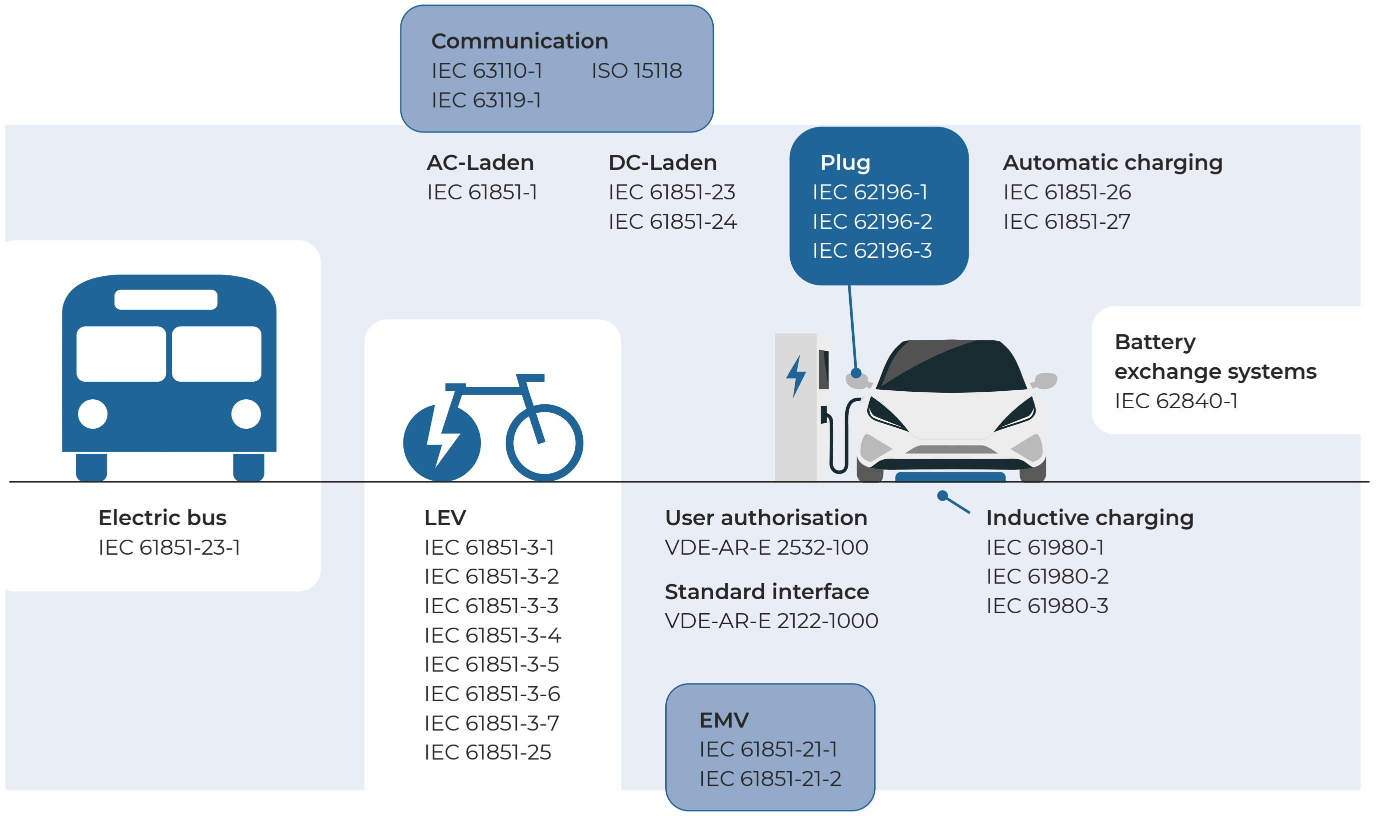

Figure 1: Overview of relevant norms and standards in the field of charging of electric vehicles.

1.4. Thematic delimitation

The range of electric vehicles available on the market and those expected in the future is much wider than can be illustrated in this guideline. Accordingly, this document is limited to passenger cars and commercial vehicles approved for participation in public road traffic with a battery as an energy storage device, so-called "Battery Electric Vehicles" - BEV for short - and "Plugin Hybrid Electric Vehicles" - PHEV for short. to the vehicle groups of the so-called "Battery Electric Vehicles" - BEV for short - and "Plug-in Hybrid Electric Vehicles" - PHEV for short. Both concepts are characterized by the option of charging the vehicle either with wires or wirelessly via the electrical power supply system designed for this purpose.

Other important vehicle groups with electric drives which will not be discussed in detail below are:

- Buses
- Commercial vehicles
- Scooters
- Pedelecs and e-bikes

BEVs draw their operating energy from the vehicle battery, which supplies one or more electric motors as the sole source of propulsion.

PHEVs are a special form of hybrid vehicles, characterized by the implementation of combustion engines and electric motors. What distinguishes these from other hybrids is the charging interface, which enables the traction battery to be charged while stationary.

02 Charging

There are various options available for supplying electric vehicles with electrical energy from the alternating current system:

In conductive charging with **alternating current (AC charging)**, the electrical energy from the alternating current system is first transferred to the vehicle in usually one or three phases. The charger installed in the vehicle performs the rectification and controls the charging of the battery. In most cases, the vehicle is connected to the AC system via a suitable power source, e.g. an AC charging station or AC wall box. Charging is usually controlled via a simple communication interface between the vehicle and the charging station (in future ISO 15118).

Charging with direct current (DC charging) requires a connection between the vehicle and the charging station via a charging cable, whereby the charger is integrated in the charging station. Charging is controlled via a special communications interface between the vehicle and the charging station. Conductive charging is also commonly referred to as wired charging at present.

With **inductive charging**, energy is transferred using the transformer principle. Standards now also exist for this technology.

Information on the implementation of this standard can be found in the "Roadmap for the implementation of ISO 15118 - Standardized communication between vehicle and charging point".

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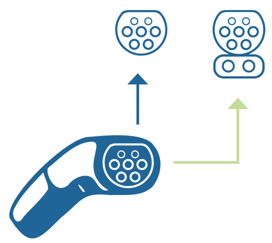
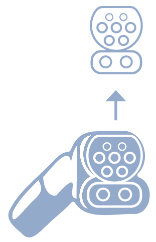
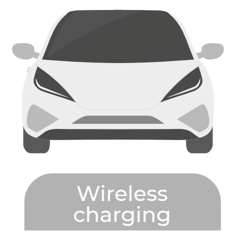
Table 1: Vehicle-side couplers for charging electric vehicles (according to definition as per EU directive)

	AC charging	DC charging	Inductive charging
Normal charging	3,7 kW 7.4 kW 11 kW 22 kW	10 kW 20 kW	3,7 kW 7.4 kW 11 kW 22 kW
Fast charging	44 kW	50 kW	
High-power charging		150 kW 350 kW 450 kW	
	TYP 2 Combo 2 	Combo 2 	Coil 

© VDE FNN Or minimum standard as per charging column ordinance

2.1. Normal charging and fast charging

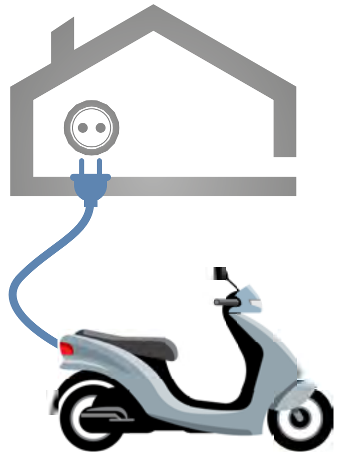
The definitions for normal and fast charging are defined in EU Directive 2014 / 94 / EU "Deployment of alternative fuels infrastructure" and refers to the charging power applied during the charging process.

For example, all charging processes with a charging capacity of up to 22 kW are classified as normal charging, charging processes with higher capacities are called fast charging.

These classifications are shown in Table 1. In addition to the classic DC charging stations with outputs from 50 kW upwards, smaller DC wall boxes with outputs of 10-20 kW are increasingly being considered.

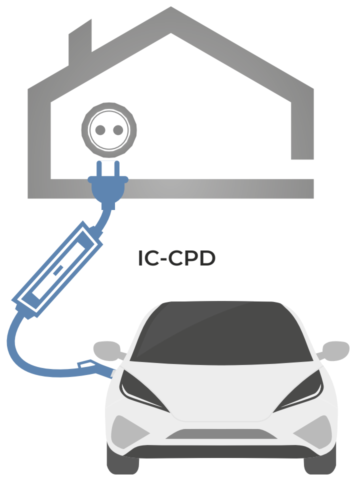
2.2. Charging modes

Wired charging of electric vehicles (including pedelecs, e bikes, etc.) can be done using the different charging modes defined in the system standard DIN EN 61851-1. This charging modes also include charging devices that are not permanently connected to the installation.



