



TOTALLY INTEGRATED POWER

Electrical Infrastructure for E-Car Charging Stations

SIEMENS

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Chapter 1

Electromobility in Times of Climate Change



1 Electromobility in Times of Climate Change

In many countries, electromobility is considered an essential component to mitigate climate change, as well as a contribution to national sustainability strategies, and it is an element for a climate-friendly energy and traffic policy. When electric vehicles are charged with power from renewable energies, no CO₂ is emitted for generating the energy of propulsion. In Germany, there are also reflections and already first prototypes for electric vehicles being used as mobile storages in order to store power from renewable energies and feed it back on demand to stabilize future smart grids.

Within the scope of the national development plan for electromobility, the Federal Republic of Germany had set the target of establishing at least one million electric vehicles (cars) by 2020, as well as five million vehicles by 2030 [1]. Considering the development of new electric vehicle registrations mainly in the last two years (see Fig. 1/1), this development scenario is definitely realistic for the streets of Germany.

In other countries, too, governmental measures support and promote the transition to electromobility.

According to EV-Volumes (The Electric Vehicle World Sales Database [3]), 6.75 million electric vehicles were registered worldwide in 2021, both battery electric vehicles (BEV) and plug-in-hybrid electric vehicles (PHEV). This corresponds to an increase of 108 % in comparison with the previous year, despite pandemic and supply bottlenecks. For 2022, the German automotive association (VDA) predicts to hit the 10 million limit with a BEV share of 68 % [7]. An overall overview of new electric vehicle registrations worldwide is given in Fig. 1/2.

For a positive effect in the life cycle assessment, it is absolutely necessary to cover the energy demand for charging the batteries in electric vehicles with energy from renewable sources. If the annual worldwide energy demand for this purpose was below 20 GWh in the year 2018, the demand in the year 2030 is expected to be 321 GWh [2]. Due to the different necessary behavior for usage and charging, the statements made on energy demand only allow conclusions on the power demand – and thus on the load of the electric power distribution networks – to a certain extent. In order not to overload the electrical networks due to electromobility, it will be essential to extend them, but – above all – to make use of the possibilities offered by an energy management system for controlling the power flow in accordance with the network capacities.

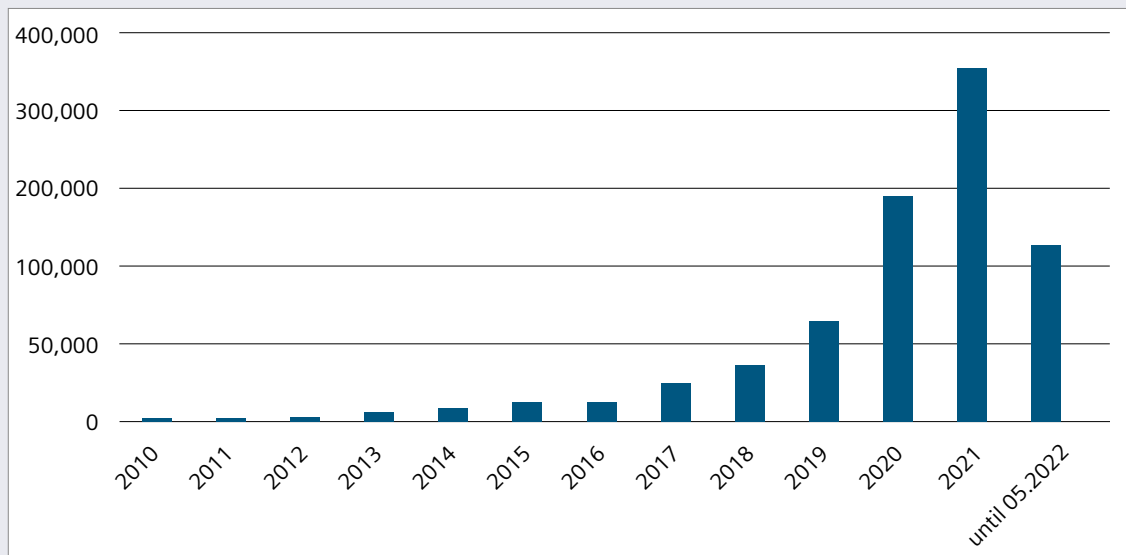


Fig. 1/1: New electric vehicle registrations in Germany [2]

Apart from the life cycle assessment, the cost-efficiency of the electric vehicles is a main issue for their acceptance. The determining factor is the price for the lithium-ion batteries used in each case. In the last decade, the price dropped strongly. If the costs were about 600 €/kWh in the year 2010, 83 €/kWh are expected for the year 2025 [2].

Another important factor of acceptance is the charging process itself. This means, how many charging points are available with which charging power at which locations at the different times.

For example, according to the charging pole register of the BDEW, Germany reports around 44,000 public charging points in March 2021, every seventh of them being a DC quick charging station.

This corresponds to an increase of about 10 % as against the previous year, despite Covid and lockdown. Apart from that, uniform standards for charging, authentication and payment are decisive [4].

The growing demand for the charging infrastructure required for electromobility places a new challenge on planners, installers, as well as on plant and system operators.

A structured procedure in the planning is the way to go here in order to determine the type and number of necessary charging points, deduce possible diversity factors, and optimally control the additional power demand in the network by using intelligent energy management systems, thus ensuring cost-efficiency when dimensioning the operational equipment.

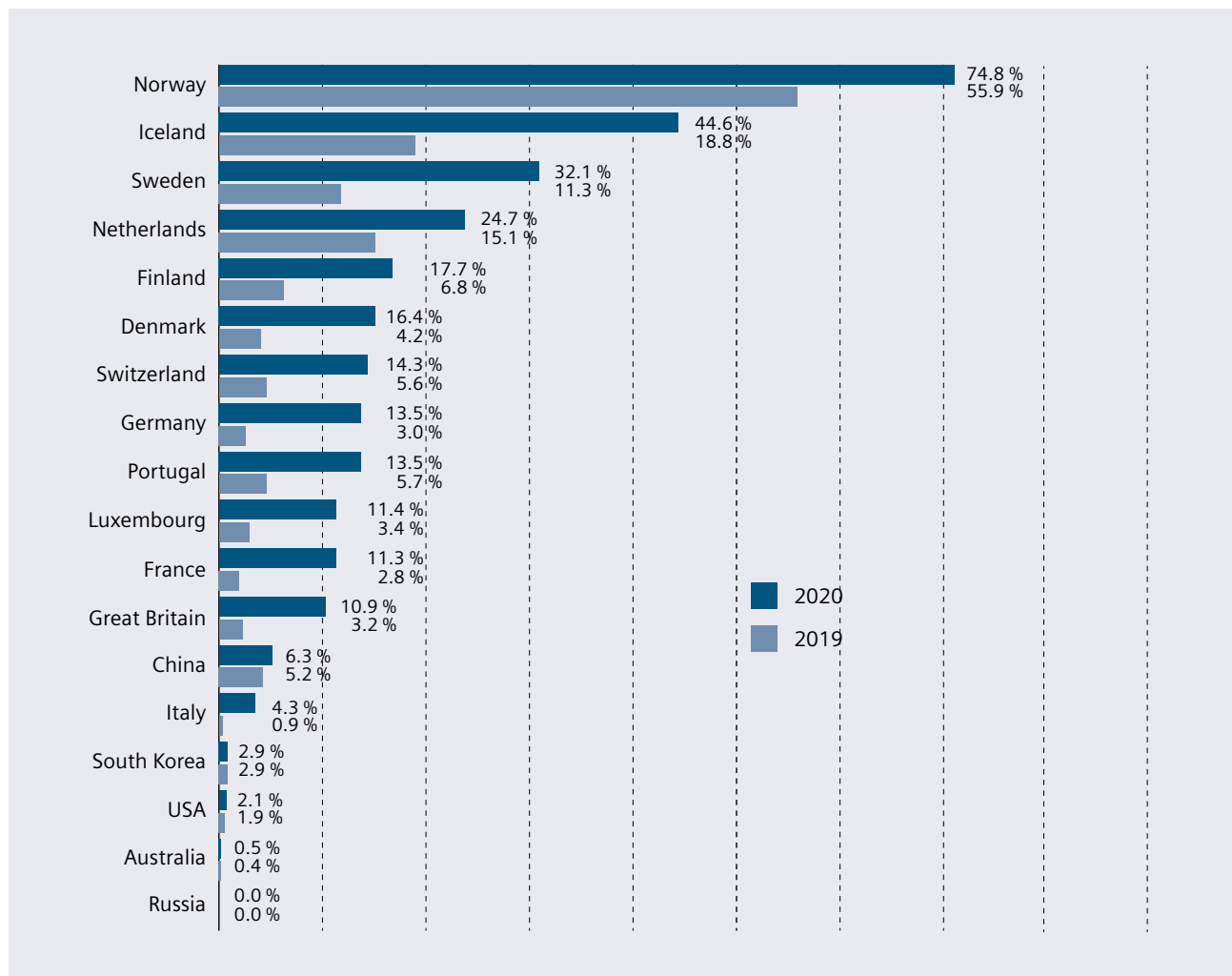


Fig. 1/2: Share of new electric vehicle registrations (BEV) worldwide by countries [7]

The following chapters of this application manual mainly deal with the planning aspects of the electric power supply of a charging infrastructure for wired (conductive) charging of electric vehicles and electric buses.

Solution approaches are shown based on examples.

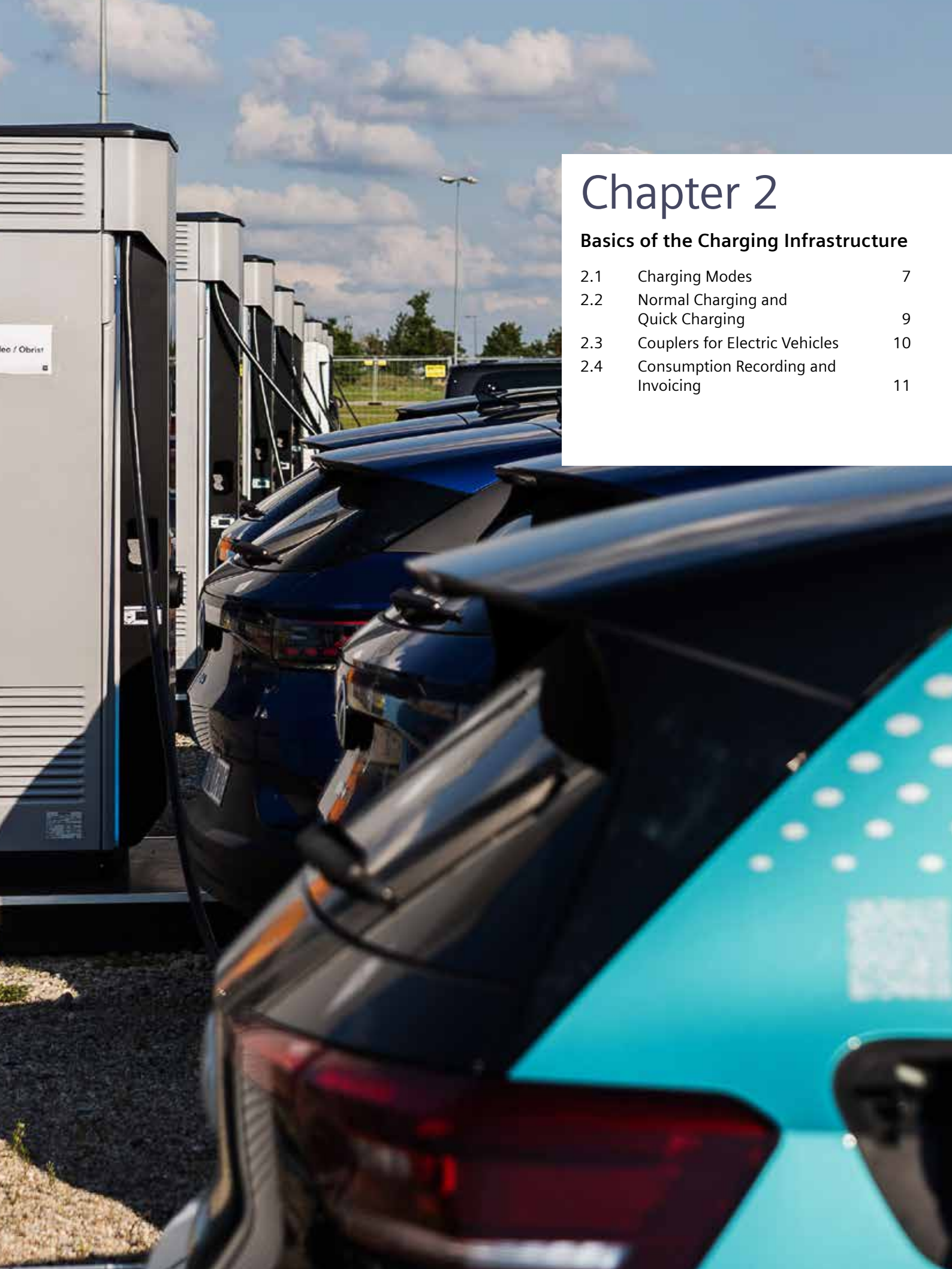
Standards

Safe operation of a charging infrastructure is ensured by the compliance with standards. In this context, a lot of information has been worked out and updated in the last years.

An overview of the most important standards related to the charging infrastructure (network side) is given in Tab. 1/1. The information in brackets contains the national transpositions for Germany from the respective international standard.

Task	Document no.	Title
Connection to the low-voltage network	IEC 60364-7-722 (VDE 0100-722)	Low-voltage electrical installations - Requirements for special installations or locations - Supplies for electric vehicles
Electrical equipment: Charging systems	IEC 61851-1 (VDE 0122-1)	Electric vehicle conductive charging system - General requirements
Electrical equipment: AC charging	IEC 61851-22 (VDE 0122-2-2)	Electric vehicle conductive charging system - AC electric vehicle charging station
Electrical equipment: DC charging	IEC 61851-23 (VDE 0122-2-3)	Electric vehicle conductive charging system - DC electric vehicle charging station
	IEC 61851-23-1, draft (VDE 0122-2-31, draft)	Electric vehicle conductive charging system - DC electric vehicle charging stations for electric vehicles with charger with automatic connection (→ pantograph; e.g., for e-buses)
Electromagnetic compatibility (EMC)	IEC 61851-21-1 (VDE 0122-2-11)	Electric vehicle conductive charging system - Electric vehicle on-board charger EMC requirements for conductive connection to an AC/DC supply
	IEC 61851-21-2 (VDE 0122-2-1)	Electric vehicle conductive charging system - Electric vehicle requirements for conductive connection to an AC/DC supply - EMC requirements for off-board electric vehicle charging systems
Plugs and cable connections	IEC 62196 series (VDE 623-5 series)	Plugs, socket outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles
	IEC 62752 (VDE 0666-10)	In-cable control and protection device for mode 2 charging of electric road vehicles (IC-CPD)
Communication	IEC 63110-1, draft (VDE 0122-110-1, draft)	Protocol for management of electric vehicles charging and discharging infrastructures - Basic definitions, use cases and architectures
	IEC 63119-1 (VDE 0122-19-1)	Information exchange for electric vehicle charging roaming service - General
Inductive charging	IEC 61980 series (VDE 0122-10 series)	Electric vehicle wireless power transfer (WPT) systems
Battery swap systems	IEC 62840 series (VDE 0122-40 series)	Electric vehicle battery swap systems
Light electric vehicles such as e-bikes and pedelecs	IEC/TS 61851-3 series, draft (VDE V 0122-3 series)	Electric vehicles conductive traction power supply system - Requirements for light electric vehicles (LEV) communication

Tab. 1/1: Standards of the charging infrastructure (network side)



Chapter 2

Basics of the Charging Infrastructure

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2 Basics of the Charging Infrastructure

For the acceptance of electromobility, easy access to charging possibilities as well as a quick and safe charging process are extremely important. Besides the availability of electric vehicles, the associated charging infrastructure therefore plays a decisive role for the electrification of road traffic. VDI 2166 Sheet 2 or DIN SPEC 91412 define the infrastructure used for charging electric energy storages of electric vehicles (batteries) from an electrical supply or distribution system.

For charging infrastructures, a difference is made between:

- **Charging point**

Connection for charging an electric vehicle; the electric vehicle is connected by means of a cable; only one electric vehicle can be charged at a charging point at the same time

- **Charging station**

(alternatively: EVSE)

Charging equipment for electric vehicles, free-standing as a charging pole, or as a wallbox mounted on a wall or post; one charging station has one or multiple charging points

- **Charging space**

Parking space with an available charging point for an electric vehicle

- **Charging park or charging location**

Location equipped with one or multiple charging stations; electric vehicles can park and charge at these locations.

As for the charging infrastructure, there will be a great need for further development in the next years, as illustrated in the statistics [2] for charging points (Fig. 2/1).