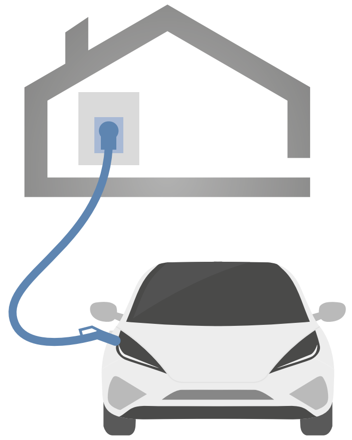
2.2.1 Charging mode 1 (mode 1)

This charging mode describes charging with alternating current at a standard national house hold socket ("earthed socket") or a single or three-phase industrial socket (e.g. "CEE socket") without communication between the vehicle and the infrastructure (see warnings in 3.4.2). It is only supported by manufacturers of LEVs (Light Electric Vehicles) and the presence of a residual current device in the existing infrastructure is recommended.



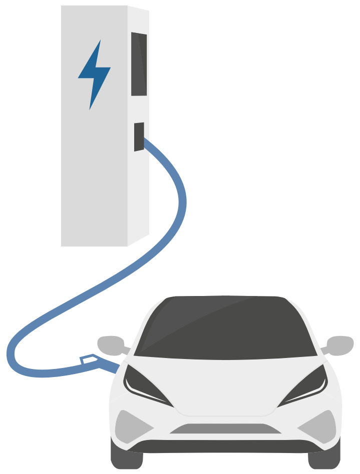
2.2.2 Charging mode 2 (mode 2)

As with charging mode 1, household sockets or industrial sockets with alternating current can be used in this charging mode on the infrastructure side. In contrast to the previous mode, there is a control and protection device ("In Cable Control and Protection Device" ICC PD) in the charging cable of the vehicle. It provides protection against electric shock in the event of insulation faults if the customer connects the vehicle to a socket that was not intended for charging electric vehicles when installed. A pilot signal is used to exchange information and monitor the protective earth connection between the IC CPD and the vehicle. For new installations, changes and expansions of electrical systems, a residual current device shall be installed in the infrastructure. This shall be taken into account when creating charging points for this charging mode. Furthermore, the current carrying capacity of the socket and the wiring installation behind it must be taken into account, which is often not designed for a permanent load.



2.2.3 Charging mode 3 (mode 3)

Charging mode 3 is used for single-phase or three-phase charging with alternating current for permanently installed charging stations (so-called wallboxes). The safety functionality including a residual current device is integrated into the overall installation, meaning that only one charging line with a dedicated connector is required. Often, there is also a charging line permanently connected to the charging station. The infrastructure and vehicle communicate via the charging line (see 6.3.1). In this charging mode, the connectors are interlocked on both sides of the charging line, thus avoiding pulling under load. For charging with alternating current, this charging mode is preferable to charging modes 1 and 2.



2.2.4 Charging mode 4 (mode 4)

Charging mode 4 is intended for charging with direct current (DC charging) at permanently installed charging stations. The charging line is always firmly connected to the charging stations. In contrast to the other charging modes with alternating current, the charger is integrated into the charging station. As in charging mode 3, the charging station and vehicle communicate via the charging line. The connector is also locked in accordance with charging mode 3.

2.2.5 Communication between the vehicle and charging station

In charging modes 2, 3 and 4 there is always a basic communication ("Low Level") between the charging station (for charging modes 2 of the IC-CPD) and the vehicle, via which information about the basic operating states is exchanged.

Additional communication in accordance with the ISO 15118 standard is also possible in charging mode 3. If charging mode 4 is used in conjunction with the "Combined Charging System", extended communication ("High Level") is always required. DIN SPEC 70121 will be successively replaced by ISO 151181.

Communication in accordance with ISO 15118 enables the exchange of numerous data with the charging station, such as information on energy requirements, the planned duration of the charging process and information on prices and billing. These options should also be taken into account for charging mode 3 during the selection of charging technology when establishing new charging stations.

Charging modes 3 and 4 are based on an infrastructure special-

Charging points with charging modes 3 and 4 are recommended for new constructions, since current and future passenger cars and light commercial vehicles generally support charging mode 3 for AC charging and, if necessary, charging mode 4 for DC charging.

ly built for electric vehicles and offer a high degree of electrical safety (personal protection) and protection in case of overcurrent (system protection). The charging connectors are locked in all charging modes. This provides additional protection against being touched and manipulated by third parties.

For publicly accessible charging stations for alternating current charging, the LSV mandates that a type 2 connector be used in accordance with EN 62196, as well as a Combo-2-connector for charging with direct currents. The latter is based on the Type 2 plug pin assignment but requires special vehicle couplings with two additional DC poles.

2.3. Combined Charging System

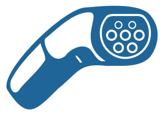
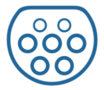
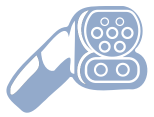
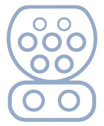
The Combined Charging System (CCS) is an EV charging system based on the international standards IEC 61851 1, IEC 61851 23, Annex CC and IEC 61851 24 for the charging device and on the standards for charging connectors according to IEC 62196 (FF configuration only). The on-board CCS connection combines three-phase alternating current charging (max. 44 kW) with the possibility of rapid direct current charging in a single system. Depending on the vehicle equipment and charging device, charging currents of up to 500 A can be achieved. As a system, the CCS includes the connectors as well as the control functions and the communication between the electric vehicle and the infrastructure and offers the solutions for all necessary charging scenarios (see National Platform Mobility Charging Use Cases). The extended communication intended for DC charging with CCS is based on DIN SPEC 70121 or ISO 15118. On the vehicle side, electrical safety is specified by ISO 17409.

The CCS offers the following option for permanently installed charging stations:

- Charging in charging mode 3: AC charging with the type 2 plug in accordance with the IEC 62196 2 standard in combination with communication between the vehicle and the charging device according to the pilot signal in accordance with IEC 61851 1 Annex A and ISO 15118 (optionally).
- Charging in charging mode 4: DC charging in accordance with the IEC 61851 23 Annex CC standard with the Combo 2 plug in accordance with the IEC 62196 3 standard (FF configuration) in conjunction with communication between the vehicle and the charging device based on DIN SPEC 70121 or, in future, ISO 15118.

The following image shows an overview of the system's on-board couplers:

Table 2: Combined Charging System – a system for AC and DC charging

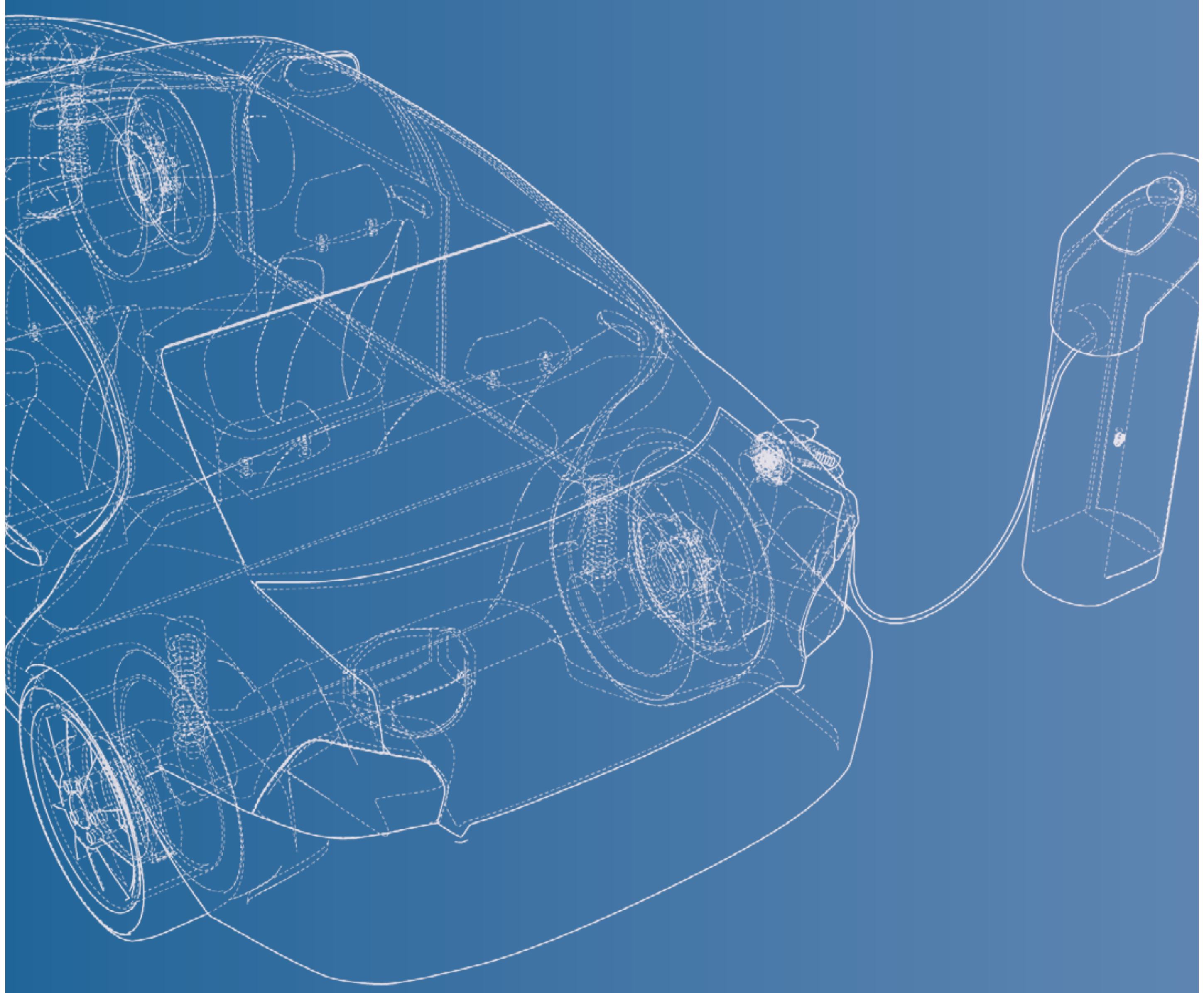
Charging	Functions	Plug	Communication	Charging
AC 1 or 3-phase	1-phase AC charging/ 3-phase AC charging with plug Type 2 IEC 62196 2	Type 2 	ISO 15118	
DC	DC charging with plug Combo 2 IEC 62196 3	Combo 2 	ISO 15118 DIN SPEC 70121	

With CCS, a charging system has been developed and standardized that fulfills all the prerequisites for achieving a uniform, user-friendly and high-performance charging infrastructure. Its interoperability especially predestines the system for use in publicly accessible areas. Furthermore, the system already meets the requirements higher charging capacities. For this reason, the National Platform Future of Mobility (NPM) recommends that the infrastructure be expanded as quickly as possible to conform to CCS.

It should be noted that not all charging stations and not all vehicles support all the options described above. DC charging currents above 200 A require special thermal management. The charging cables used are actively cooled at high charging powers. Charging stations have their own cooling units for this purpose.

For example, if a vehicle is equipped with a Combo 2 charging socket, it is always generally always possible to connect to AC type 2 and DC Combo 2 charging points. The maximum charging capacities depend on the respective equipment and are automatically adjusted between the charging device and the vehicle.

The establishment of a charging infrastructure with CCS based on international standards ensures interoperability for charging electric vehicles in Europe.



03 Planning

3.1. Demand for power input

The correct dimensioning of the power input is the basic requirement for safe and reliable operation. The planning process shall therefore consider

- The **type and number of vehicles** to be expected for this **location**,
- The **charging capacity** of the vehicles to be connected,
- The expected average **parking time** and
- The **charging behavior** of the vehicle owner
- In addition, **Load management** can be used to reduce the demand for power input.

The variability of these influencing factors is very high and makes it difficult to set guideline values for the number of charging points and the capacity to be installed.

3.1.1. Determination of the charging capacity and number of charging points

Single phase AC charging is the lowest common denominator for charging electric vehicles. According to VDE-AR-N 4100 and most of the Technical Connection Conditions (TAB) valid in Germany, single-phase charging up to 4.6 kVA is generally permissible; in individual cases, the distribution network operators may stipulate different requirements. For higher charging capacities, three-phase AC- or DC-charging shall be used.

The combined charging system supports charging currents of up to 500 A. The charging capacity depends on the vehicle-specific charging voltage. The first series-produced vehicles that can be charged at 800 V will thus achieve charging capacities of 300 kW and more. Depending on the number of charging points, the necessary AC power inputs can be in the range of several MW and requires the expansion of the existing infrastructure. In order to reduce investments on the grid side and to avoid load peaks, the combination with stationary battery storage systems is an option. These plants are planned and operated on an industrial scale.

It is expected that many of the charging stations available will be based on the above-mentioned grading of the power inputs.

The following table illustrates the relationships between charging technology and potential charging capacity:

Table 3: Current typical values when charging electric vehicles

Vehicles	Charging technology	Charging capacity (kW)	Charging current (A)	Charging infrastucture grid connection
	AC 1-phase	Up to 3,7	Up to 16	AC, 1-phase 230 V, 16 A
	AC 3-phase	Up to 22	Up to 32	AC, 3-phase 400 V 3 x 32 A
	DC	Up to 150	Up to 200	AC, 3-phase 400 V 3 x 125 A
BEV und PHEV electric vehicles	HPC	Up to 350	Up to 500	AC, 3-phase 400 V 3 x 125 A

The expected average daily mileage can give an indication of the charging capacity required.

The charging time of an electric vehicle's battery depends on, among other things, the charging power available from the infrastructure. Particularly in electric vehicles with larger battery capacities or fast-charging batteries, a significantly reduced charging time can be achieved by three-phase AC charging or DC charging with greater power.

For each charging station, it shall be determined how many charging points are to be made available and whether they are to be operated at full power at the same time.

3.1.2. Load management

As an alternative or in addition to reinforcing the grid connection, what is known as a power management system can be used. With such a power management system, various parameters of the charging processes, such as the maximum power or the prioritization of charging processes, can be defined. Power management can help to avoid or reduce cost-intensive load peaks, especially in larger properties or avoid a necessary grid expansion or increased grid connection. If several charging processes are running simultaneously, the use of a power management system prevents the electrical installation from being overloaded.

A power management system leads to a reduction of simultaneous power peaks, meaning that the requirements for the installation's dimensioning can be reduced. Power management is particularly useful for buildings with multiple users, such as for the underground car park of an apartment building. This does away with the need for an expensive grid connection and the electrical installation design that allows for power peaks, as these are rarely required.

Power management is particularly useful in the case of connections that are not only billed according to the amount of energy delivered, but also according to the maximum power requirement (power and labor price), (mandatory for an purchase > 100 000 kWh/a). This can stop electric vehicles from charging at a time when the other uncontrolled consumers are already causing a power peak. Instead, electric vehicles should charge when the load from the uncontrolled consumers is low. Depending on the number of and power requirements of the electric vehicles, it may also make sense for not all vehicles to be charged at the same time and collectively exhibit a high load peak.

Network operators offer reduced network fees for charging stations if they are registered as controllable consumption facilities (see Section 14a EnWG). Details shall be agreed with the network operator. The registration is often done by the electrician personally.

Power management can also be implemented to improve the use of renewable energies. If necessary, integration into a home energy management system (HEMS) to integrate all relevant devices and systems (using an overarching communication standard such as EEBUS) should be provided for, among other things, self-use of solar power.

The simultaneity factor shows how many electrical consumers are operated simultaneously at full power in a household or circuit. It is calculated using the power budget of all consumers that are to be considered and means a statement can be made about the total power input required.

Example:

If, for example, the sum of the outputs of all consumers installed in a single-family house is 25 kW and a simultaneity factor of 0.5 is applied, a total power input of at least 12.5 kW would need to be provided.

Value-added services such as dynamic power or energy management can be offered as additional services. This requires connections to the corresponding service providers (charging station operators, metering point operators, electricity distribution, etc.) via the backend. For planners / installers, this results in the need to provide suitable network connections.

In certain commercial and industrial areas, charging stations are not permitted for fire protection reasons. This predominantly applies to operating facilities that have fire hazards, as per DIN VDE 0100-420, as well as explosive areas or areas with explosion hazards. The garage regulations of the respective federal state shall also be observed when installing charging stations. These regulations indicate the rooms in which motor vehicles may not be parked.

3.2. Arrangements for metering and value added services

For the operation of a complex charging infrastructure, it is recommended that appropriate measures for recording consumption are already provided for in the planning stage. The requirements of the Measurement and Verification Act (MessEG) and the Measurement and Verification Ordinance (MessEV) must be taken into account for charging processes that are brought to billing.

Various functions of the charging infrastructure, such as authentication, transmission of the charging point status, transmission of meter reading and billing information or power management, require access to a so-called backend, i.e. a downstream network structure such as a database server on which the information is stored or from which it can be retrieved.

3.3. Installation location

The location shall be selected in such a way that all actions involved in charging are always safe. It shall be possible to connect the vehicle without using extension leads or cable drums. The charging station shall therefore be installed in the immediate vicinity of the parking areas to be supplied with power, but shall not pose a hazard to persons or vehicles. Details about installation locations in public and semi-public areas should be coordinated with municipal concepts for electromobility and charging infrastructure at an early stage. This provides an opportunity for suitable contact persons in the municipal administration to be identified; these persons are often part of building, urban planning, transport or environmental authorities. The type of the charging station installation - free-standing as a charging column or wall-mounted as a "wallbox" - should be determined in advance. Stability of the entire structure shall be ensured. The nature of the structures to which the charging station will be attached shall be taken into account (e.g. wall thickness and material).

The type and dimensions of the charging station should be selected to suit the environment. Adequate lighting shall be provided at the place of operation. Depending on the installation site and the type of use, the charging station shall meet requirements with regard to environmental factors: mechanical strength (impact protection, vandalism, graffiti), weather resistance (suitable protection type, operating temperature range), UV light resistance, corrosion resistance, vibrations.

3.4. Electrical installation

Despite the same basic principle, there are important differences between classical electrical consumers in the household and supplying an electric vehicle with electrical energy. These differences very quickly highlight the need for thorough planning and generous design:

while no special precautions need to be taken when operating a washing machine, for example, the special requirements of the charging process shall be taken into account when charging an electric vehicle. Although the washing machine also has a high power consumption, it only uses this potential for a comparatively short period of time (to heat up the water).