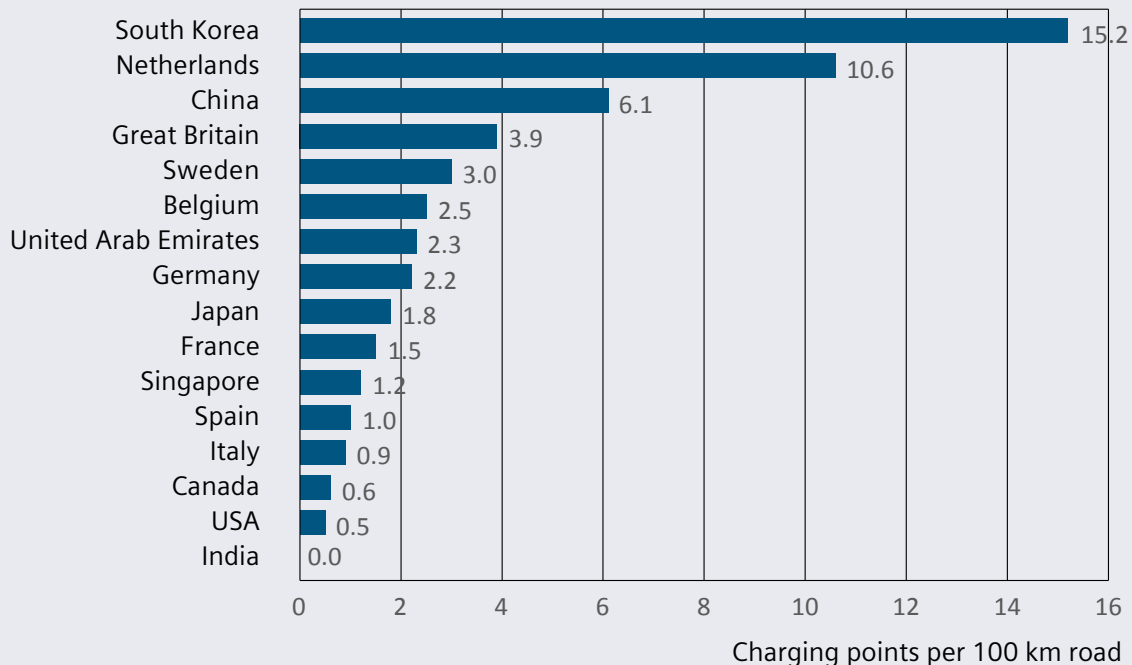


Fig. 2/1: Number of charging stations referred to road length in individual countries in the year 2020 [2]

2.1 Charging Modes

For wired (conductive) charging of electric vehicle batteries, four different charging modes are defined in IEC 61851-1 (VDE 0122-1).

The charging modes 1 to 3 (AC charging) describe the charging of an electric vehicle with a charger located in the vehicle (on-board charger).

In charging mode 4 (DC charging), the charger is not installed in the vehicle (off-board charger). In this case, the charging rectifier is located in the charging station.

Charging mode 1

In charging mode 1, a standard charging cable is connected directly to a common household or a single- or three-phase industrial socket outlet (colloquially: CEE socket outlet). The charging current is 16 A as a maximum. There is no communication between the vehicle and the infrastructure. The use of a residual current device (RCD) on the infrastructure side is absolutely necessary. Charging mode 1 only supports two-wheeled vehicles.

Charging mode 2

Analogously to charging mode 1, the charging cable is also connected here via a common household or industrial socket outlet. In charging mode 2, the charging cable is equipped with a box containing a control and protection device, the so-called IC-CPD. This device takes on the protection against electric shock in the event of an insulation fault. The protective conductor between the IC-CPD and the vehicle is monitored through a pilot signal. The maximum charging current is limited to 32 A.

Connection methods

Fig. 2/2 shows the connection methods distinguished in IEC 61851-1 (VDE 0122-1).

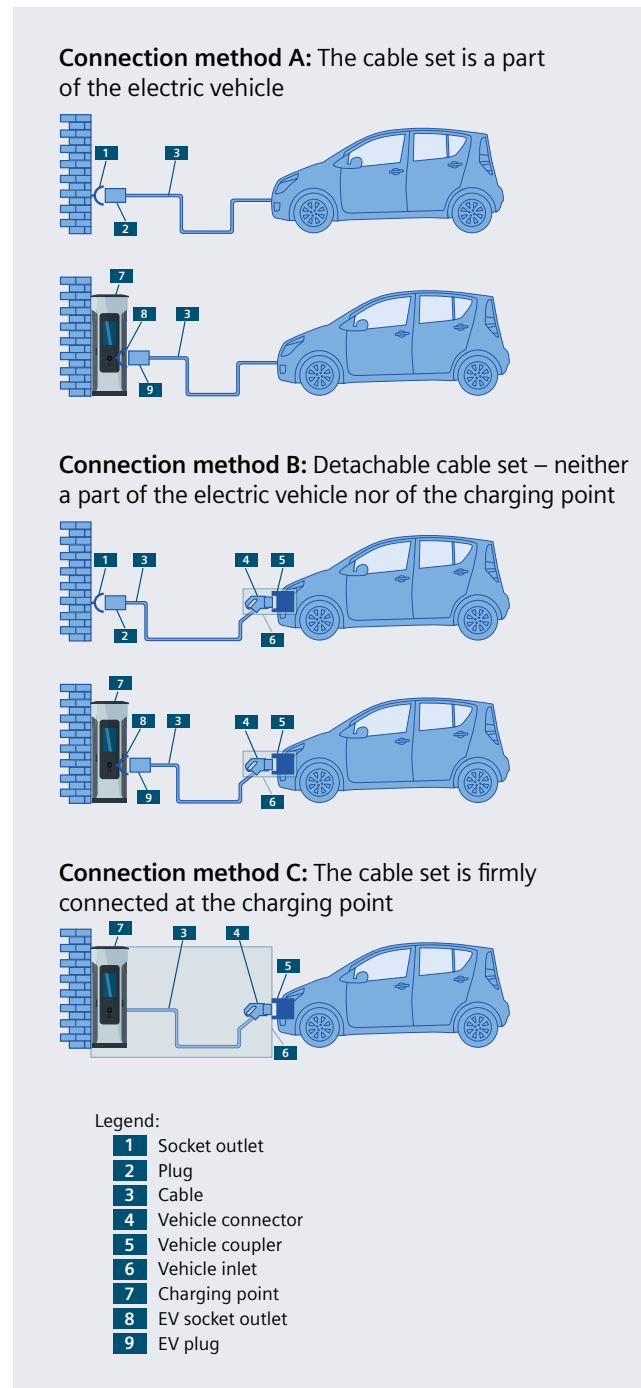


Fig. 2/2: Connection methods for the charging modes according to IEC 61851-1 (VDE 0122-1)

Charging mode 3

In charging mode 3, a firmly installed charging station is available on the infrastructure side. If no residual current device (RCD) is integrated in this charging station, this equipment has to be provided at the supply cable to the charging station.

The charging cable is firmly connected to the charging station. Alternatively, the connection to the vehicle can be established through a cable with plug-in facilities for the specific purpose. The communication between the electric vehicle and the charging station is implemented via the charging cable. When a plug type 2 (Tab. 2/3) is used, the charging cable is interlocked on both sides. The maximum charging power is 22 kW (at 400 V).

Charging mode 4

In charging mode 4, the DC charging process takes place on firmly installed charging stations (DC charging); when connected to an AC system, with a charging rectifier. The charging cable, which also provides the communication between the charging station and the electric vehicle, is firmly connected to the charging station. The plug connectors are generally interlocked. For electric vehicles that can be charged with both alternating current (AC) and direct current (DC), the charging rectifier that may be installed in the vehicle is bypassed during DC charging. The maximum charging power is presently in the range of up to 400 kW, with the intention of up to 900 kW being reached in the near future.

Charging mode 1	Charging mode 2	Charging mode 3	Charging mode 4
AC network connection through – Customary household socket outlet, 1-ph. (so-called “Schuko socket outlet”) – Industrial socket outlet, 1-/3-ph. (so-called “CEE-socket outlet”)	Like charging mode 1, but with a control and protection device (IC-CPD)	AC network connection through a firmly installed charging station	DC network connection or AC network connection with rectifier through a firmly installed charging station for DC charging (for DC charging, the on-board charger is bypassed)
Charging power ratings			
1-ph.: max. 16 A / 250 V 3-ph.: max. 16 A / 480 V	1-ph.: max. 32 A / 230 V ¹⁾ 3-ph.: max. 32 A / 400 V ²⁾	1-/3-ph.: Typical charging power ratings are: 3.7 kW – 7.4 kW – 11 kW – 22 kW	DC charging: 10 up to approx. 400 kW Typical charging power ratings are: 50 kW – 150 kW – 400 kW
Necessary functions of the charging station			
–	– Verification of correct connection of the vehicle – Permanent monitoring of the protective conductor’s continuity – Switching the system on/off		
Optional functions of the charging station			
–	– Selection of the charging current – Determination of the ventilation requirements in the charging area – Detection/setting of the momentarily available load current of the charging station (EVSE) – Blocking/releasing the coupler – Controlling the current flow in both directions (not for charging mode 2)		
Charging rectifier			
On-board	On-board	On-board	In the charging station
Communication			
–	Between IC-CPD box and on-board charger	Modules and interfaces for charging management and safety functions integrated in the EVSE; alternatively, separate RCD protection required	
Network feedback			
No	No	Possible	Possible

1) 230 V IEC voltage or 250 V UL voltage

2) 400 V IEC voltage or 480 V UL voltage

Tab. 2/1: Characteristic features of the charging modes according to IEC 61851-1 (VDE 0122-1)

2.2 Normal Charging and Quick Charging

Depending on the charging power, a difference is made according to the EU Directive 2014/94 (on the deployment of alternative fuels infrastructure) between “normal power recharging” and “high power recharging”. A charging power of up to 22 kW is defined in the directive as “normal power recharging”, and a higher charging power as “high power recharging” (Tab. 2/2). The corresponding terms commonly used today and in this application manual are “normal charging” and “quick charging”.

The wallbox design for a charging station is only available for the normal charging category, whereas charging poles are available for all types of charging stations, depending on their design (Tab. 2/2). High-power charging with currents of more than 200 A DC requires a special thermal management. Here, the charging cables are actively cooled by a cooling unit integrated in the charging station.

Charging process	Typical charging power ratings		Type of charging station	
	AC charging	DC charging		
Normal charging	3.7 kW		Wallbox	Charging pole
	7.4 kW			
	11 kW	10 kW		
	22 kW	20 kW		
Quick charging		50 kW		
High-power charging		150 kW		
		400 kW		
Ultra-high-power charging		Up to 900 kW		

Tab. 2/2: Categorization of charging processes according to charging power and type of charging station

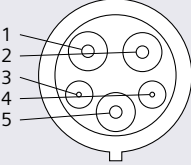
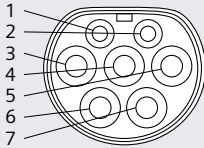
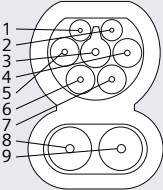
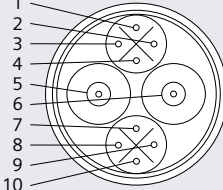
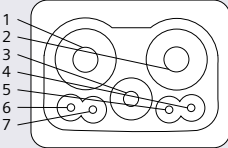


2.3 Couplers for Electric Vehicles

Currently, there are no globally standardized couplers for charging the batteries of electric vehicles. Car manufacturers in the regions of Europe, Asia and America have each created their own standard types. Tab. 2/3 shows a short summary of the most common types with their main features. In Europe, type 2 was established for AC charging, and the CCS standard – also called Combo 2 – for DC charging. The combined charging system (CCS) offers the advantage of both DC and AC charging with just one type of plug-in connection. Here, the plug type 2 was extended with the two contacts for DC charging.

All couplers stated in Tab. 2/3 include the option of a communication between the charging station and the electric vehicle. For the connection types 1 and 2 as well as CCS, the communication takes place via two data lines with standardized interfaces:

- The proximity pilot (PP) recognizes the permissible current-carrying capacity of the cable assembly
- The control pilot (CP) is a bidirectional interface and transmits, for example, the charging status and the permissible charging power.

Type 1	Type 2	CCS (Combo 2)	CHAdeMO V1.0 and V2.0	CHAdeMO V3.0 ("ChaoJi")
				
Contacts				
1 L1 2 L2 / N 3 CS 4 CP 5 PE	1 PP 2 CP 3 L1 4 PE 5 N 6 L2 (DC -) 7 L3 (DC +)	1 PP 2 CP 3 PE 4 N 5 L1 6 L2 7 L3 8 DC - 9 DC +	1 PE 2 CP1 3 - 4 CP3 5 DC + 6 DC - 7 CS 8 CAN-L 9 CAN-H 10 CP2	1 DC + 2 DC - 3 PE 4 CC1 5 CC2 6 S + 7 S -
Charging power				
AC 1-ph. up to 32 A	AC 3-ph. up to 63 A DC up to 500 V / 80 A	AC 3-ph. up to 63 A DC > 500 V / up to 350 W	DC up to 100 kW (V1.0) DC up to 400 kW (V2.0)	DC up to 900 kW
Area of circulation				
America and Asia	Europe	Europe	Asia	Asia
Legend: PE Protective earth DC + / - Direct current, positive/negative pole L1, L2, L3 Line 1, 2, 3 N Neutral conductor CS Connection check signal CP (1, 2, 3) Control pilot 1, 2, 3 PP Proximity pilot S + / - Data connection via CAN bus (S + / CAN-H, S - / CAN -L) CC (1, 2) Connection confirmation (1: charging station → vehicle, 2: vehicle → charging station) CAN-H / -L Data connection via CAN bus				

Tab. 2/3: Common couplers on electric vehicles

For AC charging, a simple, cost-efficient interface is generally implemented for a “basic” communication, which must primarily ensure a secured charging. These are analogous signals with a PWM procedure (Pulse Width Modulation) according to IEC 61851-1 (VDE 0122-1) or with a LIN communication (Local Interconnect Network) according to ISO 17987. In the case of CCS, an extended (“high level”) communication according to ISO 15118 was enabled. This is a digital communication mandatory for DC charging (charging mode 4) that enables the exchange of numerous data such as, for example, specifications on the energy demand, the planned duration of the charging process, as well as information on the price and the invoice.

For CHAdeMO V1.0 and V2.0 (abbreviation for CHArge de MOve), six communication lines are used:

- CP1 and CP2: control relays 1 and 2
- CP3: charging readiness
- CS: connection check
- CAN-H and CAN-L: data connection via CAN bus high & low.

The next generation of CHAdeMO V3.0 is also known as “ChaoJi”, which shall enable even ultra-high-power charging up to 900 kW. Here, the communication lines are reduced to four:

- S+ / S-: data connection via CAN bus high and low
- CC1: activating the vehicle and checking the connection to the charging station
- CC2: connection check with the vehicle.

2.4 Consumption Recording and Invoicing

When charging services are invoiced, the unambiguous assignment of the service to the user is enabled by means of an authentication procedure. Installations of charging stations outside of the private area are generally able to do this.

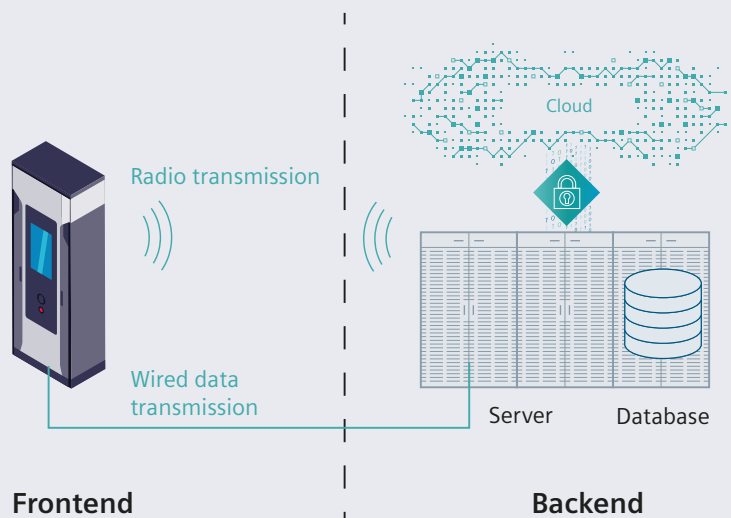
Possible procedures are, for example:

- Cash payment, cash card, debit card
- RFID card, NFC device
- Mobile SMS, smartphone app, Internet
- Plug & Charge.

Depending on the location and the accessibility of the charging stations, as well as on a limitation to specific user groups, the planning shall consider measures, procedures and systems allowing to monitor, evaluate and invoice the charging service. These are usually defined as backend systems (see the box: Frontend – Backend). Backend systems require a secured communication connection to the charging points.

Frontend – Backend

Frontend and backend are IT terms. The term frontend defines hardware and software components that play a role for the user, whereas the backend is required for the process performance without the user seeing it. In the case of electrical charging, the charging stations with display, control board, reader, data transmission, etc. represent the frontend, while the hardware and software (for example, a charging management) form the backend in the cloud or in a data center. The digital communication between frontend and backend can take place via wired protocols or radio protocols.



In most cases, this is a cloud-based software solution. Essential data exchange information has to be defined, such as contract ID, charging point ID, meter ID, initial meter reading, final meter reading, energy output, charging duration, connection duration, etc. This information must at least meet the respective national requirements on data security and data protection. For data exchange between the backend system and the charging station, the OCPP (Open Charge Point Protocol) has established itself as the appropriate data protocol.