With electric vehicles, a very high electrical output is used for the duration of the charging process - sometimes for several hours. Consequently, the charging infrastructure shall be designed accordingly.

Safe recharging over several hours while unattended shall always be possible, not only in private, but also in publicly accessible areas.

3.4.1. Grid connection

The potential of a domestic connection can be exhausted if charging several electric vehicles simultaneously. Therefore, when a charging station is connected, the domestic connection shall be checked to verify it can supply the level of power required for simultaneous charging. It may be necessary to strengthen or expand the domestic connection to supply power to electric vehicles, although this measure is preferable to installing a power management system (see 3.1.2). The network operator receives the necessary information through the application for commissioning of the electrician. For charging stations with a capacity of more than 12 kVA, the NAV and VDE-AR-N 4100, as well as the Technical Connection Conditions (TAB) require approval by the network operator and a data sheet for the charging device, as well as a commissioning notification. In addition, a control interface (see VDE-AR-N 4100 chapter 10.6.4) shall be provided from 12 kVA upwards. In addition, VDE AR N 4100 mandates compliance with the symmetry requirement (asymmetrical load <4.6 kVA) .

The requirements of VDE-application-rule VDE-AR-N 4100 shall be taken into account in the low voltage grid, both for directly connecting charging stations to the public distribution grid and

VDE-AR-N 4100 "Technische Anschlussregeln Niederspannung" (Technical low voltage connection rules) regulates the technical connection conditions and deals with the special requirements of electromobility.

For charging infrastructures with outputs of ≥ 3.6 kVA and under 12 kVA, the network operator shall be notified. It should be noted that even with a relatively small number of smaller capacity systems, the total capacity limit for the local power supply of 12 kVA can quickly be exceeded and, in addition to the obligation to register, the network operators shall give their approval. Therefore, in order to avoid successive, unnoticed overloads, the demand that could arise in the future when designing the local installations shall be carefully considered. The residential location or the expected clientele, as well as the urban development of the municipality, can give an indication of this. Generous dimensioning of the corresponding supply lines, distributors and other components from the outset can avoid high consequential costs of later aftermarket installation or conversion.

in residential and commercial areas. Depending on the power input of the charging device to be installed and the planned use, measures shall be taken regarding the power supply. The registration of the changed grid connection ratio is carried out by the executing electrically skilled person or the electrical company.

The following documents are relevant for the grid connection:

- VDE-AR-N 4100
- VDE-AR-N 4110
- TAB
- NAV
- FNN Hinweis Netzintegration Elektromobilität (FNN Notes on grid integration electric mobility)

Clickable QR code (only available in German)

3.4.2. New installations and aftermarket installation

When planning new builds or conversions, it should be kept in mind that a significant increase in sales of electric vehicles is expected. Depending on the location and usage group of a property, the demand for charging infrastructures can therefore increase significantly very quickly. DIN 18015-1 is the basis for the planning of electrical installations in residential buildings. It makes provision for a supply line for a charging device, designed for a continuous current carrying capacity of 32 A, from the main distribution board or meter cabinet to the charging station. In order to avoid considerable follow-up costs, it is advisable to provide at least one appropriate conduit to accommodate such a line already when planning new buildings. Furthermore, a separate conduit for a communication line, e.g. a network line to the charging station, is to be laid in order to connect the charging station to the intelligent house or power management for future applications.

In large properties, it shall also be considered whether each parking space should have battery charging directly connected to the respective billing measurement. Alternatively, central charging stations can be provided, which are set up, operated or billed by service providers.

Unlike new installations, existing electrical installations were generally not designed to charge electric vehicles. For this reason, charging using untested installations can be dangerous. This applies not only to the charging process from the charging device, but also to the upstream installation. Here, it is important to avoid overloads and thus the risk of fire or impairment of the existing residual current devices' function.

It is therefore recommended to have the existing electrical installation checked for the new requirements before such use (for example, with the E-CHECK). DIN VDE 0100-722 describes the special requirements for the installation of circuits for the power supply of electric vehicles as well as their regenerative power supply. Among other things, a separate final circuit with a separate fuse and residual current device is required for each charging point. A simultaneity factor of 1 shall be assumed for the fuse and residual current device if no power management is available. If no residual current device is installed on the charging infrastructure side, it shall be retrofitted. Please note that it shall be suitable for charging electric vehicles.

As mentioned in Section 3.1.2 "Power management", the simultaneity factor of a distribution circuit supplying several charging points can be reduced if power management is implemented.

Even in the case of new installations and extensions of existing systems, an electrician should be informed about the intended use (for charging electric vehicles).

It is therefore recommended to install operating modes 3 or 4. These offer application security and convenience.

3.4.3. Notes on the setting up the system

The charging infrastructure for electromobility is part of the energy systems or electrical equipment. Energy installations shall be constructed and operated in such a way to guarantee technical safety. Subject to other legal provisions, the generally recognized rules of technology shall be observed (cf. Section 49 EnWG). This also includes extending, changing and maintenance. It is assumed that these requirements are met if the technical rules of the VDE have been observed. This means that compliance with the VDE standards during construction, expansion, modification and maintenance is of particular importance for safety and functionality, but also for legal protection.

The installation of a charging station permanently connected to the grid for charging modes 3 and 4 or the installation of a protective contact or industrial socket for charging modes 1 and 2 in an existing infrastructure represents an extension of the electrical system. When integrating charging stations into existing electrical systems in particular, the installation conditions shall be checked in advance by a qualified electrician. For new installations and extensions, VDE-AR-N 4100 and VDE 0100-722, among others, shall be observed. Furthermore, the availability of the power input shall be clarified with the network operator.

The electrical installation of a house is designed for the requirements at the time of construction. For this reason, existing installations may not be suitable for high-power charging over longer periods of time. It is therefore recommended to have existing installations checked by a registered electrically skilled person before connecting electric vehicles and, if necessary, to have them upgraded accordingly.

Sockets with earthing contacts are designed in accordance with DIN VDE 0620-1 for domestic use and similar applications and can only be energized with the maximum rated current of 16 A for limited periods of time and are therefore not suitable for permanent charging electric vehicles. When charging electric vehicles for several hours, increased resistance in the circuit can occur due to aging processes of the contacts, at terminal points in the supply line or due to improper installation. This results in an increased fire hazard as a result of impermissible heating - this is called "hotspot".

If charging stations are planned in commercial and industrial areas or in garages with a floor space of 100 m² or more, any existing regional regulations, such as the state building code and the information on property protection from the "Publication of German insurers on loss prevention - Charging stations for electric road vehicles" (VdS 3471) must be taken into account. This shall be coordinated with the fire protection authority, building authority and insurer.

In the LSV published at the time of creating this guideline, a notification to the regulatory authority is required for publicly accessible charging stations. For the couplers of the charging points, it is recommended to use type 2 AC sockets in accordance with DIN EN 62196 2 or Combo 2 DC vehicle couplings in accordance with DIN EN 62196-3.

3.5. Lightning and surge protection

3.5.1 Surge protection requirements

If a charging device (e.g. wallbox, charging columns) is permanently installed, requirements for overvoltage protection must be observed. In DIN VDE 0100-722 (VDE 0100-722):2019-06 Section 443, surge protection against transient overvoltages is mandatory for publicly accessible connection points.

The measures for implementing this requirement are contained in DIN VDE 0100 534. A type 2 surge protective device (SPD type 2) is the minimum requirement for protecting the power supply connection. If the charging column is supplied from a building with an installed lightning protection system, a lightning current arrester (SPD type 1) or combined arrester (SPD type 1 and 2 with type 1, 2 and 3 protection) shall be used.

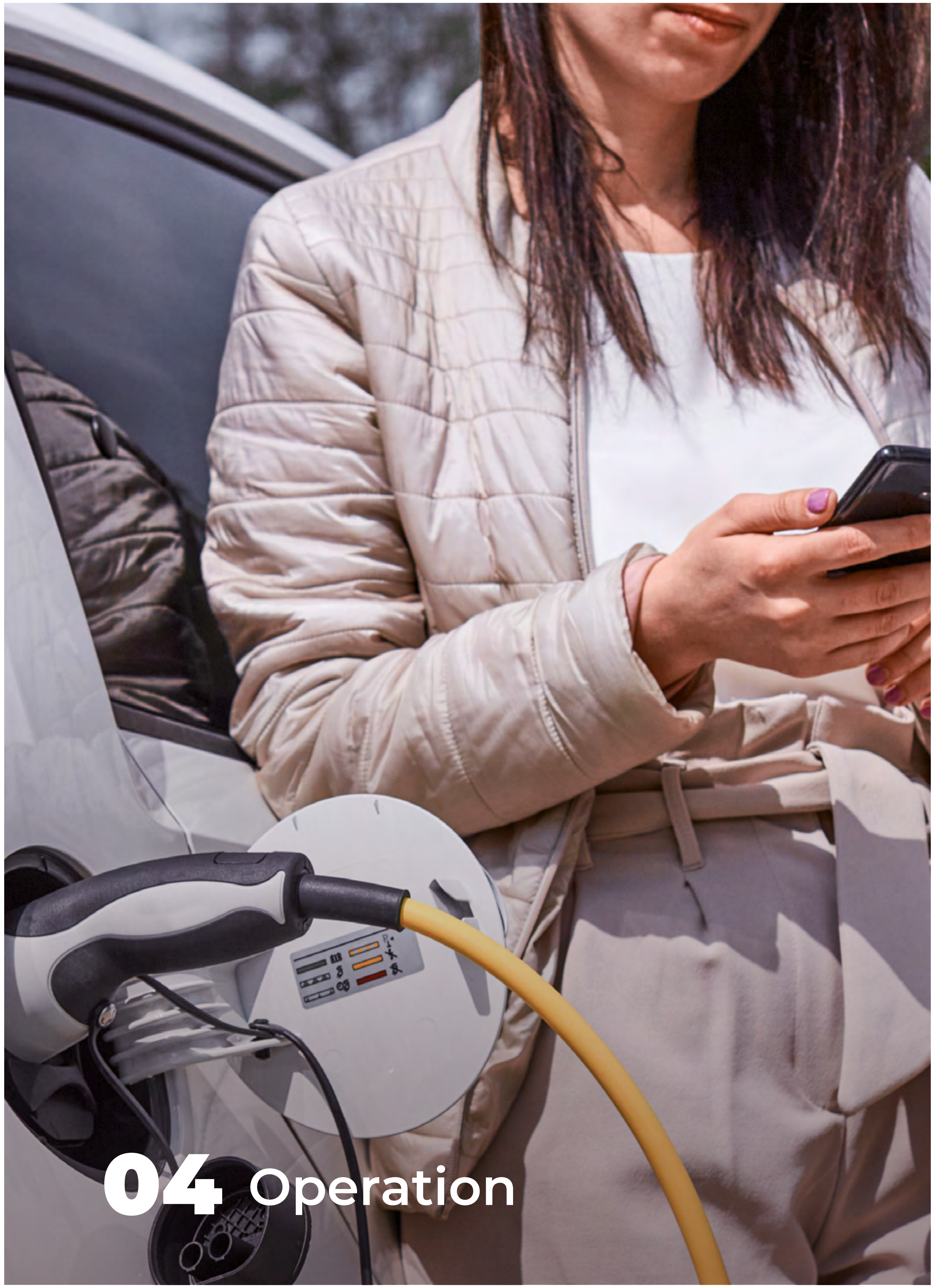
Publicly accessible charging columns are often also directly connected to the network of an energy supplier and fitted with a meter. In these cases, VDE-AR-N 4100 shall also be observed. Here, it makes sense to install the surge protection in the main power supply system before the meter. A lightning current arrester (SPD type 1) or combined arrester (SPD type 1 and 2 with type 1, 2 and 3 protection) shall be installed in this area. The requirements for SPDs of charging stations directly connected to the grid are contained in VDE-AR-N 4100.

In addition to the energy supply protection, the data transmission for the recording the consumption data shall be protected. The information technology connection is to be made with SPD Type 1 (D1 and C2) or SPD Type 2 (D1 and C2) in the same way as to the power connection.

3.6. Qualifications and right to perform

As per DIN VDE 1000-10, only electrically skilled persons may be entrusted with tasks relating to the assessment, planning, construction, expansion, modification and maintenance of charging infrastructure. The specifications of DGUV regulation 3, which are crucial for accident insurance, stipulate that the tradesperson shall have the relevant qualification for this type of work.

Additionally, under energy law, Section 13 of the Low Voltage Connection Ordinance (NAV) requires that the installation company be entered in the distribution system operator's register of installers for the construction, expansion, modification and maintenance of certain parts of an electrical system.



04 Operation

The following chapter specifically looks at the concerns and requirements for operating the charging infrastructure. In addition to the aspects mentioned in the previous section, other safety-related aspects after commissioning are discussed here. Additionally, this part of the guide contains extensive information on the handling of the systems as well as explanations on billing the charging cycles and the amount of energy supplied.

4.1. Safety

Even after the charging infrastructure has been commissioned, various specifications shall be observed from a safety point of view.

4.1.1 Instructions for using charging cables

Charging lines shall be handled with care and protected from mechanical damage. In the case of permanently installed charging lines, the operator of the charging station shall ensure the safety of the charging lines as part of their scope of responsibility. The charging line shall be checked by the user for visible damage before each use. Defective couplers and lines can no longer be used. After using the charging line and the couplers, these shall be placed in the designated receptacles or stowed in the vehicle

4.1.2 Fire protection

Special fire protection measures may be necessary in garages in commercial and industrial areas. Here, the local ordinances must be observed. These usually include that no highly flammable materials may be stored in the immediate vicinity of the loading area. In addition, the installation of fire alarm systems in commercial and industrial areas is recommended in order to be able to detect and fight a fire at an early stage. For safety reasons, the use of extension cables, multiple sockets, cable drums, travel adapters etc. is not recommended when using the charging infrastructure.

Regular checks ensure that the operational safety of the system can be maintained and that defects are recognized in good time.

4.1.3 Inspection

Regular testing of charging equipment is recommended and must be ensured in the area of publicly accessible and commercially used charging stations. The content of the tests and the test periods are derived from standards, manufacturer and installer instructions and, depending on the installation location and type of use, also from legal requirements (e.g. occupational safety and health and safety regulations) and the accident prevention regulations of professional associations (DGUV regulation 3).

4.1.4 Data protection / Data security

The implementation of measures for data security and the protection of personal data shall be carried out in accordance with legal requirements (including the Federal Data Protection Act BDSG, state data protection laws and the European Data Protection Convention).

4.2. Operation

4.2.1 Ergonomics

Questions of ergonomics and use can only be partially answered for the overall system, but not for the individual aspects.

The operating concept and the available status displays for any existing user authentication shall be user-friendly and support the user in all steps of a charging process. With publicly accessible charging stations, customer-friendly, non-discriminatory access shall be ensured.

Certain basic rules apply, some of which shall be implemented in the planning phase. Some example aspects that have to be considered from an ergonomic point of view are:

- Simple and intuitive operation
- Good legibility of any displays
- Good lighting and illumination of the charging area and the charging station
- Operability for left and right-handed people
- Good operability and accessibility for people with disabilities, such as wheelchair users or little people
- Generally understandable, reduced text if necessary
- Instructions for use
- Easy access to the controls even when the vehicle is parked

4.2.2 Access

Depending on the accessibility of the charging station, there are minimum requirements to be met. These are generally specified by Directive 2014/94 / EU dated October 22, 2014 on the development of the alternative fuels infrastructure. The Directive has been transposed into German law by the "Charging Column Ordinance (LSV)". According to the directive of the applies:

“All publicly available charging points shall also enable users of electric vehicles to charge their vehicles selectively, without having to enter into a contract with the electricity supply company or operator in question.”

Methods that allow ad hoc use shall be used. This means spontaneous and system-wide charging with a medium that provides access and, if necessary, the corresponding payment option at the charging station itself.

Possible authentication methods are:

- Telephone hotline
- Cash payments, money cards, debit cards
- RFID card, NFC device (according to VDE-AR-E 2532-100)
- Cell phone/SMS
- Smartphone app, internet
- Plug & Charge (according to ISO 15118)

For authentication before charging, displays and controls on the charging point or media such as smartphone apps and SMS can be used. Successful cases are already in use: Smartphone apps or RFID cards are examples of authentication methods currently in use. In the future, Plug & Charge (PnC) is expected to become more widespread, with automatic authentication between vehicle and charging station. This requires the implementation of the ISO 15118 series of standards.

4.2.3 Instructions

It shall be ensured that suitable instructions for installation, commissioning, operation and maintenance are available. The required instructions shall be made available to the respective groups of persons.

4.3. Billing and management

Depending on the installation location and type of use, it shall be specified whether the charging station is to be accessible exclusively to a closed user group or to the public. For the operation of a complex infrastructure, it is recommended that appropriate measures for the monitoring, evaluation and billing of charging cycles be provided for as early as the planning stage, especially as, among other things, the LSV sets specific requirements for publicly accessible charging infrastructures which can have a significant impact on the construction and design of the infrastructure. The facilities for these measures are called backend systems. Suitable interfaces between the charging stations and the backend are required.

Billing individual charging processes may be necessary for reasons related to the selected business model (e.g. accounting for electricity sold, remuneration for electricity used by a photovoltaic system) or for reasons related to accounting and tax law (e.g. allocation of costs to cost centers, taxation of non-cash benefits when electricity is sold to private employee vehicles).

Reliable, secure authentication that is easy for the customer to use is a prerequisite for correct billing of the amount of energy transmitted or the charging service used. This is an essential aspect for the acceptance of electric mobility. The implementation of data security and the protection of personal data shall be carried out in accordance with legal requirements.

For customer-friendly use of the charging infrastructure, E DIN IEC 63119-1 stipulates that the providers or operators of such charging infrastructures are to conclude contracts with each other in order to enable customers to use the infrastructure across providers by means of so-called "roaming".

When recording and billing the amount of energy, the requirements of the measurement and calibration law as well as the Price Indication Ordinance shall be met.