Charging poles offer, in conjunction with a backend system from Siemens, additional functions such as evaluations for maintenance specifications or firmware updates. The charging customer does not get in contact with the backend. In contrast to this, the charging station as the frontend is designed to make all operating interfaces available to the customer's human-machine interface (HMI) and the electric vehicle in a safe, user-friendly, and reliable way.

For invoicing the charging service, there are various business models, for example: as a lump sum, according to usage duration, to charging power, or to the amount of energy received. For correct recording and invoicing of the amount of energy, approved – i.e., calibrated – meters must be used.

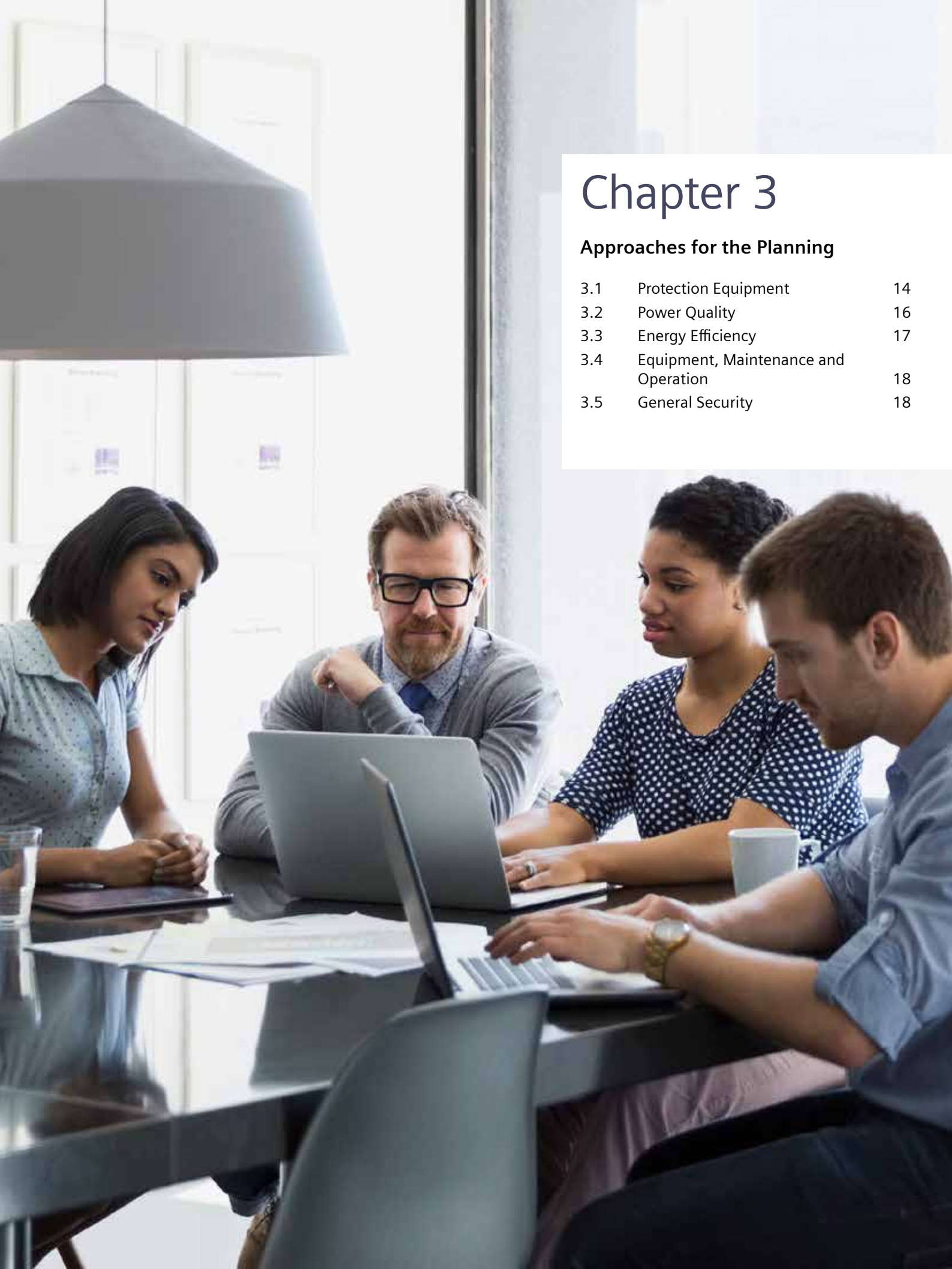
In Europe, the Measuring Instruments Directive 2004/22/EC (abbreviated as MID) was released for this purpose; in Germany and Austria, the procedure to verify conformity with the weights and measures legislation must additionally be followed. The location of MID-certified measuring devices may vary depending on the use case.

Case study 1

The amount of energy shall be invoiced to each individual user as a charging service based on the purchased charging power. For this purpose, every charging point has to be invoiced separately. This is preferably done within the charging station. If the charging station is equipped with just one charging point, the measurement can be carried out in the supply cable to the charging station. To do this, a communication is required from the charging station to the backend system, as well as a communication from the measuring device to the backend system.

Case study 2

For charging services to be invoiced based on the usage duration or as a lump sum, the amounts of energy received must nevertheless be recorded if this is mandatory due to national law, for example, to delimit power volumes for the reallocation charge on renewable energies (in Germany: "EEG-Umlage"). In Germany, this is also known by the term "third-party delimitation" ("EEG-Umlage 2021"). Depending on the network configuration, the total quantity can be captured through one measuring point.



Chapter 3

Approaches for the Planning

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3 Approaches for the Planning

To ensure a safe and efficient supply, planning the infrastructure outside of the home charging area – which means charging with charging mode 3 for AC or charging mode 4 for DC – requires the consideration and assessment of several aspects related to charging, including their effects on the electrical characteristics and their feedback.

The most important influence factors are:

- The type and number of vehicles to be charged at a specific location
- Available or requested charging duration
- Charging power of the vehicles
- Network-connected load available.

Apart from the protection equipment, energy efficiency and power quality must also be taken into account when dimensioning the charging infrastructure.

3.1 Protection Equipment

The following shall be considered when selecting the protection equipment:

i) Protection against electric shock

According to IEC 60364-7-722 (VDE 0100-722), the protection of an AC charging point covers the following:

- A residual current device (RCD as RCCB), at least type A according to IEC 61008-1 (VDE 0664-10) in connection with an overcurrent protection device, or
- A residual current device with integrated overcurrent protection (RCD as RCBO), at least type A according to IEC 61009-1 (VDE 0664-20) with a rated differential current ≤ 30 mA.

The residual current device can be integrated in the charging station, or at the beginning of the supply cable to the charging station if the charging station is equipped with only one charging point. For charging stations with multiple charging points, no common RCD (a so-called “group RCD”) may be used for protection against electric shock. Regarding selectivity, the residual current device of the charging point may have to be coordinated with upstream residual current devices.

In addition, appropriate measures must be taken against DC residual currents. For this, residual current devices type B are adequate according to IEC 62423 (VDE 0664-40). Integrated measuring equipment detects DC residual currents of more than 6 mA and disconnects the charging station or the affected charging point automatically.

ii) Lightning and surge protection

During the charging process, switching operations in the electrical energy supply or also lightning strikes can cause transient overvoltages that can damage the charging stations, the charging infrastructure, or the connected vehicles (for example, in the charging controller or in the battery). In charging stations located inside of buildings, the lightning and surge protection has to be coordinated with that of the supplying network. For charging stations located outside of buildings, it is advisable to set up a separate surge protection, which should cover both the high-current and the communication-related part.

If there is an additional risk of a direct lightning strike into a charging station because the latter is located in the lightning protection zone LPZ 0_A according to IEC 62305-4 (VDE 0185-305-4), a surge protection device (SPD) according to IEC 61643-11 (VDE 0675-6-11) is to be installed (Fig. 3/1). In this case, it is recommended to use an arrester combination of at least type 1+2. If there are any electronic components (communication or control connections), the use of an arrester combination type 1+2+3 shall be provided for. Furthermore, it will be necessary to install a separate local earthing. The earthing resistance should be limited to 10 Ω .

If an outdoor charging station is only located in the lightning protection zone LPZ 0_B (Fig. 3/1) – for example, because it is installed close to a building wall – only indirect effects of a lightning strike are to be expected. In such cases, the charging station has to be equipped with a surge arrester type 2; if electronic components are provided, with an arrester combination type 2+3.

iii) Backup protection or combined short-circuit protection

At a location equipped with multiple charging stations supplied through a common low-voltage network, short-circuit currents of more than 10 kA at the connecting point of the charging station are not uncommon. Therefore, the planning shall take into account that the electrical components installed in the charging station withstand the short-circuit conditions determined for the specific mounting location. Here, a cost-efficient solution is using the backup or combined short-circuit protection according to IEC 60364-5-53

(VDE 0100-530). Ideally, this protection is already integrated in the charging station by means of tested switchgear and controlgear assemblies, and the manufacturer of the charging station ensures compliance with this protection by specifying the maximum permissible short-circuit current of the components installed. In all other cases, the planner has to coordinate the backup or short-circuit protection for the charging station independently. This may possibly require the use of a short-circuit limiting overcurrent protection device that has to be provided for at the beginning of the circuit of the charging station.

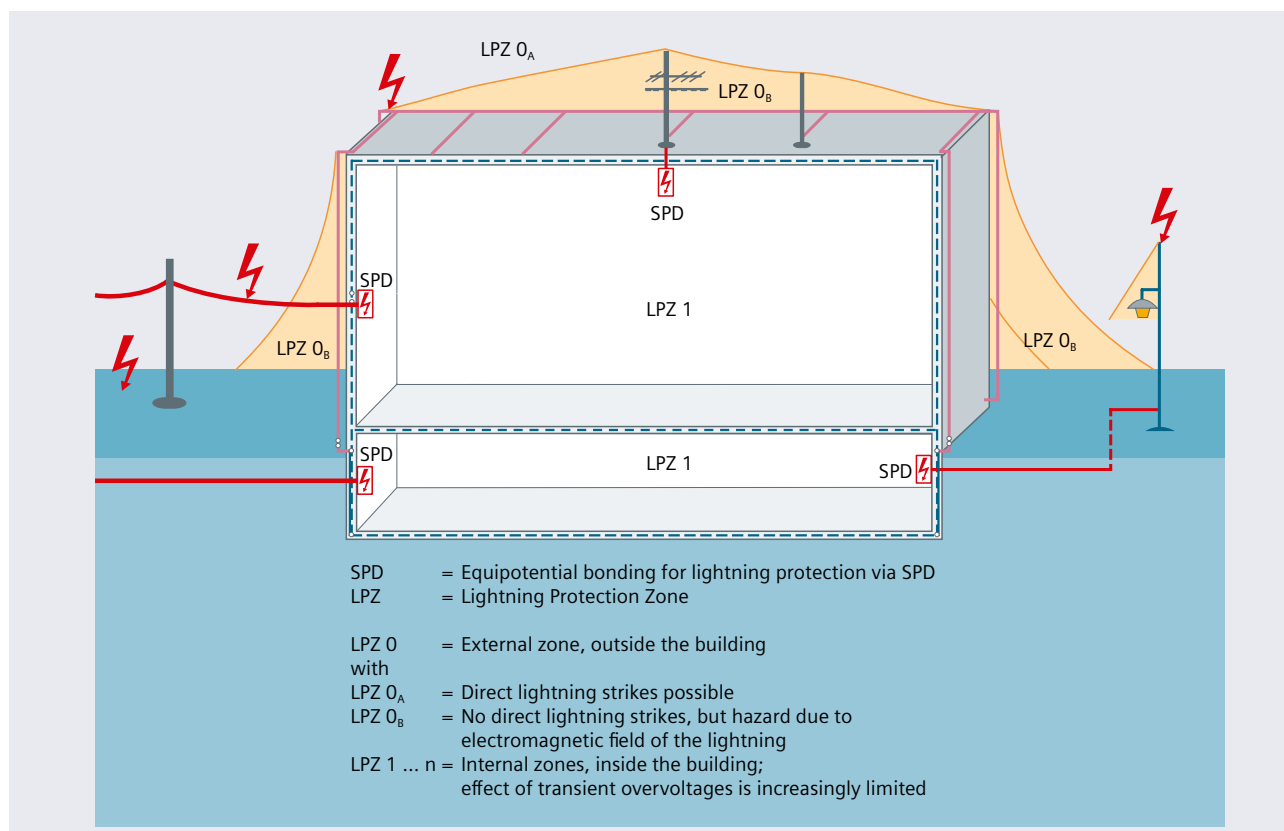


Fig. 3/1: Illustration of the lightning protection zones according to IEC 62305-4 (VDE 0185-305-4)

3.2 Power Quality

In power distribution networks with integrated charging infrastructures, particular attention has to be paid to the power quality. Apart from flickers, voltage dips, and voltage asymmetries, the power quality also covers voltage distortions or possible feedbacks from harmonic currents, which may be quite considerable due to the electronic equipment of on-board and off-board rectifiers. Other consumers that fed in parallel from the supply network must not be disturbed by them to an impermissible extent. This means that they must continue operating properly, and must not be damaged. Limit values for voltage distortions at the connecting point to the public network are described in the EN 50160 (DIN EN 50160) standard and in Tab. 3/1. These are 10-minute mean values of each harmonic voltage (r.m.s. values), which must be met to 95 % within any desired weekly interval under normal conditions.

Moreover, it is stipulated that the total harmonic distortion (THD) of the supply voltage THD_U (sum of all harmonics up to the ordinal number $h = 40$) be less or equal to 8 %:

$$THD_U = \sqrt{\sum_{h=2}^{40} (u_h)^2} \leq 8 \%$$

The corresponding values for non-public and industrial networks are defined in IEC 61000-2-4 (VDE 0839-2-4).

Due to the different technologies of the on-board charging rectifiers in the vehicles and the off-board charging rectifiers in the charging stations, with their respective harmonic filtering measures, no definite statements can be made on their feedbacks. A higher short-circuit power at the connecting points of the substations may lead to smaller voltage distortions, but it may have a negative impact on the electrical components in the charging station with respect to their short-circuit protection.

Odd harmonic				Even harmonic	
No multiples of 3		Multiples of 3			
Ordinal number h	Relative voltage amplitude U_h / U_1	Ordinal number h	Relative voltage amplitude U_h / U_1	Ordinal number h	Relative voltage amplitude U_h / U_1
5	6.0 %	3	5.0 %	2	2.0 %
7	5.0 %	9	1.5 %	4	1.0 %
11	3.5 %	15	1.0 %	6 to 24	0.5 %
13	3.0 %	21	0.75 %		
17	2.0 %				
19	1.5 %				
23	1.5 %				
25	1.5 %				

Tab. 3/1: Electromagnetic compatibility level for the individual harmonic voltages U_h in relation to the fundamental wave voltage U_1 (ordinal $h = 1$) according to EN 50160

For this reason, it is generally recommended to install the corresponding power quality recorders at the point of interconnection and at the relevant points of the medium- and low-voltage network, such as for example SICAM Q100 at the point of infeed, or measuring devices with detection of the individual harmonics (currents and/or voltages) and their THD, for example SENTRON PAC4200. This way, possible limit value violations can be detected and recorded during operation, and the size and location of passive and active filters can be deduced immediately in order to take countermeasures. Ideally, the corresponding space for installing these devices in the electrical service locations should already be reserved in the planning phase.

The fact that AC charging stations are not always connected to three-phase systems, as it is common practice in Europe, has a great impact on the power quality. In Asian countries and in the USA, which are important sales markets for the automotive industry, single- or two-pole charging (phase 1 – neutral: L1 – N, or phase 1 – phase 2: L1 – L2) is frequently used in both private and public areas. Therefore, car manufacturers often install cost-effective single-phase on-board charging rectifiers. If several of these vehicles are charged at the same location, the result may be a great load unbalance and voltage asymmetries in the network. To solve this problem, it is thus recommended to connect the charging stations in alternating phase sequence when they are installed in a three-phase system.

3.3 Energy Efficiency

To install and operate a charging infrastructure with multiple charging stations as most cost-efficiently as possible, the following topics have to be considered in the planning:

i) Place of installation, load center

The infeed for the charging infrastructure (for example, the transformer substation) should be located as close as possible to the load center. This minimizes transmission losses and voltage drops. This means that charging stations with a higher connected load, such as for example quick charging stations, should be placed in the direct proximity of the network infeed.

If several floors of a parking garage are equipped with charging stations with the corresponding high power, a feeding transformer should be installed in every level or at least in every second level. The power is transmitted at medium-voltage level, whereby the connection to the medium-voltage network can be performed centrally.

ii) Energy management

If an energy management system is used and eventual charging times are considered, it is possible to distribute the power acquisition and the utilization of the network uniformly, to cut peak loads, and to optimize the total energy demand in this way. According to IEC 60364-7-722 (VDE 0100-722) and if there is no energy management available, the diversity factor must be set to 1.0 for the charging infrastructure, thus adjusting the network to the sum of the installed connected loads of the charging stations.

iii) Energy costs

In DC quick charging stations with power outputs of 50 kW and more, the power loss of the charging rectifiers with the electronic elements used there cannot be neglected. This power loss stresses the electrical installation in the building infrastructure, and very high power loss costs may arise over the operating time. For the planning, a value of 10 % of the nominal power per charging station can be taken as a basis here.