4.3.1 Capturing information about charging cycles

The information to be collected for each charging cycle (e.g. contract ID, charging point ID, meter ID, meter start status, meter end status, energy delivered, charging duration, connection duration) shall be defined. In the event of a power failure, no data, especially that of current charging processes, may be lost. Data protection and data security concerns shall be taken into account.

The use of identifiers (ID codes) is necessary for the unambiguous identification of the actors involved by electronic means (e.g. to implement charging current roaming). According to the international standard ISO 15118, a so-called Operator ID and a Provider ID have been introduced for the identification of charging points, which is used as a basis to ensure the assignment of the Charging point ID (known as EVSE ID) to the operator. For mobility providers, the Contract ID (known as EVCO-ID) enables the assignment to the provider. In Germany, BDEW issues the necessary ID codes for electric mobility providers and infrastructure operators.

4.3.2 System monitoring and preventing unauthorized access

Centralized monitoring is useful for efficient planning of service tasks, especially when operating a large number of charging stations. Evaluations can help to optimize the use of existing and future charging stations.

The facilities of the charging station should be protected against unauthorized opening by third parties (e.g. locking cylinders). Within the charging station, there should be separate physical access points to the technology for the personnel of the respective distribution system operator and for the personnel of the charging station operator (e.g. double locking cylinder or locking system).

The need to bill for charging cycles often also exists in the private sphere, for example in the use case of reimbursing electricity costs to the employee by the workplace if the employee charges his business electric vehicle using their private power connection. In this case, metering is necessary if accurate taxation is to be made possible outside of lumpsum contributions.

This use case requires that a communicative charging station be installed in the private household of the employee. From a legal point of view, however, this is a purely fiscal process, so that the special energy law requirements do not apply when kilowatt-hours are charged in accordance with the requirements of measurement and calibration law. The application is therefore less complex to implement.

It should be noted, however, that the provisions of the Renewable Energy Sources Act (EEG) may constitute a supply of PV electricity to third parties, which entails additional requirements in terms of documentation and data collection. Specific tax and technical advice from experts is, in any case, advisable in individual cases.

05 Use case

This chapter provides concrete recommendations and tips for various target groups and application examples with regard to the planning, construction and operation of charging infrastructure.

A checklist follows some basic explanations and general advice. This focuses on some of the most important application scenarios and provides the individual user groups with targeted information for their specific requirements. In addition, the checklist provides the respective "basic knowledge" in concise and chronological form. Essential measures can be addressed and worked through step by step.

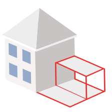
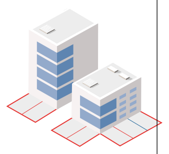
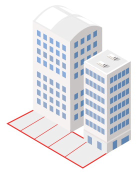
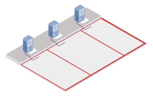
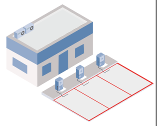
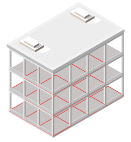
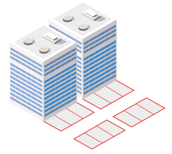
5.1. General information and recommendations

In order to be able to make statements about individual user groups and special application scenarios, the classifications of the conceivable use cases shall first be defined. According to the current GEIG, for new construction of residential buildings with more than five parking spaces, every parking space must be equipped with conduits for electrical cables, and for non-residential buildings with more than six parking spaces, every third parking space must be equipped with conduits.

The following figure describes the identified use cases according to their most important characteristics and compares them.

A fundamental distinction can be made between private and publicly accessible applications. This is important in terms of technical requirements as well as relevant legislation and funding opportunities. For example, the regulations on minimum technical requirements for the safe and interoperable construction and operation of publicly accessible charging points for electric vehicles (Charging Column Ordinance - LSV) has made publicly accessible charging points as the subject of the regulations.

Table 4: Overview of the locations of the charging infrastructure

	Private installation site			Publicly accessible installation site			
Typical locations for charging infrastructure	 Garage or parking space at home	 Parking spaces (e. g. underground car parks of residential complexes, apartment buildings, apartment blocks)	 Company parking spaces on private premises	 Charging station/ Charging Hub in town	 Charging station/ Charging hub on axles (e. g. highway, federal highway)	 Customer parking spaces or parking garages (e. g. shopping centers)	 Roadside/ public parking spaces
Charging technology	Charging mode 3 or 4						
Power supply	Using existing domestic connection	Via existing connection to the system or separate connection to the low or medium voltage network					Via existing infrastructure or new connection to the low or medium voltage network
Metering	Alternatives: 1) Use of existing electricity meters 2) Separate meters for use Special electricity tariffs	Alternatives: 1) Use of existing electricity meters belonging to the owners/ tenants of each individual parking space 2) Separate meters for owners/ tenants of a respective parking space to allow them to use special electricity tariffs	Alternatives: 1) Use of the property's existing electricity meters 2) Separate meters for the use of special electricity tariffs for charging current only		"Via electricity meter in the charging station" is assigned to the use case "Charging station/ charging hub on axles		Via electricity meters in the charging station
Billing	Options: • According to amount of energy delivered		Options: • According to amount of energy delivered • independent of usage flat rate	Options: Depending on the desired business model, for example: • According to amount of energy delivered • independent of usage flat rate			

5.1.1 Publicly accessible

A charging point located on private or public premises is publicly accessible if the parking space of to the charging point can be used by an undefined group of persons or a group of persons that can be determined according to general criteria (e.g. in next to public car parks, business premises or customer car parks).

5.1.2 Private

If, on the other hand, access to a charging point is only granted to a group of persons who have been determined or can be determined in advance, there is no publicly accessible charging point as defined by the LSV. For example, charging points located on private carports or private garage entrances are not publicly accessible charging points.

5.1.3 Other example cases, demarcation

An access authorization that has been acquired in advance, which may be necessary in certain circumstances, does not exclude public access to a charging point as long as it can be obtained by anyone. However, if access is only granted to individuals or a special group of people from the outset, there is no public access to the charging point located in the area in question and the use is private.

Examples:

- Company car parks for employees or residents - underground car parks in housing estates are only accessible to a closed user group of authorized persons, such as company employees, or after users have acquired the appropriate authorization.
  → Private, not publicly accessible
- Customer parking lots in shopping centers, for example, generally allow access for all users.
- A time restriction, e.g. business hours or maximum parking time, and billable use does not change this.
  → Publicly accessible

5.1.4 Considerations for property owners and managers

If parking spaces are equipped with charging infrastructure, they should also be clearly marked and signaled as such and, if necessary, reserved. Good visibility, combined with the provision for exclusive use by electric vehicles, makes the charging station attractive and ensures high capacity utilization.

The proactive planning and establishment of a sufficient number of charging points can prevent vehicle owners from using

The use cases are based on specifications of the NPM. Further information on area coverage is available in the Report "Area-wide charging infrastructure".

Clickable QR code

extension cables, cable drums, multiple sockets, travel adapters, etc. to supply their vehicles with electricity via existing sockets in living rooms, basements or corridors, causing avoidable hazards.

A residual current device (RCD), which is mandatory when installing a charging station, can also be selected with foresight if the station or wallbox is not already equipped with it: instead of a standard type A circuit breaker, either a FI type A EV (specially developed for the requirements of electromobility) or directly a FI type B for detecting all types of AC and DC residual currents can be installed.

5.2. Checklist

The following checklist offers a good basis for the initial consultation.

Furthermore, VDE offers a “Checklist private charging station: What to consider for the installation?”.

“Checklist: Private charging stations: What shall be considered for installation?”

Clickable QR code (only available in German)

Checklist for the initial consultation

Customer — Surname, Name: ....

Resident of — Street, No.: ....

Postal Code, Place: ....

Vehicle — Manufacturer, Model: ....

Capacity: .... kWh Charging capacity (max.) .... kW

Installation of a charging point

Version A

Charging capacity up to: .... kW

Expected charging time: .... h:min

- ☐ Possible without tech. changes
- ☐ Possible with
  - ☐ Extension of meter system
  - ☐ Replacement of meter system
  - ☐ Increase in performance by power supply companies
  - ☐ Installation of load shedding
  - ☐ ....
  - ☐ ....

Version B

Charging capacity up to: .... kW

Expected charging time: .... h:min

- ☐ Possible without tech. changes
- ☐ Possible with
  - ☐ Extension of meter system
  - ☐ Replacement of meter system
  - ☐ Increase in performance by power supply companies
  - ☐ Installation of load shedding
  - ☐ ....
  - ☐ ....

Optional

- ☐ Self-generated electricity can be used
  - ☐ Power generation already available
  - ☐ A power generation system can be installed
- ☐ Storage batteries can be used
  - ☐ Existing storage batteries can be used
  - ☐ A storage battery can be installed
- ☐ Power management systems possible
  - ☐ Integration into existing management system possible
  - ☐ A management system can be installed

Consulting E-Mobility Specialist Company

Consultant: ....

Date: ....

Signature:

06 Prospects

Electromobility as a viable alternative to established mobility schemes has been becoming more and more established and has been reaching an increasingly broad audience for several years. The medium to long-term demand for new forms of transport and solutions to future mobility challenges is already reflected in the considerably intensified efforts towards development on the political and economic side. This dynamic development affects not only the technical aspects, but also guidelines and standards. Originally set up to support technological development, some standards are now being revised and updated to reflect new technical knowledge.