3.4 Equipment, Maintenance and Operation

The groups of persons provided for maintenance and operation work have a great influence on the equipment of the electrical systems and the charging infrastructure. In case of different responsibilities for the charging stations and the electrical systems, it must first be ensured that the service personnel for the charging stations is able – as much as possible – to de-energize or disconnect every single charging station. The associated access and switching authorizations for electrical service locations must be provided. Moreover, the remote operation of motor operating mechanisms at the switching devices and the prevention of an impermissible reconnection is absolutely essential. Alternatively, the service or operating personnel of the electrical supply network must be present on site during any maintenance work.

For maintenance and operation of the charging infrastructure, considerable costs may arise for the operator over the service life. The use of durable, low-maintenance equipment, both in the supply network and in the charging stations, is of vital importance here. Monitoring systems, installed as an isolated solution or as a part of a superior energy management system, supply the necessary data or information (operating times, utilization, time characteristics, etc.) to be able to draw conclusions for planning a targeted and timely maintenance of the equipment.

The availability and service readiness of the charging infrastructure can thus be ensured at a high level throughout the entire lifetime.

3.5 General Security

If the place of installation of the charging station has not been selected appropriately (for example, risk of accidental collision with the charging station during maneuvers on the parking space), the charging station should be equipped with an additional mechanical protection. Useful materials could be, for example, pillars, skirting protection brackets, safety barriers, or prominently marked high curbstones.

Charging infrastructure installations should be protected against vandalism to the greatest possible extent. Switchgear, transformers, or electrical service rooms are per se secured against unauthorized access. For operational equipment like charging stations, which must at least be partially accessible to the public, it has to be decided in each individual case to which extent a supervision technology with a deterrent potential against vandalism will be reasonable and purposeful. In this context, the business model of the investor also plays an important part. For charging stations that shall generate a benefit autonomously (for example, electric filling station), another protection and safety concept is normally worked out than for charging stations that represent an extended customer service for an existing business.

As charging stations are also accessed at night, or can also be installed in buildings with little daylight, the German guideline VDI 2166 Sheet 2 recommends an illuminance of 100 lux at the charging point to ensure safe operation.

Chapter 4

Connection of Charging Stations
in Buildings – Cable or
Busbar Trunking System



4 Connection of Charging Stations in Buildings – Cable or Busbar Trunking System

While the electric power supply of outdoor charging stations exclusively happens via cables, there is an option to use busbar trunking systems when they are installed in a building, such as an underground parking garage or a parking garage building. Which installation system is to be preferred for the electric power distribution essentially depends on the number of charging stations.

In an installation with cables, each charging station is generally powered individually from the low-voltage distribution board. Depending on the number of circuits that are to be laid on the same route, this means considerable space requirements and expenses for cable ducts. In this context, special attention must be paid to the derating factors for determining the current-carrying capacity of the cables and the resulting cable cross-sections. The values for the derating factors and the current-carrying capacity of cables are provided in IEC 60364-5-52 (VDE 0100-520) and – especially for Germany – in VDE 0298-4.

An installation with a busbar trunking systems is easier compared with a cable installation. In most cases, the trunking elements can be installed directly above a parking row without bigger expenses. They are connected to the respective charging station via so-called tap-off units. In a building or structure, the charging stations are generally executed as a wallbox, as they can be mounted on a wall (Fig. 4/1).

A special advantage of busbar trunking systems is their flexibility with possible later extensions. In a later retrofit with additional charging stations, the existing busbar trunking system can be extended and expanded in different directions, often without any adjustments having to be done in the low-voltage distribution board. The precondition is, of course, that the system was designed accordingly for the power requirements of the extension.



Fig. 4/1: Connection of wallboxes to a busbar trunking system

As an example, Fig. 4/2 illustrates the space requirements of a cable installation compared with the installation of a busbar trunking system. The lack of room height and route width in parking garages and underground parking garages often represents a great obstacle to a classical cable installation.

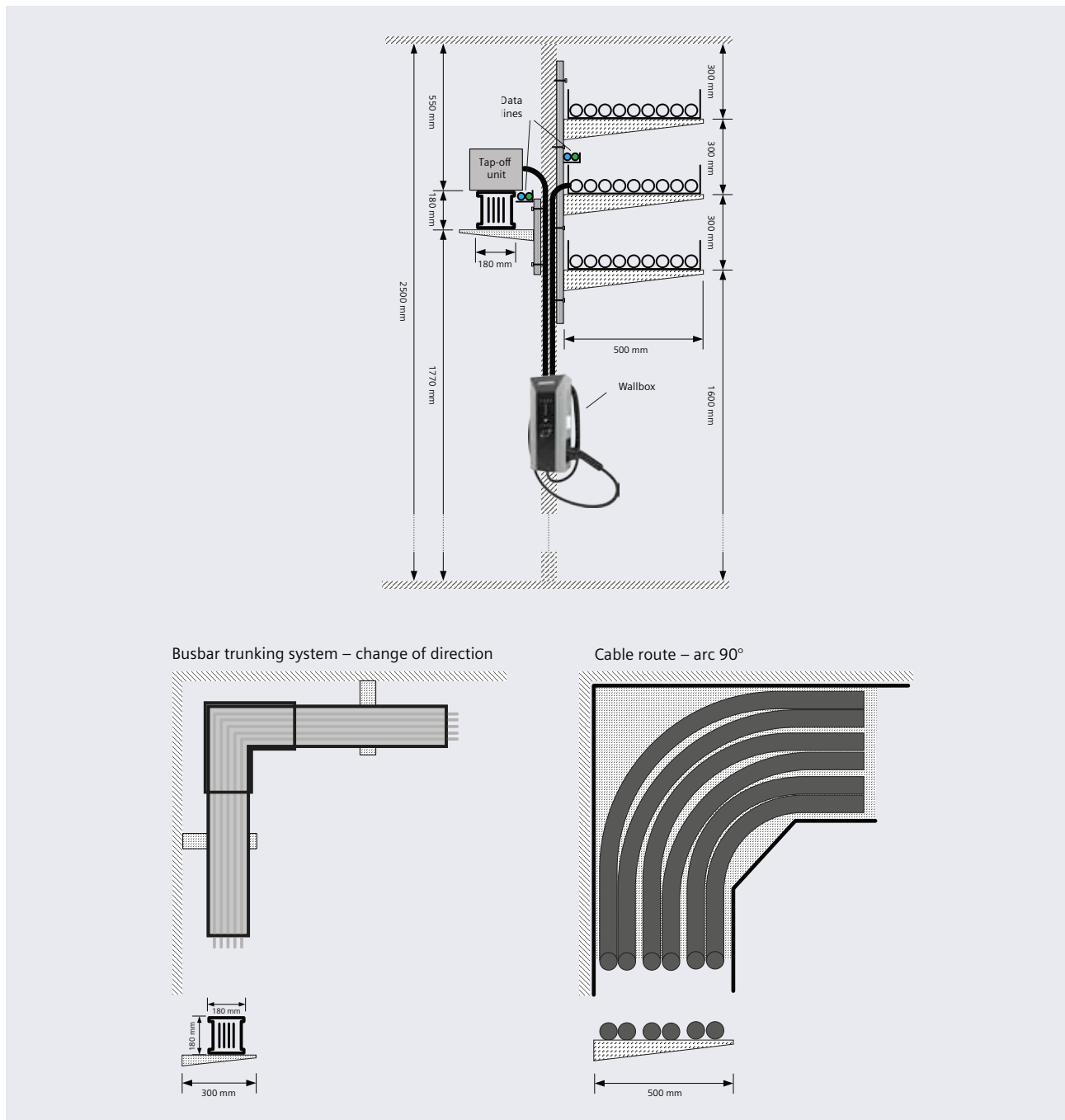


Fig. 4/2: Space requirements during installation: Exemplary comparison between a cable route and a busbar trunking system

For cable installation, each charging station requires a separate individual outgoing cable feeder at the low-voltage distribution board. Depending on the power requirements, several cubicles of a switchboard are needed for this in most cases.

In an installation with busbar trunking systems, entire rows or areas of charging stations are usually supplied via one common busbar run. Here, only one outgoing feeder cubicle towards the busbar trunking system is required per switchboard, which generally leads to smaller switchboards and, as a result, to lower space requirements for electrical service rooms.

Furthermore, the fire load in the building is presumably significantly higher for cable installation compared with the metallic design of the busbar trunking systems.

Tab. 4/1 contrasts the advantages and disadvantages of both installation methods.

Chapter 7 illustrates project examples with cables and busbar trunking systems in comparison.

	Feature	Busbar	Cable
	Conformity with standards	- Design verified system in accordance with IEC 61439-1 / -6 - High current-carrying capacity, operational safety, and short-circuit withstand strength ensured by testing	- Individual solution - Compliance with standards much more difficult to prove (for example, consideration of derating factors due to ambient conditions and installation method)
	Fire load	Very low	Very high, dependent on cable type
	PVC-/halogen-free design	On principle, trunking units are halogen-free	Standard cables are not PVC- or halogen-free; halogen-free cables are extremely expensive and have long delivery times
	Flexibility in the event of expansions or the relocation of load focal points	- Adaptable power supply - Very high flexibility thanks to variable tap-off units, which can be modified, added, or replaced as required, even while energized - No downtimes	- Rigid power supply - Higher efforts due to replacement of existing devices or expansion with additional outgoing feeders in the switchboard and the associated modifications in the cable installation - This includes long downtimes
	Space requirements	- Very low thanks to compact design; installation with contours matching the building structure - Smaller installation surface thanks to reduced size of the central switchboard	- High space requirements due to bending radii, installation method, and accumulation - Larger installation surface of the central switchboard due to integrated switching devices for the cable feeders
	Troubleshooting and error correction	Easy thanks to clearly arranged installation and switching devices close to the consumer	Time-consuming due to less clearly arranged installation and switching devices far away from the consumers
	Electromagnetic influence	Low influence thanks to suitable arrangement of conductors	- Relatively high for standard cables - No defined arrangement of conductors
	Installation time	Short installation time	Long installation time
	Connection to automation and energy management systems as well as to the cloud (IoT)	Simple and cost-efficient integration thanks to standardized powerline technology	Complicated due to installation of parallel communication cables

Tab. 4/1: Advantages and disadvantages of the installation versions cable – busbar

Chapter 5

Estimation of the Power Demand

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5 Estimation of the Power Demand

As a first step for dimensioning or planning the distribution network, the power demand for the charging location has to be estimated. Oversizing will result in unnecessary investment costs. Undersizing will reduce the operability of the charging infrastructure. Both are to be avoided.

Energy is the product of power and time. Conversely, this means that the charging power can be determined based on the charging time and the required energy demand. The supply network has to be designed according to the resulting charging power. The essential influence factors for the dimensioning options with respect to the necessary charging power should be discussed and coordinated in advance with the plant operator.

Important influence factors are, for example:

- **Type of use and resulting charging time**
Generally, the charging time available is considerably higher in a staff parking lot and a bus depot than in a highway rest area, a parking garage, or the parking area of a shopping center

- **Driving distances to be covered with the charged amount of energy**

The energy charging demand depends on the number of kilometers to be travelled in the next driving cycle after recharging. Employees or customers of a shopping center generally drive shorter individual distances than electric buses or electric vehicles on a journey

- **Occupation cycle at charging stations or charging points**

Here, it has to be determined in which time sequence the charging stations will presumably be occupied. For a shopping center or a highway rest area, rush hours may have to be expected, in which all charging stations are used simultaneously. The utilization of company parking lots, however, will be determined by the predominant working time model (flextime / shift system).

During the planning phase, the intended use of the charging location primarily defines the optimization options for a power estimation. An energy management system is predestined to continue this optimization in operation. As an example, Tab. 5/1 shows typical charging times as well as the power demand of a charging location for different types of use.

	Company parking lots for employees	Car stop, highway rest area, business park	Parking garage, customer parking lot, shopping center	Bus depot
Charging power per charging point	4.2 to 22 kW	50 to 300 kW	11 to 22 kW	100 to 200 kW
Available charging time to be expected	6 to 8 h	20 min to 3 h	1 to 4 h	6 to 8 h
Relative energy charging demand	Low to medium	Very high	Low to medium	High to very high

Tab. 5/1: Typical charging times and power outputs for a charging point with different types of use

5.1 Examples for Simple Estimations

With the help of some examples, it is easy to describe the influence the use of a load management system and the assumed energy required by the electric vehicles exerts on the power demand of an infrastructure. The following parameters are used as a basis:

- Number of charging points N :
 $N = 50$ charging points with a charging power P of 11 kW each
- Efficiency of the charging unit and the battery in the electric vehicle η :
 $\eta = 90\%$
- Power factor $\cos \varphi$ of the charging unit:
 $\cos \varphi = 0.98$
- All charging stations are occupied in a very short period of time, almost simultaneously. According to IEC 60364-7-722, a diversity factor of $g = 1$ must be used here for the calculation.

5.1.1 Case 1: Without Energy Management

As all charging points are occupied here and the full charging power is delivered, the sum S of all connected loads of the individual charging points results from:

$$S = \frac{g \cdot N \cdot P}{\cos \varphi}$$

with the data given above:

$$S = \frac{1 \cdot 50 \cdot 11 \text{ kW}}{0.98} = 561 \text{ kVA}$$

5.1.2 Case 2: Energy Management System Available, Stipulation of an Available Charging Duration

This case refers to staff parking lots that shall be equipped with charging points, and which are used for charging the electric vehicles during the average stay of 7 hours at the working place. 50 kWh are assumed as the mean charging capacity of the vehicle batteries E_{batt} , considering a mean battery discharge $\Delta f_{\text{discharge}}$ of 70 % at the beginning of the charging processes.

An energy management system can now reduce the charging power in such a way that the charging process through each active charging point will charge each vehicle almost completely in the given period of 7 hours (no typical charging characteristic is specified, which means that – for approximation – charging is effected uniformly with the charging power specified by the energy management).

The amount of energy absorbed by the vehicle batteries, $E_{\text{batt,tot}}$, results from:

$$E_{\text{batt,tot}} = N \cdot E_{\text{batt}} \cdot \Delta f_{\text{discharge}}$$

with the data given above:

$$E_{\text{batt,tot}} = 50 \cdot 50 \text{ kWh} \cdot 0.7 = 1750 \text{ kWh}$$

The mean charging power for each charging point can be calculated from the charging energy:

$$P = \frac{E_{\text{batt,tot}}}{N \cdot \eta \cdot t_{\text{charge}}} = \frac{1750 \text{ kWh}}{50 \cdot 0.9 \cdot 7 \text{ h}} = 5.56 \text{ kW}$$

Together with the equation from Section 5.1.1, this results in a total charging power demand S for the electric power supply of the 50 charging points:

$$S = \frac{1 \cdot 50 \cdot 5.56 \text{ kW}}{0.98} = 283 \text{ kVA}$$

If the total charging power demand of 283 kW is set into relation with the nominal connected load from case 1, this results in a diversity factor of nearly 0.5 referred to the connecting point. Consequently, the charging points are sufficiently dimensioned with a nominal power of 11 kW each.

5.1.3 Case 3: Energy Management System Available, Stipulation of a Driving Distance and the Charging Duration

For the parking lot of a shopping center, $N = 50$ charging points shall be dimensioned so that an average amount of energy can be charged that is sufficient for covering a defined driving distance. Due to their location, operators of shopping centers generally know the catchment area of their customers, their local distribution, and their average stay.

The following assumptions are made:

- Average energy consumption of an electric vehicles E_0 :
 $E_0 = 20 \text{ kWh per } 100 \text{ km}$
- Customer catchment area d_0 :
 $d_0 = 20 \text{ km (round trip = } 40 \text{ km)}$
- Average stay t_0 :
 $t_0 = 2 \text{ h}$

With the help of a charging management, the available power of the charging points can be controlled over time in such a way that the assumed amount of energy to be rated is not exceeded.

The total amount of energy $E_{\text{batt,tot}}$ is:

$$E_{\text{batt,tot}} = N \cdot (2 \cdot d_0) \cdot E_0 =$$

$$50 \cdot 40 \text{ km} \cdot 0.2 \text{ kWh/km} = 400 \text{ kWh}$$

This results in a total charging power demand S and the average charging power P per charging point:

$$S = \frac{E_{\text{batt,tot}}}{\cos \varphi \cdot \eta \cdot t_{\text{charge}}} = \frac{400 \text{ kWh}}{0.98 \cdot 0.9 \cdot 2 \text{ h}} = 227 \text{ kVA}$$

$$P = \frac{E_{\text{batt,tot}}}{N \cdot \eta \cdot t_{\text{charge}}} = \frac{400 \text{ kWh}}{50 \cdot 0.9 \cdot 2 \text{ h}} = 4.44 \text{ kW}$$

If the total charging power demand of 227 kVA is set into relation with the nominal connected load from case 1, this results in a diversity factor of nearly 0.4 referred to the connecting point. The individual charging points would be sufficiently dimensioned with a nominal power of 11 kW each. The power demand of a bus depot can also be estimated accordingly. For this purpose, the consumption of a bus and its stay at the depot as well as the kilometer distance must be known for the charging process.