Thanks to enormous research efforts and political movement to promote the technology, significant progress has been and is being made in the field of electromobility. This is perceptible even over relatively short periods of time. In some areas, it can already be forecast as to where the journey of further development may take us. An example of this is the increase in vehicle voltage, which enables higher charging capacities.

This outlook is intended to address some interesting versions of future electromobility technologies and illustrate the possible further evolution of the charging infrastructure described in this guideline.

6.1. Further development of standards

Currently (as of October 2021), some of the relevant standards for setting up a charging infrastructure are being revised. Other standards are already being developed in order to take account of the rapid developments in the field of electromobility. This will lead to changes in the applicable standards. Product developments and conformity evaluations shall consider the current versions of the standards.

IEC 61439-7 (VDE 0660-600-7) defines specific requirements for the design of AC and DC charging devices.

6.1.1 AC charging as per DIN EN 61851-1

System standard DIN EN IEC 61851-1 for wired charging was published in the 3rd edition in December 2019. In the meantime, a correction has appeared, since in some places there was talk of a disconnection, although it is a shutdown.

It takes into account the developments and standardization projects in electromobility that have taken place in the meantime. The new edition will take into account the separate product standard IEC 62752 for the charging cable set for charging mode 2 (IC-CPD) as well as the product standard IEC/TS 61439-7 (VDE V 0660-600-7), that will have been developed in the meantime, which specifies the housing requirements (DIN EN 60529) for charging stations, particularly depending on the installation location and intended use. In addition, the new version will comply with the latest findings on possible DC residual currents in electric vehicles, include requirements for DC residual current protection and thus be synchronous with the requirements of DIN VDE 0100 722.

6.1.2 DC charging as per DIN EN 61851-23

The DC charging standard DIN EN 61851 23-11 (VDE 0122-2-3) went into immediate revision after its publication in 2014 to take account of the rapid development in the field of DC charging. An essential objective of the second edition is charging with currents >200 A. In addition to the further development of DC charging station systems, aspects of bidirectional energy flows are also included.

6.1.2 Payment systems as per VDE-AR-E 2532-100:

The aim of the VDE-AR-E is to create uniform standards for handling authentication and billing processes at charging stations. To this end, it defines the minimum requirements for reliable and data protection-compliant systems for recognizing authorization at charging stations, specifically involving two application systems: remotely via backend (for example, apps) and RFID transponders (for example, credit, debit or charging cards). Thus, this VDE-application-rule allows the minimum standards (contactless payment system with credit and debit card option) to be met with highest possible security.

6.1.2 Energy management systems as per VDE-AR-E 2122-1000:

VDE-AR-E 2122-1000 specifies minimum requirements for communication between a charging facility with one or more charging points for electric road vehicles and local energy management downstream of a grid connection point, taking into account grid-side requirements. It contains the necessary information for energy management and will also deal with bidirectional energy flows in the future.

6.1.3 Communication between electric vehicle and charging infrastructure as per ISO 15118

ISO 15118-20 further develops the functions of ISO 15118-2. It additionally enables, among other things, the storage of multiple charging certificates in the vehicle for PnC and also supplements the load management function of ISO 15118-2 with the possibility of regenerative power supply. Publication is scheduled for the end of 2021

6.2. Intelligent power grids - "Smart grids”

The idea of the intelligent power grid ("smart grid") is based on comprehensive networking between energy generators, energy storage units and energy consumers. The aim is to achieve the most efficient operation possible with a secure energy supply, while also being flexible when it comes to the respective demand and supply situations of the smart grid networked components.

6.2.1 Energy recovery into the electrical power network

The recovery of electrical energy (bidirectional charging) from the vehicle battery into the electrical system is being increasingly considered. There is also an increasing number of applications that describe the supply of power to individual electrical consumers from the battery of the connected electric vehicle. An inverter installed in the vehicle or in the charging infrastructure ensures that the direct current stored in the vehicle battery is converted into the alternating current required by the consumer. With this in mind, the first normative activities, which are designed to address the question of how bidirectional charging can be sensibly and safely integrated into a superordinate system, are underway.

6.2.2 Grid usability

Electric vehicles can only contribute to grid stability and grid support if the electric vehicle is connected to the electrical grid at a time when energy is in demand.

Grid control is most practical in the private sector, as here there are long service lives with high flexibility potential in comparison to publicly accessible charging stations. Network expansion can thus be reduced. This can be used to optimize the need for grid expansion with a positive impact on the development of electricity costs.

In the future, in addition to the reduction of the charging power during the charging process when there are “bottlenecks”, energy recovery over longer periods and the provision of a controlling power range over short periods (seconds and minutes) may also be able to effectively support the power grid. This is technically feasible and has already been successfully implemented in pilot projects.

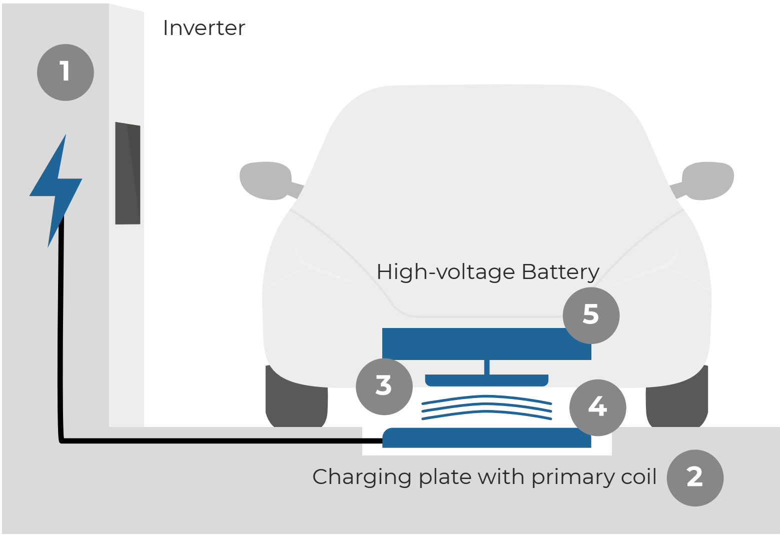
At present, however, neither the electric vehicles nor the charging stations are designed for grid-connected energy recovery as standard. This use case has not yet been considered in detail by standards. It is planned that the 3rd edition of IEC 61851 23 will deal with the topic of the CCS charging process.

6.3. Inductive charging

Inductive charging uses the principle of electromagnetic induction to contactlessly transfer electrical energy from the charging infrastructure to the electric vehicle.

The following image illustrates the principle:

Principle of inductive charging



The charging infrastructure consists of the connection to the existing electrical installation **1** and a charging plate **2** in which the coil and inverter are integrated. A charge receiver **3** with a coil and a rectifier are located in the floor of the electric vehicle. This converts the electrical voltage induced by the electromagnetic alternating field **4** into the direct current required to charge the high-voltage battery **5**.

The energy is transferred contactlessly via the air gap between the charging plate and charging receiver in the vehicle floor. The safety system of the charging infrastructure only allows energy to be delivered if the vehicle is correctly positioned above the primary coil. For this reason, vehicles with inductive charging equipment necessarily have a vehicle assistance function, since without this it is hardly possible for drivers to park the vehicle within the tolerance limits. According to IEC 61980-3 and ISO 19363, a minimum positioning accuracy of 75 mm in the direction of travel and 100 mm perpendicular to the direction of travel is specified, which may be restricted by the manufacturer.

Inductive charging makes the everyday use of an electric vehicle easier and makes it easy for even short stops, for example, to be used to charge the vehicle. As with wired charging, the technical connection conditions shall also be taken into account here (see 3.4.1 Grid connection). This means that it can be charged with single phase at charging capacities of up to 4.6 kVA. When planning higher charging capacities, a 3-phase connection shall be provided. The power classes currently under discussion as part of the standardization process go up to a charging capacity of 22 kW.

The electrical installation for connecting an inductive charging station shall comply with the requirements of VDE 0100. In addition, the requirements must be observed in accordance with DIN VDE 0100-722. Existing installations for wired charging which have been built according to these requirements can also be used when converting to inductive charging stations. The manufacturer's instructions for the charging station shall also be observed for the installation. The charging plate shall be laid in a way suitable for the respective design.

DIN EN IEC 61980 describes the requirements for inductive charging devices. The specific requirements for the vehicle side are described in ISO 19363. The IEC and ISO standards are currently being developed and adapted to the state of the art in the responsible committees. The standards provide limits for field strengths that are kept so low that, according to current knowledge, there is no adverse effect on the health of living beings, although this may still change – the limits are still under discussion at the EU level. Additionally, intrinsic safety of the system is required on both the vehicle and the network side so that the energy for the inductive charging process is shut down or a shutdown occurs in the event of a potential hazard (e.g. heating of metallic objects in the area of the magnetic field).

With inductive charging, communication that controls the charging process also takes place wirelessly. WiFi according to IEEE 802.11 and ISO 15118-8 is used for this purpose. The messages are standardized in ISO15118-20.

6.4 Heavy electric commercial vehicles

To meet the increasing requirements for reducing CO_2 emissions in the mobility sector, developers are also working on solutions for electrified heavy commercial vehicles. Various technologies are currently being investigated, but a commitment to a uniform solution throughout Europe has yet to be made. The technologies under discussion include battery-electric trucks and buses with significantly higher charging capacities. These charging capacities in the megawatt range are intended to enable sufficient recharging even of heavy commercial vehicles at break times during long-distance journeys. Based on current DC charging standards, necessary adjustments due to the higher voltage and current values will be anchored in new standards. A standard to anchor the system requirements (based on IEC 61851-23) is currently in the application phase, while the development of a standard for the description of a new plug-in interface (project number IEC 63379) has already begun.

Literature

IEC 61851 series for Charging Infrastructure

- **DIN EN IEC 61851-1:2019-12; VDE 0122-1:2019-12**
- **DIN EN IEC 61851-1 Corrigendum 1:2021-06; VDE 0122-1 Corrigendum 1:2021-06**
  Electrical equipment of electric road vehicles - Electric vehicles conductive charging system
  - Part 1: General requirements
- **DIN EN 61851-23:2018-03; VDE 0122-2-3:2018-03 - Draft**
- **DIN EN 61851-23:2014-11; VDE 0122-2-3:2014-11**
  Electric vehicle conductive charging system
  - Part 23: DC electric vehicle charging station
- **DIN EN 61851-24:2017-04; VDE 0122-2-4:2017-04 - Draft**
- **DIN EN 61851-24:2014-11; VDE 0122-2-4:2014-11**
  Electric vehicle conductive charging system
  - Part 24: Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging

IEC 61980 series for Electric vehicle wireless power transfer

- **DIN EN IEC 61980-1:2021-09; VDE 0122-10-1:2021-09**
  Electric vehicle wireless power transfer (WPT) systems
  - Part 1: General requirements
- **DIN CLC IEC/TS 61980-2:2021-07; VDE V 0122-10-2:2021-07**
  Electric vehicle wireless power transfer (WPT) systems
  - Part 2: Specific requirements for communication between electric road vehicle (EV) and infrastructure
- **DIN CLC IEC/TS 61980-3:2021-10; VDE V 0122-10-3:2021-10**
  Electric vehicle wireless power transfer (WPT) systems
  - Part 3: Specific requirements for the magnetic field wireless power transfer systems

IEC 62196 series for Connectors

- **DIN EN IEC 62196-1:2020-12; VDE 0623-5-1:2020-12 - Draft**
- **DIN EN 62196-1:2015-06; VDE 0623-5-1:2015-06**
  Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles
  - Part 1: General requirements
- **DIN EN IEC 62196-1:2020-12; VDE 0623-5-1:2020-12 - Draft**
- **DIN EN 62196-2:2017-11; VDE 0623-5-2:2017-11**
  Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles
  - Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories

- **DIN EN IEC 62196-2:2020-02; VDE 0623-5-2:2020-02 - Draft**
- **DIN EN 62196-3:2015-05; VDE 0623-5-3:2015-05**
  Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles
  - Part 3: Dimensional compatibility and interchangeability requirements for DC and AC/DC pin and contact-tube vehicle couplers

ISO 15118 series for Communication
- **DIN EN ISO 15118-1:2019-08**
  Road vehicles - Vehicle to grid communication interface
  - Part 1: General information and use-case definition
- **-DIN EN ISO 15118-2:2016-08**
  Road vehicles - Vehicle-to-Grid Communication Interface
  - Part 2: Network and application protocol requirements
- **DIN EN ISO 15118-3:2016-08**
  Road vehicles - Vehicle to grid Communication interface
  - Part 3: Physical and data link layer requirements
- **DIN EN ISO 15118-20 - Draft**
  Road vehicles - Vehicle to grid communication interface
  - Part 20: 2nd generation network and application protocol requirements

DIN EN ISO 19363:2021-02 - Draft
ISO 19363:2020-04
Electrically propelled road vehicles - Magnetic field wireless power transfer - Safety and interoperability requirements

DIN EN 61439-7:2021-11; VDE 0660-600-7:2021-11 - Draft
DIN EN IEC 61439-7:2021-06; VDE 0660-600-7:2021-06
Low-voltage switchgear and controlgear assemblies
- Part 7: Assemblies for specific applications such as marinas, camping sites, market squares, electric vehicle charging stations

DIN EN IEC 62752:2021-07; VDE 0666-10:2021-07 - Draft
DIN EN 62752:2017-04; VDE 0666-10:2017-04
In-cable control and protection device for mode 2 charging of electric road vehicles

DIN VDE 0100-722:2019-06; VDE 0100-722:2019-06
Low-voltage electrical installations
- Part 7-722: Requirements for special installations or locations - Supplies for electric vehicles

DIN VDE 0620-1:2021-02; VDE 0620-1:2021-02
Plugs and socket-outlets for household and similar purposes
- Part 1: General requirements on fixed socket-outlets

E VDE-AR-E 2122-1000 Anwendungsregel:2021-01
Standard interface for charging points/charging stations for connection to local power and energy management

E-AR-E 2532-100 Anwendungsregel:2021-07
Requirements for an authentication for the use of electric mobility supply systems

VDE-AR-N 4100:2019-04
Technical rules for the connection and operation of customer installations to the low voltage network (TAR Low Voltage)

DIN 18015-1:2020-05
Electrical installations in residential buildings
- Part 1: Planning principles

DIN SPEC 70121:2014-12
Electromobility - Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging in the Combined Charging System

VdS 3471:2021-02
Ladestationen für Elektrostraßenfahrzeuge – Publikation der deutschen Versicherer zur Schadenverhütung. (Charging stations for electric road vehicles - Publication of German insurers on loss prevention)

EU Directive 2014 / 94 / EU
Deployment of alternative fuels infrastructure

Charging column ordinance - LSV
Regulations on minimum technical requirements for the safe and interoperable construction and operation of publicly accessible charging points for electric vehicles (Charging Column Ordinance, LSV)

Technical Connection Conditions - TAB 2019
for Network Operators (TCC)
for connection to the low-voltage network

VDE FNN Hinweis: Netzintegration Elektromobilität
Guideline for the widespread distribution of e-vehicles

VDE FNN Checkliste: Private Ladestation
What should be considered for the installation?

HEA-Broschüre: Elektromobilität
Guidelines “Ladeninfrastruktur in Wohngebäuden” (Charging infrastructure in residential buildings

Nationale Plattform Elektromobilität - NPE
- The German Standardization-Roadmap Electromobility 2020 (Version 4.0)

National Platform Future of Mobility - NPM
- Report October 2020: Comprehensive public charging infrastructure (WG 5)
- Roadmap for the implementation of ISO 15118 (WG 5 and WG 6)
  Standardized communication between vehicle and charging point
- Focus Roadmap Intelligent Load Management (WG 6)

List of abbreviations

AC	Alternating Current
AR	Application rule
BDEW	Bundesverband der Energie- und Wasserwirtschaft e. V. (German Association of Energy and Water Industries)
BEV	Battery Electric Vehicle
DGUV V3	Berufsgenossenschaftliche Vorschrift Elektrische Anlagen und Betriebsmittel (Employer's Liability Insurance Association Regulations on Electrical Systems and Equipment)
CCS	Combined Charging System
DC	Direct Current
DIN	Deutsches Institut für Normung e. V. (German Institute for Standardization)
DIN SPEC	DIN Specification
DKE	Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE (German Commission for Electrical, Electronic & Information Technologies of DIN and VDE)
EnWG	Energiewirtschaftsgesetz (Energy Industry Act)
FI	Residual current circuit breaker
FNN	Network Technology/Network Operation Forum
GEIG	Gebäude-Elektromobilitätsinfrastruktur-Gesetz
HEA	Fachgemeinschaft für effiziente Energieanwendung e. V. (Professional association for efficient energy use)
HEMS	Home Energy Management System
IC-CPD	In-Cable Control and Protection Device
IEC	International Electrotechnical Commission
ISO	International Standards Organization
kVA	kilo-voltampere, unit of apparent power
kW	kilowatt, unit of active power
LSV	Ladesäulenverordnung (Charging column ordinance)
MessEG	Mess- und Eichgesetz (Measuring and calibration law)
MessEV	Mess- und Eichverordnung (Measuring and calibration ordinance)
NAV	Niederspannungsanschlussverordnung (Low voltage connection ordinance)
NFC	Near Field Communication
NPM	National Platform Future of Mobility
PAS	Publicly Available Specification
Pedelec	Pedal Electric Cycle
PHEV	Plug-In Hybrid Electric Vehicle
PLC	Powerline Communication
RCD	Residual Current Device
RFID	Radio-frequency Identification
TAR	Technical connection rules
TAB	Technische Anschlussbedingungen
VDE	Association for Electrical, Electronic and Information Technologies
ZVEH	Zentralverband der Deutschen Elektro- und Informationstechnischen Handwerke (Central Association of German Electronics and Information Technology Crafts)
ZVEI	Zentralverband Elektrotechnik- und Elektronikindustrie e. V. (Central Association of the Electrical Engineering and Electronics Industry)