5.1.4 Case 4: Energy Management System Available, Stipulation of a Driving Distance and the Charging Duration with Limitation of the Power Demand

Case 4 is a variation of case 3. When a parking lot of a shopping center is equipped with charging points, only a maximum power rating of 150 kVA is available for the charging points at the electric power infeed due to terms of the power supply contract. With the same assumptions as for case 3, the maximum number of charging points is determined that can be operated by means of an energy management system.

The number N for the charging points results from the charging energy $E_{\text{batt,tot}}$ based on the available total charging power $S = 150 \text{ kVA}$:

$$E_{\text{batt,tot}} = S \cdot \eta \cdot \cos \varphi \cdot t_{\text{charge}} =$$

$$150 \text{ kVA} \cdot 0.9 \cdot 0.98 \cdot 2 \text{ h} = 265 \text{ kWh}$$

$$N = \frac{E_{\text{batt,tot}}}{d_0 \cdot E_0} = \frac{265 \text{ kWh}}{40 \text{ km} \cdot 0.2 \text{ kWh/km}} = 33$$

For verification, the average power per charging point P is determined. The determined P values from case 3 and case 4 will only differ slightly due to the rounding to an integer value at the charging points:

$$P = \frac{E_{\text{batt,tot}}}{N \cdot \eta \cdot t_{\text{charge}}} = \frac{265 \text{ kWh}}{33 \cdot 0.9 \cdot 2 \text{ h}} = 4.46 \text{ kW}$$

This means that the charging points are sufficiently dimensioned with a nominal power of 11 kW. With the stipulated power limitation, a higher number of charging poles would lead to an extension of the charging time or a reduction of the charging energy.

By varying the parameters and applying safety factors, the power demand to be expected can therefore be roughly estimated in the planning. The forecast for the power demand will be the more exact, the more parameters can be integrated from the operating conditions to be expected (for example, time characteristics for the occupation of the charging stations). Such simple considerations are generally advisable, as a global diversity factor for determining the power demand cannot be specified because it typically depends on the type of use and the corresponding conditions.

5.2 Integration of an Energy Storage System

In the examples from case 2 to case 4, the energy management was only used to limit the total charging power. In addition, an intelligent charging management can also control the power outputs of the individual charging points flexibly without exceeding the limited total power received from the supply network.

The use of quick charging stations, for example, may require the corresponding charging management. If electric vehicles shall be charged at quick charging stations with full power, peak loads may arise that exceed the limits of the specified power input (Fig. 5/1).

In interaction with the load management, the use of a battery storage is a practical possibility to limit the power input from the supply network in case of peak loads. The battery storage can be recharged from the network during a low-power phase, or as a buffer energy from renewable energy technologies (for example, photovoltaic systems).

Fig. 5/1 shows how a maximum peak load of 713 kW can be limited to 500 kW by using an energy storage with an energy capacity of 250 kWh. Here, the storage injects a power of 213 kW into the peak load. Accordingly, its capacity decreases. As soon as the power demand drops below 500 kW, the battery storage is slowly recharged from the network with a low energy input until it reaches its nominal capacity.

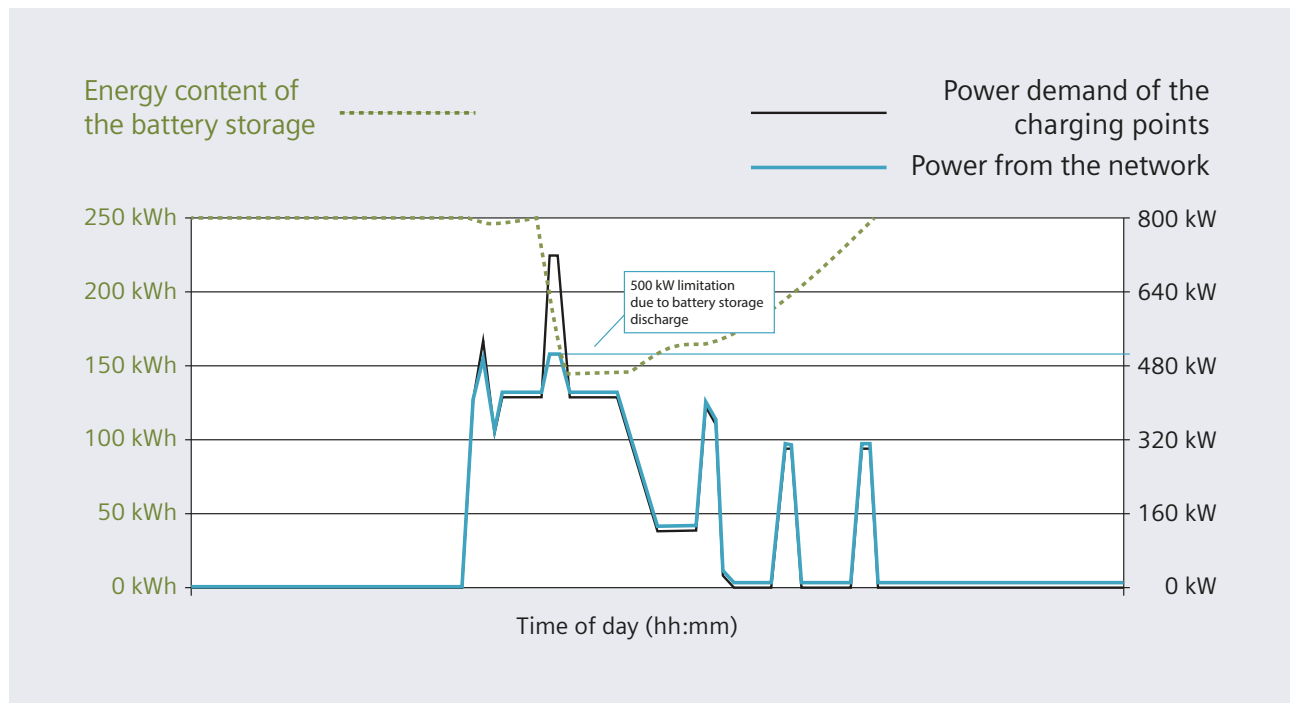


Fig. 5/1: Example for the limitation of a peak load using a battery storage

5.3 Support by Totally Integrated Power (TIP)



Your contact partners at Totally Integrated Power from Siemens (TIP) support you in the calculation and optimization of the charging power. Based on a few basic specifications, the colleagues can easily and quickly estimate the required power infeed, and determine any usable energy storage systems for you.

Checklists from Totally Integrated Power (TIP) that are put at your disposal free of charge offer support during the targeted acquisition of all data relevant for your electrical planning ([siemens.com/tip/downloadcenter](https://www.siemens.com/tip/downloadcenter)).

Additionally, the colleagues can calculate budget prices for you in the pre-planning phase, which may essentially contribute to decision-making.

Budget pricing takes the following into account:

- Medium-voltage switchgear
- Distribution transformers
- Low-voltage main distribution
- Busbar trunking systems
- Cable and line circuits including their routing
- Charging poles and/or wallboxes

In a personal conversation with you, the TIP contact partners can discuss the results and assist you with their technical expertise for assessing the results, particularly with regard to project-specific conditions.

Based on the professional feasibility estimation for the planned project, the next planning step can follow.

TOTALLY INTEGRATED POWER

Checklist for pre-planning
a charging infrastructure

Summary of influencing factors and project particularities

Project profile

☐ New construction

☐ Integration in an existing installation

Project location:

Date of implementation:

User of the charging infrastructure: e.g. employees, hotel guests, park-and-ride users, shopping customers, long-term parkers, charge-and-drive users, etc.:

Assets such as open parking garages, underground garages, electric service stations, parking areas, etc.:

Number of floors with charging points:

Number of charging points per floor:

(multiple entries possible)

Dimensions of the parking level with charging points L x W: m

(multiple entries possible)

Average floor height: m

Expandability (e.g. number of future charging points):

Billing methods of charging energy provision:

cost lump sum, exact billing of kWh, or free of charge: (multiple entries possible)

Use of load management system

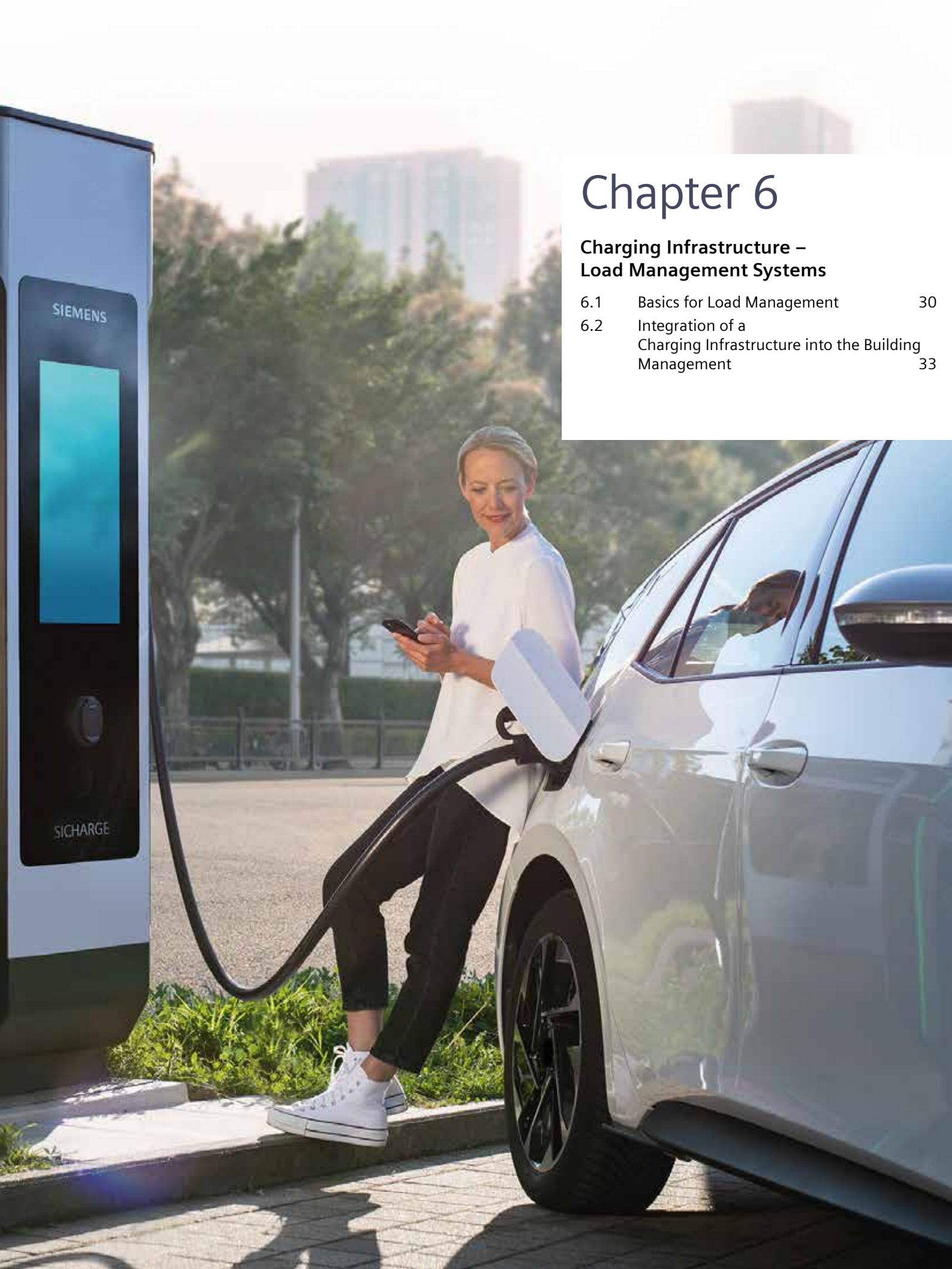
☐ Yes ☐ No

Other specifications:

SIEMENS

Totally Integrated Power 1/3

Fig. 5/2: Checklist for pre-planning a charging infrastructure



Chapter 6

Charging Infrastructure – Load Management Systems

6.1	Basics for Load Management	30
6.2	Integration of a Charging Infrastructure into the Building Management	33

6 Charging Infrastructure – Load Management Systems

According to IEC 60364-7-722 (DIN VDE 0100-722), the planning of a charging infrastructure has to take into account that charging processes may be required at all connecting points at the same time. Without an available load management system that directly prevents irregular overloads of the electrical distribution circuits, a diversity factor g of 1.0 must be applied to all affected circuits in the planning.

On this planning basis, correspondingly high connected loads with the associated high investment and operating costs would result in practice for the design of the electrical infrastructure.

When a load management system is used, the standard allows the application of diversity factors $g < 1.0$. The values to be considered in the planning depend on the respective use case and the type of use of the charging stations. If short charging times with high power outputs shall be implemented (so-called quick charging, for example in public parking spaces or highway rest areas), a diversity factor between 0.8 and 1.0 can be assumed for the planning. For charging processes with long standing times (typical applications are charging at the workplace or night-charging at home charging stations), a diversity factor in the range between 0.2 and 0.4 may be assumed (see Chapter 5).

For planning the charging infrastructure, it is recommended to equip the AC charging points perspective with a charging power of 22 kW, and to adapt or limit the power output to the current conditions by means of a load management system.

6.1 Basics for Load Management

The expansion of the charging infrastructure can cause peak loads when electric vehicles are charged in parallel. These peak loads can temporarily overload the building connection or lead to surpassing the agreed maximum energy input values. As a result, the costs for the connected load may increase unexpectedly. Under certain circumstances, additional investments may become necessary to expand the network connection and the electrical installation.

By using an intelligent load management system, the available (network connection) power can be optimally distributed to the charging points and adapted as required, and the occurrence of expensive peak load can be prevented right from the beginning. Fig. 6/1 shows the possible characteristic of a building load over a period of 24 hours.

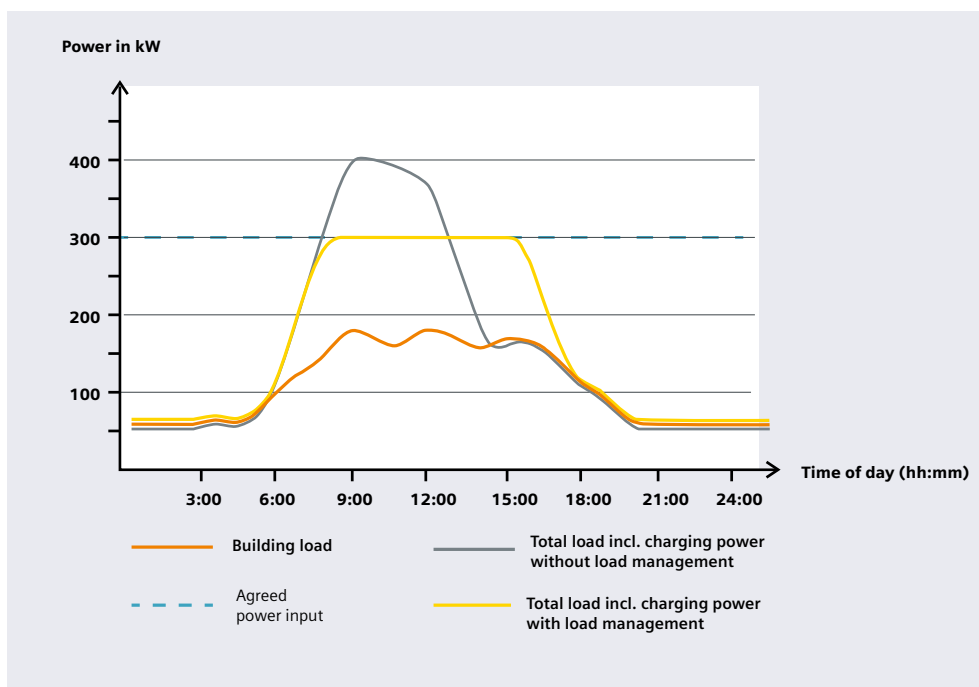


Fig. 6/1: Limitation of network-connected load by means of a load management system

The energy demand is higher in the time between 09:00 a.m. and 04:00 p.m. (beginning and end of office time). The agreed maximum power input for the network connection is 300 kW. If – at the same time of the day – 20 electric vehicles are additionally charged with 11 kW each, this would cause a peak load of 400 kW, for which the company would have to pay higher rates (Fig. 6/1 – gray curve). A load management system can prevent this peak load by redistributing the necessary charging power to other hours of the day with a lower utilization (Fig. 6/1 – yellow curve).

6.1.1 Static Load Management

In a static load management, a maximum charging power is defined that must not be exceeded (Fig. 6/2). The load from other consumers – for example, inside the building – is not considered in this case. The charging controller distributes this defined maximum charging power either uniformly to the assigned charging points, or it determines the prioritization of the charging process. This means that, the more electric vehicles start the charging process at the same time, the lower is the charging power available for all vehicles. The static load management is a simple and cost-effective solution. The disadvantage of this load management system is that – in case of a low (building) utilization – the available additional power cannot be used for charging the electric vehicles.

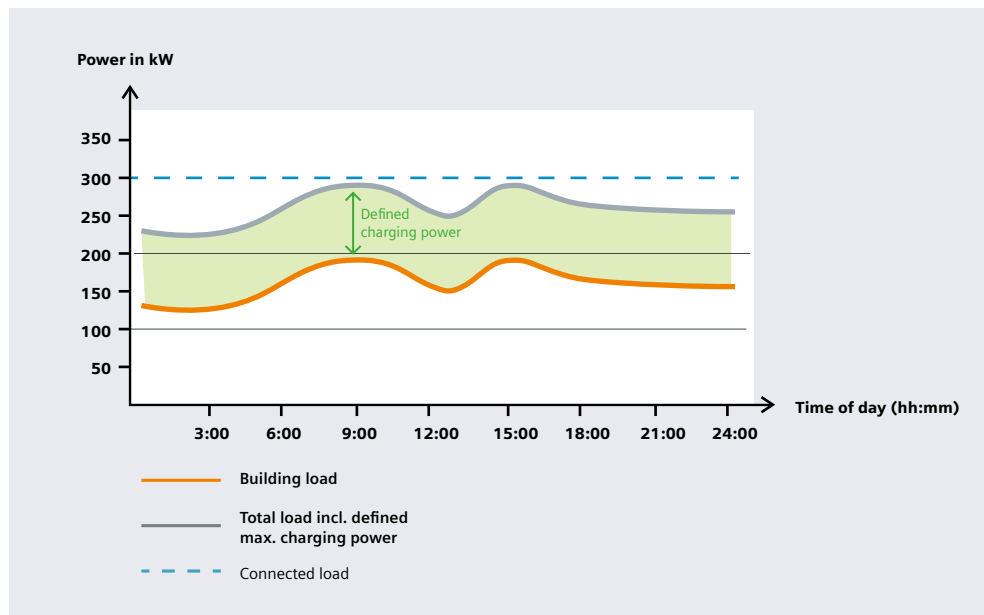


Fig. 6/2: Static load management

6.1.2 Dynamic Load Management

A dynamic load management system is particularly appropriate for companies whose energy consumption is subject to greater fluctuations, or for companies whose generating systems are coupled with renewable energies such as wind turbines or photovoltaic systems. In a dynamic load management system, the available power is continuously analyzed and optimized based on the current load situation of the network connection (Fig. 6/3).

In case of a low building load or availability of additional energy from connected embedded generating plants or renewable energies, the charging controller increases the charging power at the charging points accordingly. Analogously, the charging power is reduced automatically when the building load increases, in order to avoid peak loads and surpassing the maximum connected load.

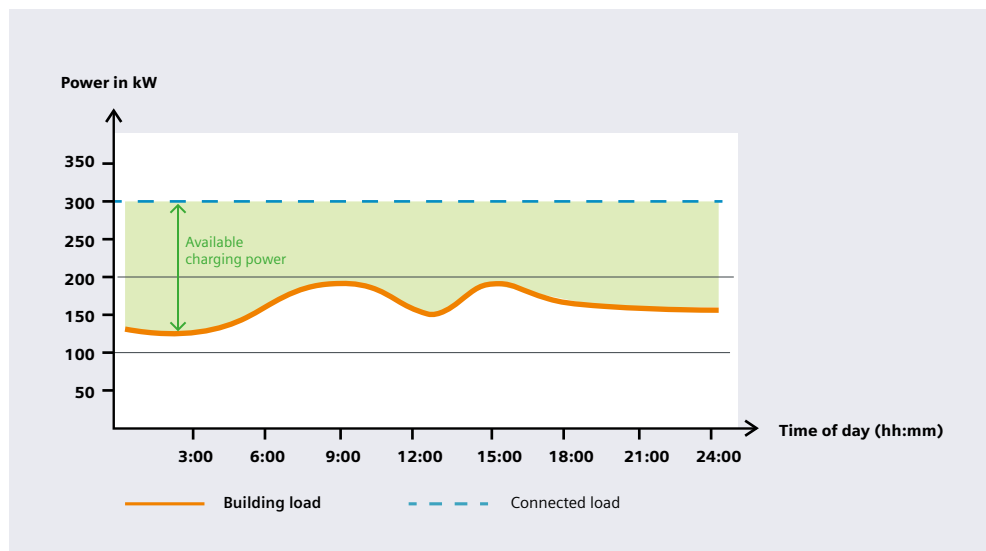


Fig. 6/3: Dynamic load management

6.2 Integration of a Charging Infrastructure into the Building Management

By integrating the charging stations into the building management system Desigo CC, a central, overlapping energy and load management can be implemented for all connected infrastructure components. Power flows and the peak load management can be displayed and controlled within this system.

The additional electric power demand of the charging stations can be monitored and controlled as a whole together with existing decentralized power sources (for example, PV plants, CHP plants) and electrical consumers from other installations. Likewise, a native integration of the charging infrastructure into a higher-level energy management system is also feasible, which enables an intelligent dynamic load management (Fig. 6/4).

Energy costs can herewith be best balanced in a cost-efficient way.

By connection to a separate, cloud-based backend system, the operations management and cost invoicing can be additionally supported and executed.

Desigo CC is a modularly designed and scalable software for building management and building automation.

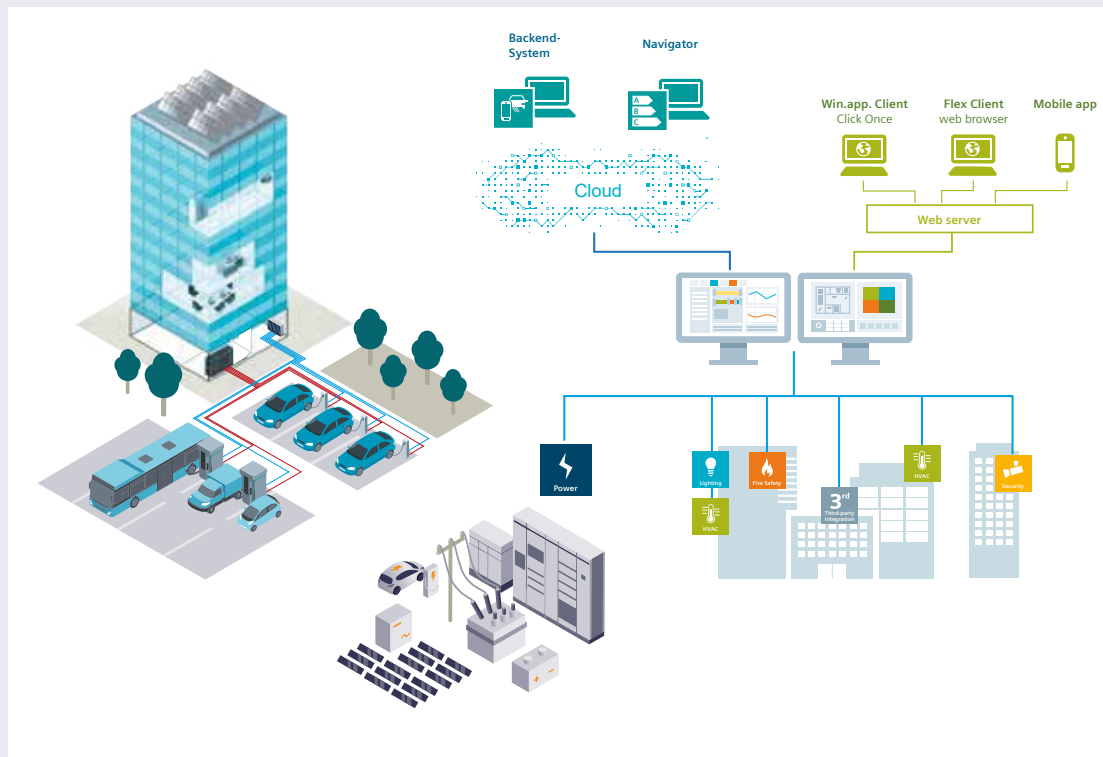


Fig. 6/4: Integration of a charging infrastructure into the building management system Desigo CC



The range of functions in Desigo CC covers the following key modules:



HVAC

Heating, ventilation, air conditioning, room automation



Fire Safety

Fire detection, fire protection flap control



Security

Intrusion protection, access control, video monitoring



Lighting

Lighting and shading control



Third-party integration

Integration of third-party components



Power

Control and energy data management for electrical components
incl. charging poles, PV, CHP, batteries

The connection of the charging stations to Desigo CC is done through an e-car adapter.

Data communication with the charging stations takes place via OCPP protocol or Modbus TCP.

The e-car adapter supplies the relevant information for the control system, for example:

- State of charging station, charging plug, plug interlock
- Charging status per electric vehicle
- Load type
- Power received (kW)
- State of charge
- Charging time
- Charging current.

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Chapter 7

Configuration Examples

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7 Configuration Examples

In this chapter, the configuration and dimensioning for charging infrastructure solutions is described on the basis of configuration examples.

7.1 Example 1 – Parking Level with 100 Charging Points

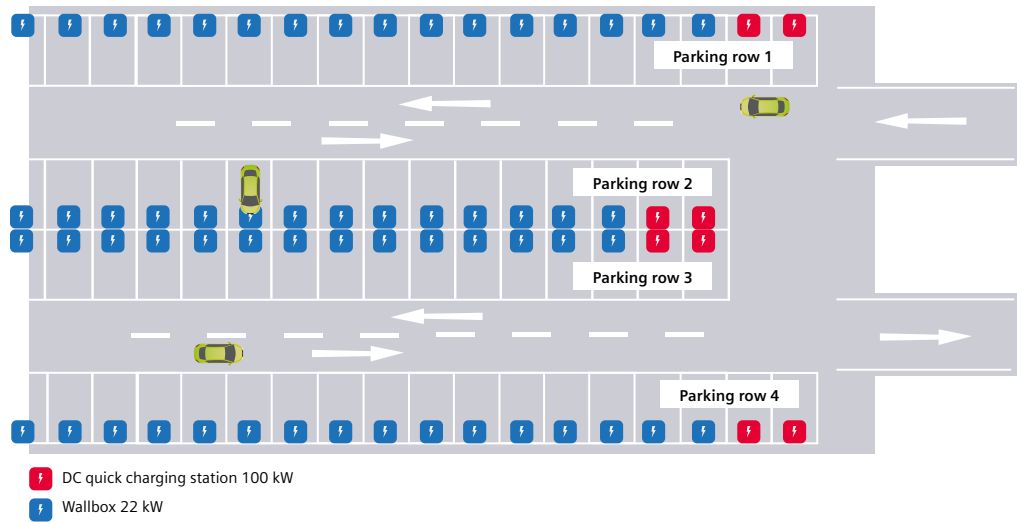


Abb. 7/1: Parking level with 100 charging points

The parking area of a parking garage in a shopping center is intended to be equipped with 100 charging points. Among that, 8 quick charging stations of 100 kW each are to be considered (Abb. 7/1).

The required connected load is to be determined, as well as the space requirements in the electrical service room for the low-voltage main distribution (abbreviated as LVMD in the following) required to connect the charging stations to the low-voltage switchboard SIVACON S8.

In the two outer parking rows 1 and 4 (26 parking spaces each), 24 wallboxes with a charging power of 22 kW each are to be installed, as well as 2 DC quick charging stations of 100 kW each.

In the two inner parking rows 2 and 3, 44 wallboxes with a charging power of 22 kW each, as well as 4 DC quick charging stations of 100 kW each are to be planned for.

The charging points are supplied from the electrical room. The distribution transformer and the LVMD are installed there.

For connecting the charging stations, two possible solution approaches are examined:

1. Connection via cable directly to the LVMD
2. Connection to busbar trunking systems supplied from the LVMD.

Power Demand Determination

The power demand for the 100 parking spaces is determined based on the method from Chapter 5.1.2 according to case study 2. To do this, a load management is installed that limits the connected load to a stipulated value. An average battery capacity of 50 kWh is assumed, whereby the vehicle batteries are discharged to 30 %.

With normal charging, the batteries are supposed to be fully charged; with quick charging, they should be charged to up to 80 % of their capacity.

The average charging time available for the parking spaces with wallboxes is estimated to be 4 h, and 30 min for the quick charging stations.

A summary of the assumed parameters to estimate the connected load is given in Tab. 7/1.

	Parking spaces	
	Wallbox	Quick charging station
Quantity	92	8
Available charging time	4 h	0.5 h
Energy to be charged related to the average battery capacity of 50 kWh	70 %	50 %
Efficiency of the charging process	0.9	
Active power factor $\cos(\varphi)$	0.98	

Tab. 7/1: Parameters to estimate the connected load

In case of full occupation of the parking spaces, this results in a charging energy of

$$\begin{aligned}
 E &= 92 \cdot 50 \text{ kWh} \cdot 0.7 + 8 \cdot 50 \text{ kWh} \cdot 0.5 \\
 E &= 3220 \text{ kWh} + 200 \text{ kWh} \\
 E &= 3420 \text{ kWh}
 \end{aligned}$$

The result is a power demand of

$$\begin{aligned}
 S &= \frac{3220 \text{ kWh}}{4 \text{ h} \cdot 0.9 \cdot 0.98} + \frac{200 \text{ kWh}}{0.5 \text{ h} \cdot 0.9 \cdot 0.98} \\
 S &= 912.7 \text{ kVA} + 453.5 \text{ kVA} \\
 S &= 1366 \text{ kVA}
 \end{aligned}$$

Then, the average charging power is

$$\begin{aligned}
 P_{\text{EVSE}} &= \frac{3220 \text{ kWh}}{4 \text{ h} \cdot 92 \cdot 0.9} = 9.7 \text{ kW} \quad \text{for the wallbox} \\
 P_{\text{EVSE}} &= \frac{200 \text{ kWh}}{0.5 \text{ h} \cdot 8 \cdot 0.9} = 55.6 \text{ kW} \quad \text{for the quick charging station}
 \end{aligned}$$

For the infeed, a 1600 kVA distribution transformer is thus required, which supplies a downstream LVMD with 2500 A.

Design option 1: Cable connection

The connection of the charging points is done with a separate cable to the LVMD.

The associated switching and protection devices are implemented as a horizontal in-line switch-fuse combination (NH, size 00).

The cables are dimensioned according to IEC 60364-5-52 (VDE 0298-4) with installation type C, characteristic numeral 30, distances of the systems "with direct contact", and reduction factor 0.72 regarding their current-carrying capacity.

Required cable cross-section:

DC quick charging station 100 kW
4 x 95 / 50 mm² (cross-section Ø = 44 mm)

AC quick charging station 22 kW
5 x 10 (cross-section Ø = 20 mm)

Determination of the number of 500 mm cable routes per parking row:

$$\begin{aligned}\text{Row 1: } & \frac{24\text{CP} \times 20 \text{ mm} + 2\text{CS} \times 44 \text{ mm}}{500 \text{ mm}} = 2 \text{ cable routes} \\ \text{Row 2/3: } & \frac{44\text{CP} \times 20 \text{ mm} + 4\text{CS} \times 44 \text{ mm}}{500 \text{ mm}} = 3 \text{ cable routes} \\ \text{Row 4: } & \frac{24\text{CP} \times 20 \text{ mm} + 2\text{CS} \times 44 \text{ mm}}{500 \text{ mm}} = 2 \text{ cable routes}\end{aligned}$$

(CP = Charging point)

The space requirements for the installation of cable routes is illustrated in Abb. 7/2, with the vertical distance between the individual cable routes, and between the cable routes and the ceiling, amounting to 300 mm.

These space requirements can create a big challenge in parking garages.

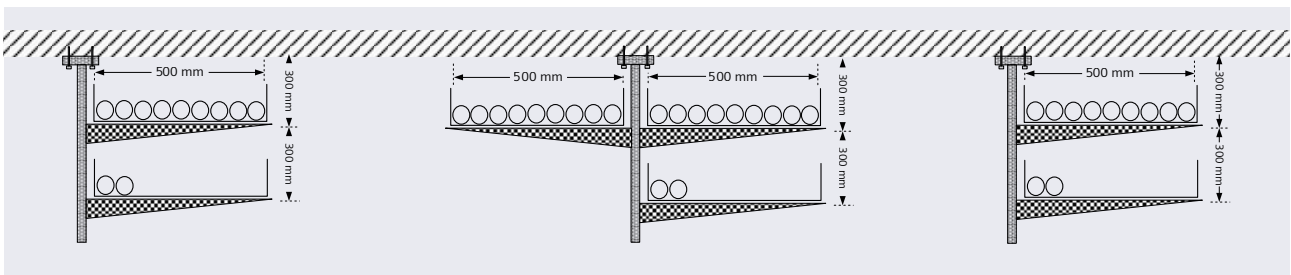


Abb. 7/2: Space requirements of cable routes; cable occupation represented as an example

The 100 charging points are centrally supplied from the LVMD. The low-voltage switchboard consists of an incoming feeder cubicle with a 3WA air circuit-breaker 2500 A and 12 outgoing feeder cubicles in non-fused technology.

Due to the short-circuit currents, 3VA molded-case circuit-breakers are used. RCD modules can be attached to them in order to implement the required protection of persons.

This makes the system independent from a possibly integrated RCD in the charging station and its short-circuit withstand strength.

The resulting total width of the low-voltage switchboard SIVACON S8 is roughly 13 m (Abb. 7/3).

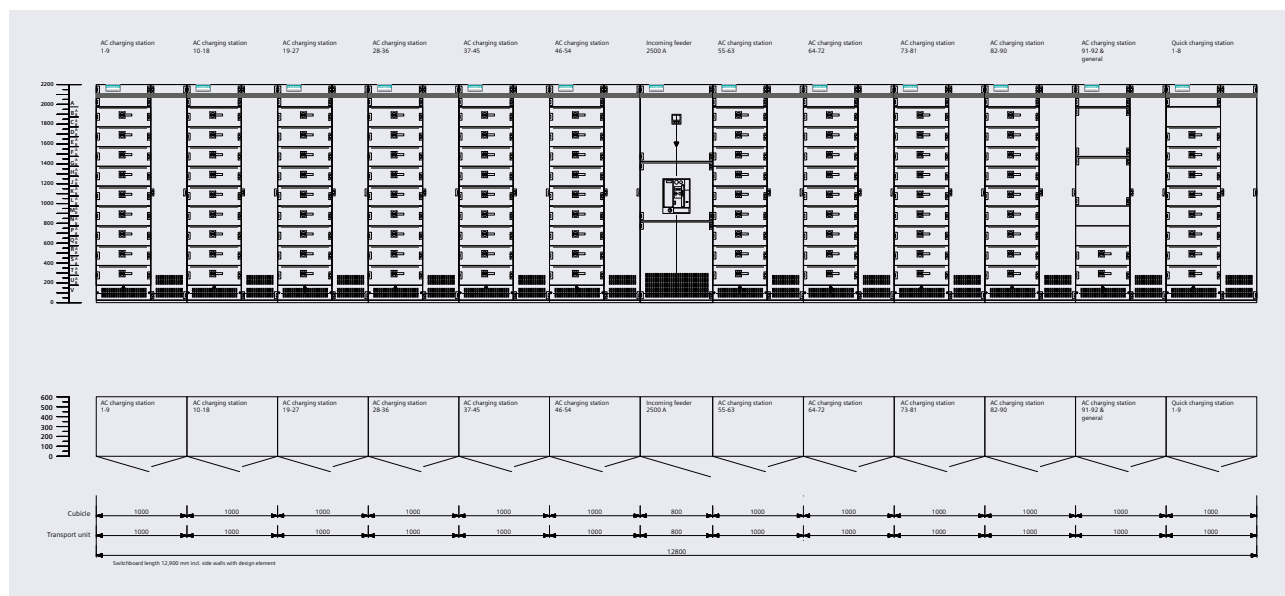


Abb. 7/3: LVMD for centralized power distribution with cables

Design option 2: Busbar trunking systems

The 3 parking rows (row 1, rows 2+3, row 4) are supplied through a busbar trunking system type BD2A, which is suspended from the concrete ceiling above the parking rows. In the steel construction, the corresponding cutouts are provided for a straight horizontal busbar run layout (Abb. 7/4).



Abb. 7/4: Cutouts in the steel structure of a parking level for a busbar trunking system

Due to the power demand in the individual parking rows, the following busbar trunking systems are configured for electrical supply:

- Parking rows 1 and 4 (outer): BD2A-630 A
- Parking rows 2 and 3 (inner): BD2A-1000 A

The space requirements for the installation of the BD2 busbar trunking systems is schematically represented in Abb. 7/5.

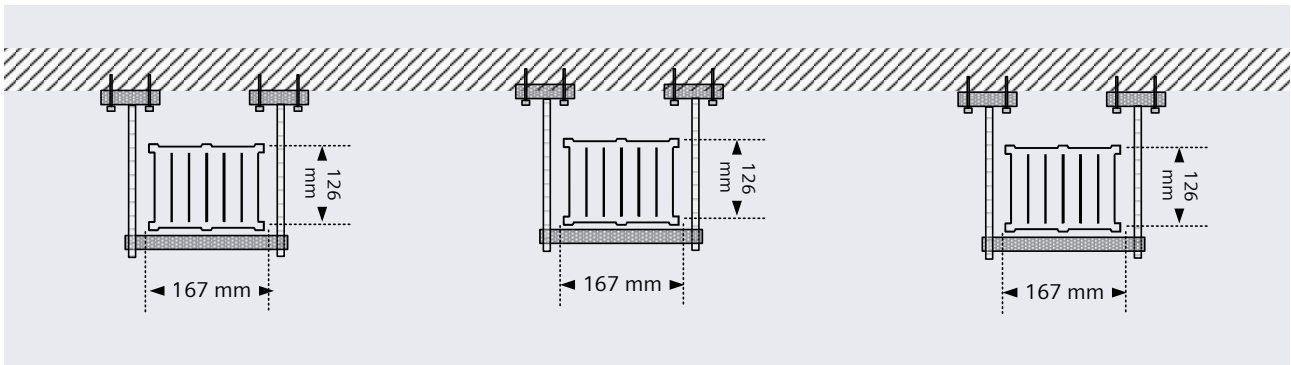


Abb. 7/5: BD2 busbar trunking system to supply the 3 parking rows

A decentralized power supply can be implemented with the help of busbar trunking systems, as the switching and protection device of each charging station is placed in the tap-off unit.

Analogously to design option 1 (cable connection), the tap-off units are equipped with non-fused technology using 3VA molded-case circuit-breakers, optionally with integrated RCD modules in order to implement the required protection of persons, regardless of the charging station and its short-circuit withstand strength.

The LVMD consists of an incoming feeder cubicle 2500 A and 3 outgoing feeder cubicles with selective 3VA2 molded-case circuit-breakers to supply the busbar runs for each parking row – 2 x 630 A and 1 x 1000 A.

The total width of the low-voltage switchboard is 2.0 m (Abb. 7/6).

As it becomes evident from the illustrations of both LVMD versions, the distribution with a decentralized supply solution using busbar trunking systems requires less than a fifth of the space compared with the centralized solution with cable installation. This can be a decisive advantage in case of lack of space in the electrical service rooms.

An additional optimization possibility is, for example, to combine two adjacent quick charging stations to one charging station with two charging points. Here, SICARGE D is the ideal solution. Since each quick charging point only requires an average power of 55.6 kW, a 150 kW design for this charging station is sufficient.

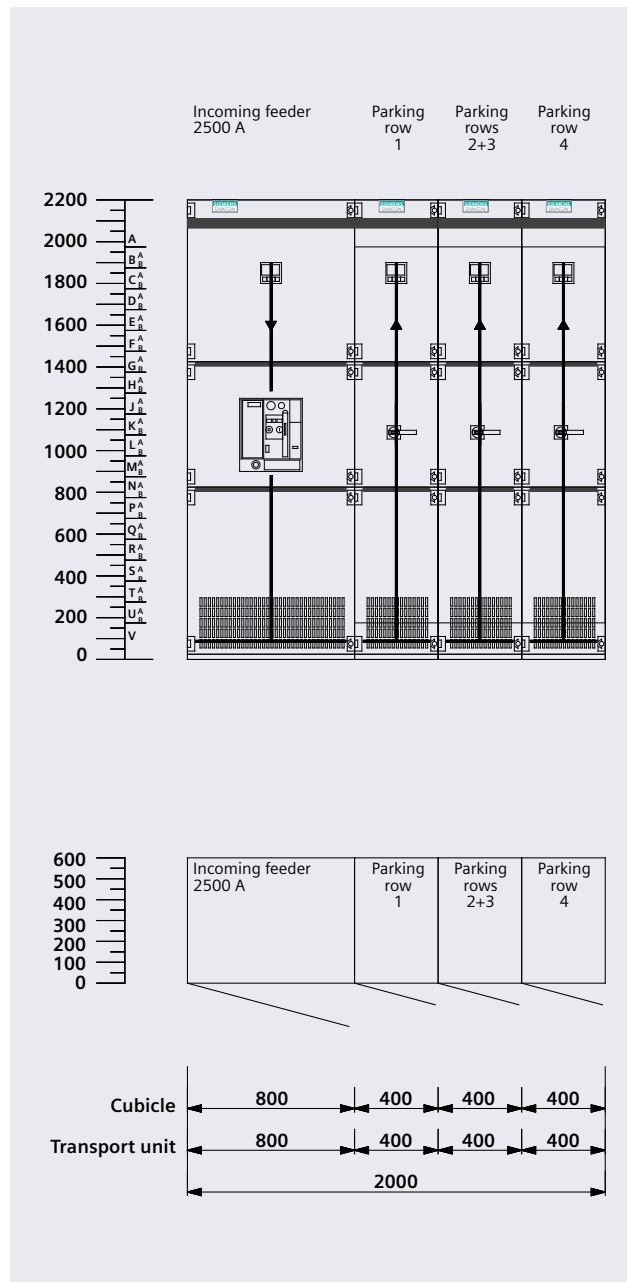


Abb. 7/6: LVMD for decentralized power supply with busbar trunking systems

7.2 Example 2 – E-Bus Depot

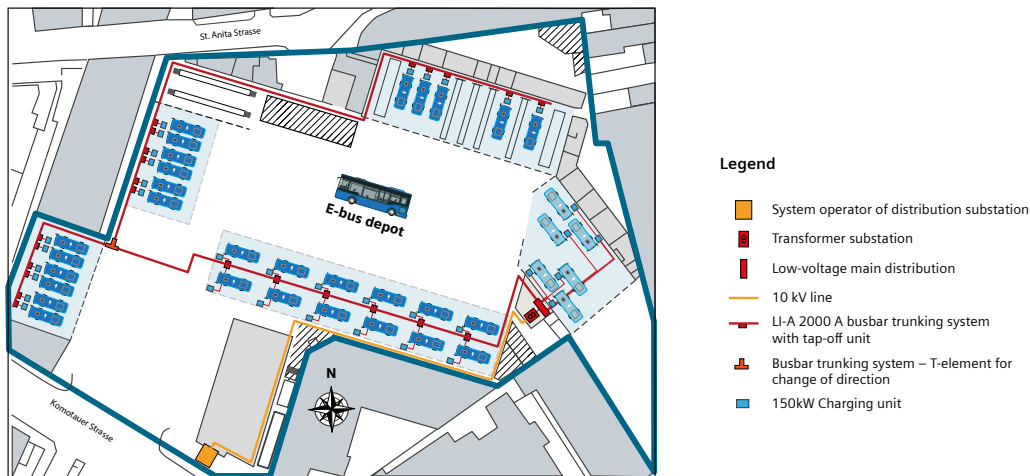


Abb. 7/7: Plan view of an e-bus depot

In this example, the power supply in a covered bus depot with 140 parking spaces is to be worked out. 35 parking spaces are intended to be configured with electric charging equipment. Abb. 7/7 shows the plan view of the bus depot. The network-side connection is done by integration into an existing 10 kV ring with a short-circuit power of approx. 250 MVA. The maximum connected load at the network interconnection point is 2 MVA. The electrical supply system should be designed with a power reserve of approx. 20 % in order to cover prospective charging power increases. The (standard) electric busses have a battery capacity of 280 kWh, and on average remain in the depot for 8 h. Out of these, 2 h are scheduled for maneuvering and cleaning of the busses, and 6 h as charging time.

The power input to be requested from the power supply company is to be determined.

For each of the 35 bus charging/parking spaces, one charging pole with a charging power of 150 kW each is to be provided.

Power Demand Determination

With regard to the electric power supply, the most important task is to estimate the required power.

The connected load for 35 bus charging / parking spaces and a charging power of 150 kW is calculated as follows, with an assumed efficiency of $\eta = 0.9$, a power factor of $\cos(\varphi) = 0.98$ for the total power demand without load management system, and taking into account a power reserve of 20 %:

$$S = \frac{35 \times 150 \text{ kW}}{0.9 \times 0.98} \times 1.2 = 7143 \text{ kVA}$$

To determine the diversity factor g , the charging duration of 6 h can be used. In this context, it is assumed that the vehicle batteries are discharged to a maximum of 20 % of their capacity to avoid deep discharge and damage. The required charging power with load management system is calculated as follows:

$$P_{\text{charge}} = \frac{280 \text{ kWh} \times 0.8}{6 \text{ h}} = 37.3 \text{ kW}$$

This results in a diversity factor at the 150 kW SICHARGE UC charging poles of:

$$g = \frac{37.3 \text{ kW}}{150 \text{ kW}} = 0.25$$

as well as a resulting connected load of:

$$S = 7143 \text{ kVA} \times 0.25 = 1786 \text{ kVA}$$

The available connected load of 2 MVA at the network interconnection point is thus sufficient.

Design

The supply concept is created depending on the conditions for the network connection on the part of the system operator, the locality of the charging points, as well as the requirements regarding equipment reserves for the infeed.

If, for example, full redundancy (n+1) is requested, an additional reserve in the form of a second transformer should be planned.

In the present example, a redundant energy infeed is not considered for cost reasons.

One suggestion for a supply concept could be as follows:

- The bus depot is supplied on the high-voltage side via an SF6-insulated medium-voltage switchgear (8DJH) comprising 2 ring-main panels with switch-disconnectors, a bus sectionalizer panel with circuit-breaker, a billing metering panel, and a transformer panel with circuit-breaker including definite time-overcurrent protection
- Due to the supply power of 1786 kVA to be requested, a 2000 kVA distribution transformer in cast-resin design (type GEAFOL) is used
- The transmission to the LVMD on the low-voltage side is implemented with a busbar trunking system in sandwich design type LI-A 3200 A
- The LMVD is supplied as a design verified switchgear and controlgear assembly type SIVACON S8 with 3WA air circuit-breakers in withdrawable design for the incoming feeder cubicle, as well as with 3VA molded-case circuit-breakers in fixed-mounted design for the outgoing feeder cubicles
- The charging poles in local proximity to the low-voltage switchboard are directly connected to the switchboard via cables. The 3VA molded-case circuit-breakers serve as switching and protection devices
- The charging/parking spaces in the periphery are connected through a busbar trunking system type LI-A 2000 A. For power transmission and distribution in the northern and southern depot area, distribution takes place via a T-unit at the tap-off point for the changes of direction
- The individual charging poles are cable-connected separately via a live, changeable tap-off unit with molded-case circuit-breaker. As molded-case circuit-breaker, the type 3VA1 is used, which takes on the short-circuit and overload protection of the charging poles.

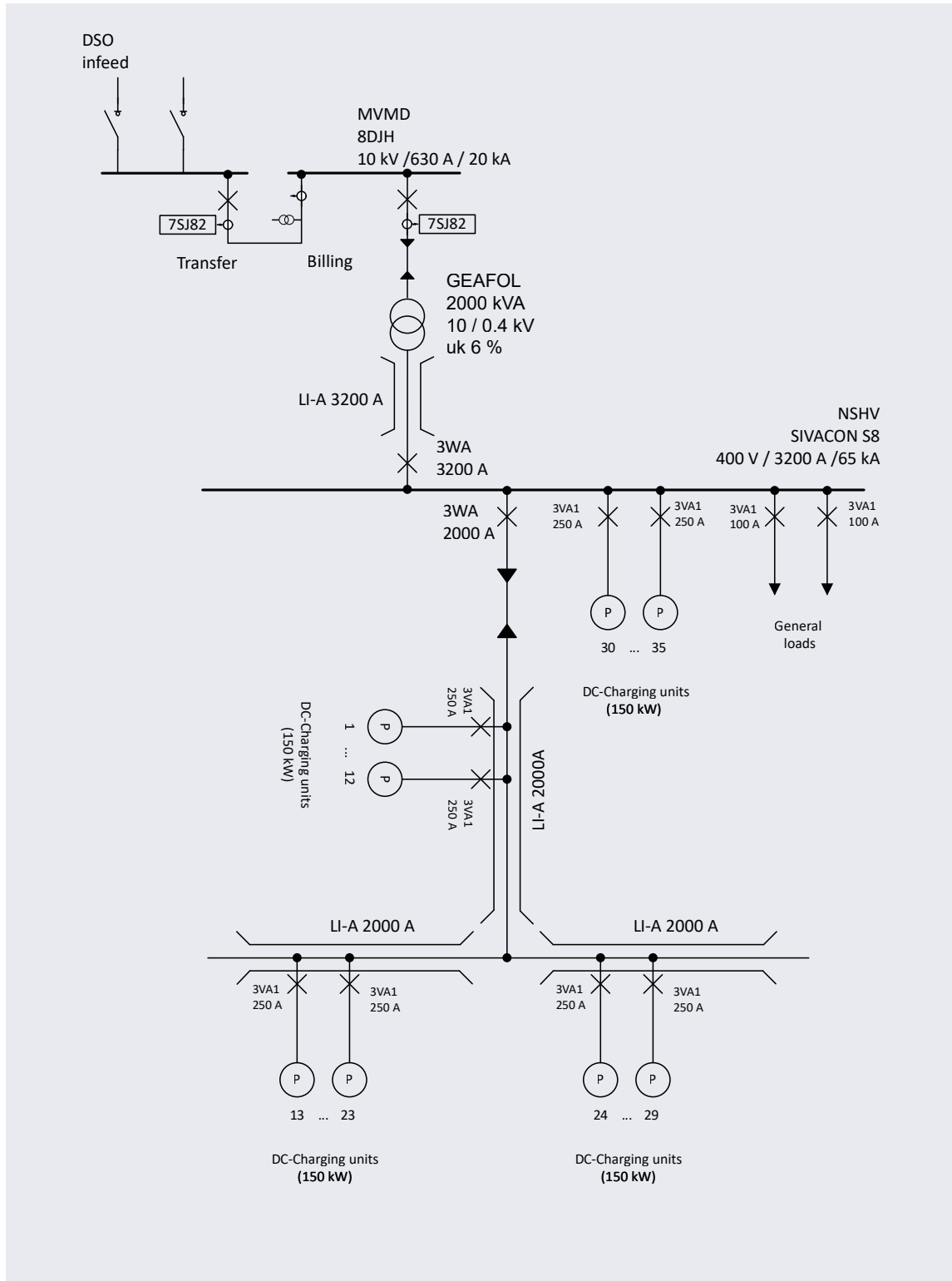


Abb. 7/8: Schematic representation of the supply concept in the e-bus depot

7.3 Example 3 – Electric Filling Station

In this configuration example, an electric filling station is to be equipped with quick charging stations for 8 charging points. It is intended to make available up to 150 kW at each charging point simultaneously during peak load times. 4 fully equipped charging stations are used, each with 300kW charging capacity and two DC charging points. The advantage of these charging stations is that they are equipped with 2 DC quick charging points. If only one charging point is occupied, the full charging power of 300 kW is available at this charging point. This ensures a quick charging.

The charging stations are supplied from a concrete substation with control aisle (alternatively, from a container solution for which, if applicable, a separate internal arc test is required). The substation contains a medium-voltage switchgear assembly type 8DJH, one transformer of 1250 kVA, a low-voltage switchboard type SIVACON S8, as well as the associated cabling (see the principle example in Abb. 7/9).



Exterior view



Interior view

Abb. 7/9: Substation with control aisle – principle example

Medium-Voltage Switchgear

The 8DJH medium-voltage switchgear is looped into the higher-level medium-voltage cable ring by means of ring-main panels equipped with short-circuit/earth-fault direction indicators according to the stipulations of the system operator. A transfer circuit-breaker panel, an air-insulated metering panel including transformer feeder form the customer part.

Overcurrent protection devices SIPROTEC 5 are used as protection devices for the circuit-breaker, for example, 7SJ82 or Reyrolle 7SR (see Abb. 7/11).



Abb. 7/10: Medium-voltage switchgear 8DJH blue GIS (free of SF6)

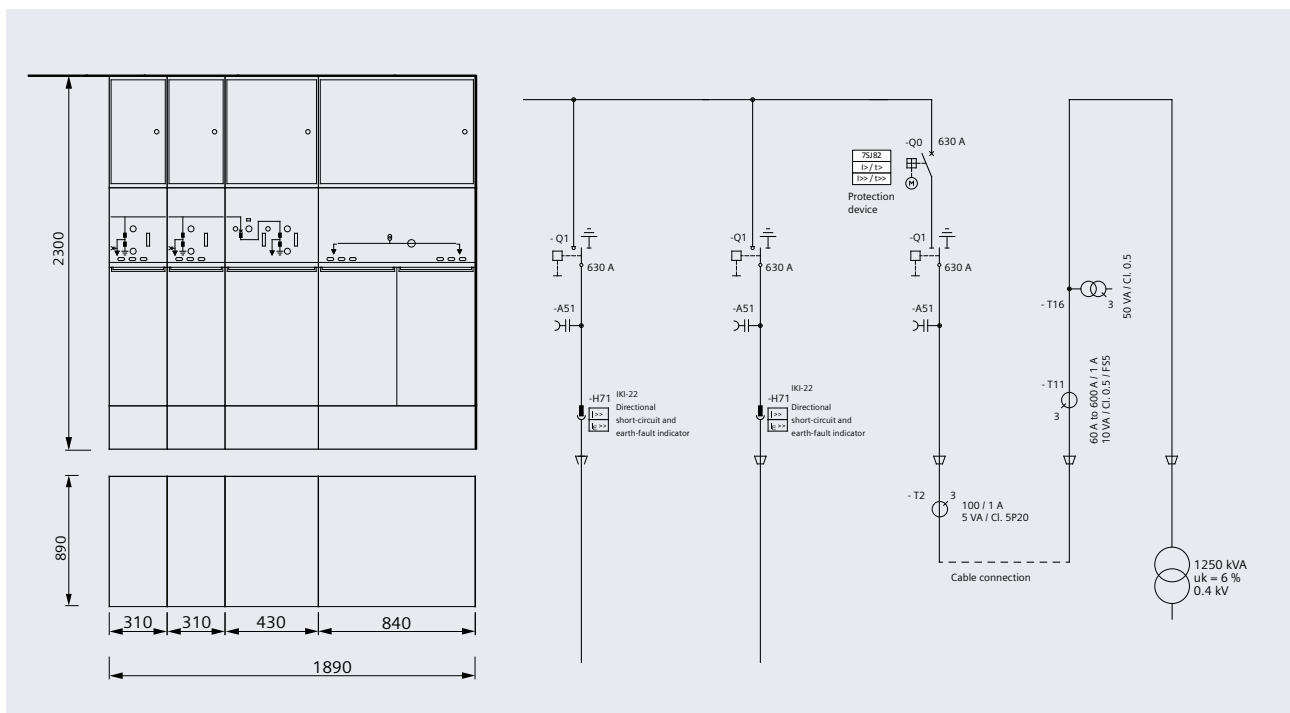


Abb. 7/11: Medium-voltage switchgear 8DJH – dimensions and single-line diagram

Distribution Transformers

Dry-type transformers type GEAFOL Neo are used.

The transformers of this product series fulfill the special requirements of the Ecodesign Directive 209/125/EC, and are designed with respect to energy efficiency in a way that is particularly low-loss and cost-efficient.

Technical features at a glance:

- Reduced weight (up to 10 %)
- Reduced dimensions
- Power loss optimized
- Reduced heat dissipation
- Long service life
- High dielectric and impulse strength
- Climatic class 3, environmental class 3, fire behavior class 1
- Certified according to VDE 0532 / IEC 60076-11 or DIN EN 60076-11
- Maintenance-free windings
- Flame-retardant, self-extinguishing insulating material.

As an alternative, the use of oil-immersed distribution transformers from the Fitformer product series is possible.



Low-Voltage Switchboard

The low-voltage switchboard SIVACON S8 (Abb. 7/12) is supplied via an open circuit-breaker type 3WA in withdrawable design. A PAC4200 measuring device in this cubicle, or the integrated measuring functions within the circuit-breaker, take on the measurement of energy and other electrical parameters such as voltage, currents, harmonics or power. Two other cubicles contain the outgoing feeders with 3VA molded-case circuit breaker with motor operating mechanism and additional device compartments for secondary systems, as well as additional components for communication and connection to the cloud.

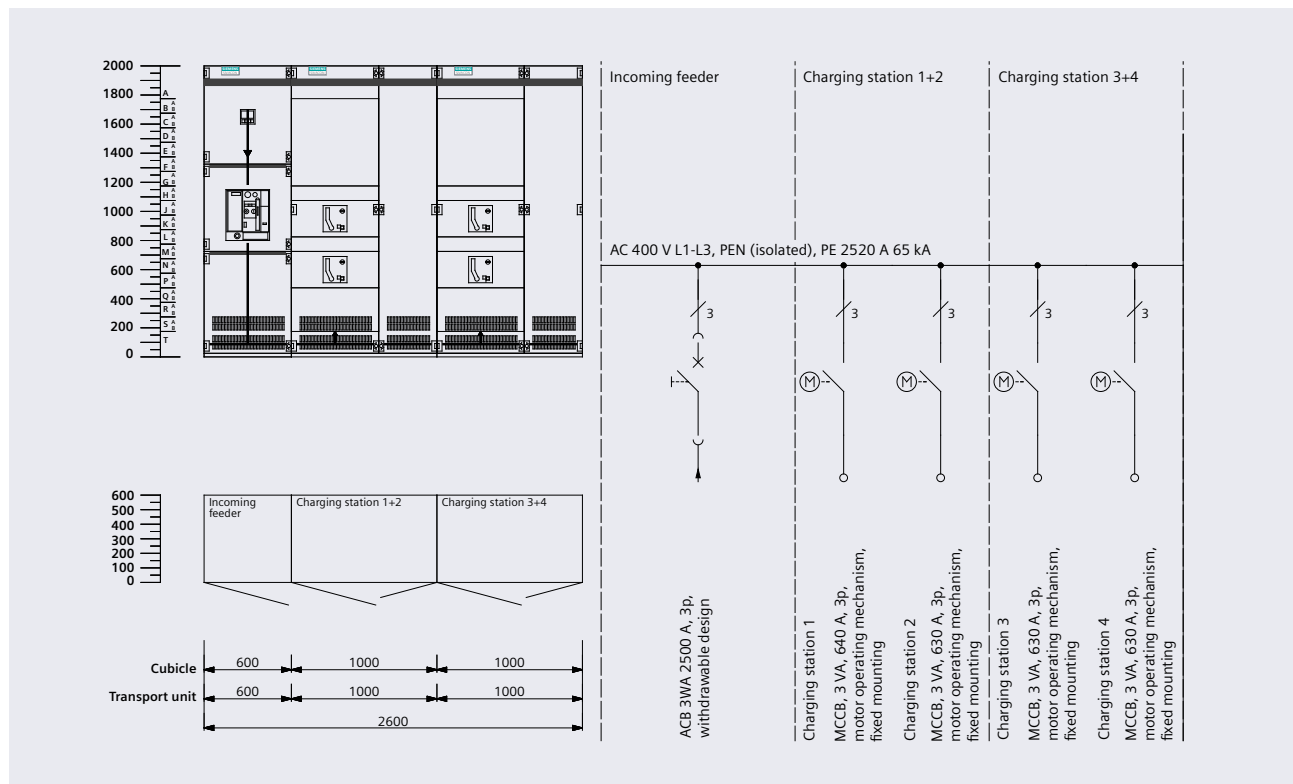


Abb. 7/12: Low-voltage switchboard SIVACON S8 – dimensions and single-line diagram

IoT Architecture

Abb. 7/13 shows a possible IoT (Internet of Things) architecture consisting of a Siemens gateway and a Siemens field controller. This combination makes it possible to collect digital and analogous data from the substation and its operational equipment in a central place. Data transmission is done by means of different communication systems, for example Modbus TCP for the low-voltage circuit-breakers, Modbus RTU for the medium-voltage protection relays, or hardware wiring to the sensors in the switchgear assemblies or at the transformer.

At field level, a COM800 communication module with the function of a data concentrator is used to transmit information from the molded-case circuit-breakers (3VA) supplying the charging poles, as well as a COM190 communication module for data transmission from the low-voltage air circuit-breaker (3WA) within the incoming feeder.

The described Siemens solution makes it possible for the operator of an electric filling station to have a real-time monitoring of the substation. Via mobile communication (3G/4G or LTE), data can be transmitted to a higher-level cloud application via a router using the MQTT protocol.

Relevant information can be visualized within the cloud environment and prepared in dashboards.

An intelligent use of cloud information can make a significant contribution to enhancing operational safety, availability and reliability of the system, and also to saving maintenance cost. The operator has the opportunity to respond to disturbances or failures in a timely manner, and access the system from remote, if required. This enhances the efficiency of substation operation in a sustainable way, and makes it possible for customers to charge their vehicles without interruption as much as possible.

Examples for useful data and functions:

- Predictive maintenance (4.0)
- Remote commissioning of the substation
- Measurement, for example, of temperature and air humidity (avoiding substation overheating, possibility to connect ventilation)
- Door contacts or motion sensors in the substation, for example, intrusion protection
- Substation overview or monitoring of the live condition of the entire substation
- Remote reset of the charging poles in case of disturbances or faults
- Monitoring, evaluation and visualization of (electrical) parameters, for example:
 - Current
 - Voltage
 - Power flow
 - Switching rates.

Data from the Siemens cloud platform can be exchanged with other external cloud solutions. Apart from the compatibility of both platform technologies, a consistent cybersecurity concept is to be considered, too.

The charging poles can be connected to a backend system through the used router. A load and energy management, remote maintenance of the charging poles, as well as the option for charging cost invoicing can be realized this way.

Data exchange between the router and the backend system takes place via Modbus TCP and OCPP.

The used Siemens field controller permits the implementation of a local load management in the substation. Communication between the field controller and the charging poles is done via OCPP or Modbus TCP protocol.

Any load throttling stipulations of the network operator – for example, to avoid peak loads in the distribution network – can be implemented by connecting the utility telecontrol system to the field controller.

If necessary, on-site monitoring and activation can be implemented using a local HMI in the substation.

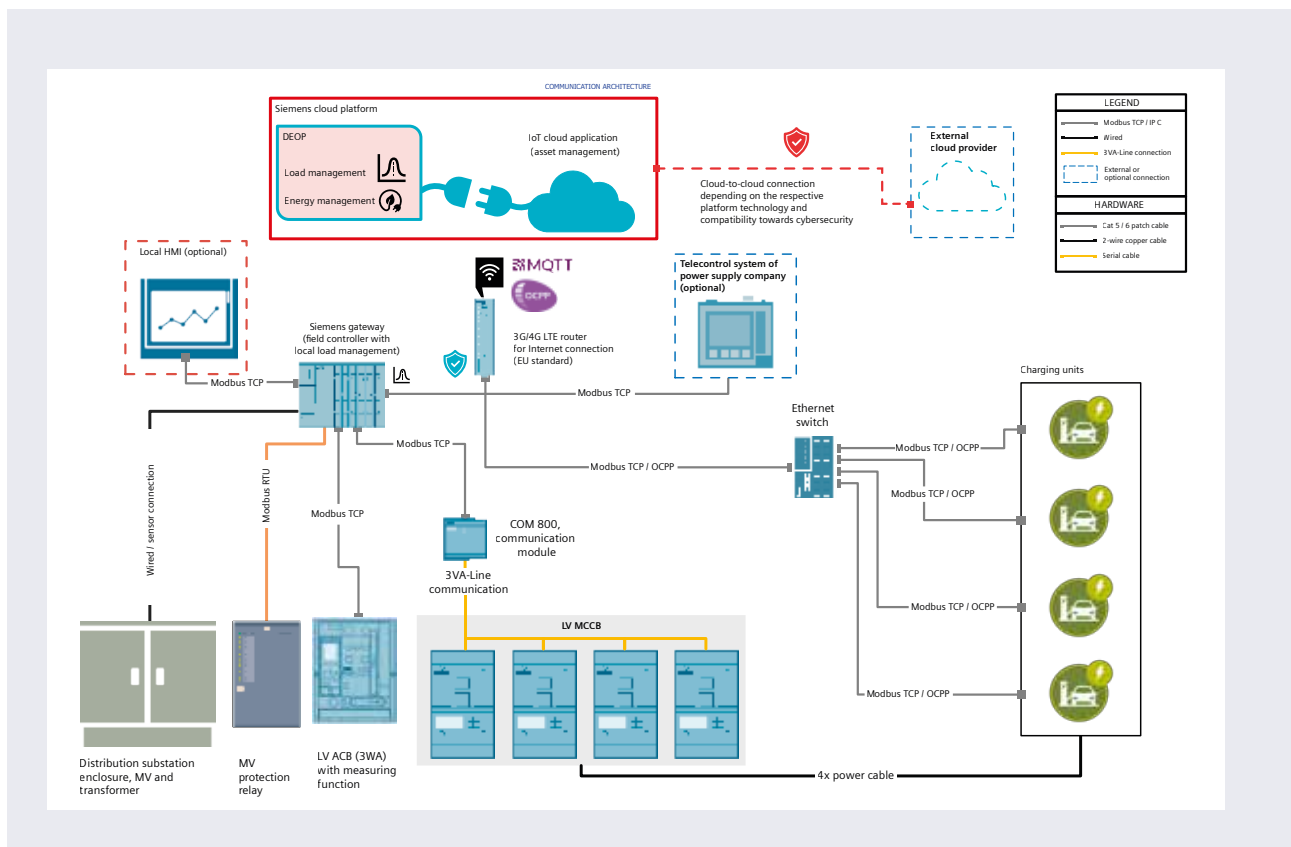


Abb. 7/13: IoT setup – hardware and architecture



Chapter 8

Annexes

8.1	List of Abbreviations	53
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8.3	Siemens Close to You	55

8 Annexes

8.1 List of Abbreviations

3G	Mobile communication standard 3 rd generation (UMTS)
4G	Mobile communication standard 4 th generation (LTE)

A

AC	Alternating Current
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B

BEV	Battery Electric Vehicle
-----	--------------------------

C

CCS	Combined Charging System
CEE	Commission on the Rules for the Approval of the Electrical Equipment
CHAdeMO	CHArge de MOve
CHP	Combined Heat and Power
CP	Control Pilot
CS	Connection Check Signal

D

DC	Direct Current
DPA	Dynamic Power Allocation
DNO	Distribution Network Operator
DSO	Distribution System Operator

E

EEG	Erneuerbare-Energien-Gesetz (German law on renewable energies)
EMC	Electromagnetic Compatibility
ERK	Eichrechtskonform (according to German weights and measures legislation)
EVC	Electric Vehicle Connect Charge & Control
EVSE	Electric Vehicle Supply Equipment

H

HMI	Human-Machine Interface
HVAC	Heating, Ventilation, Air Conditioning

I

IC-CPD	In-Cable Control and Protection Device
IoT	Internet of Things

L

LEV	Light Electric Vehicle
LIN	Local Interconnect Network
LPZ	Lightning Protection Zone
LTE	Long Term Evolution (mobile communication standard)
LVMD	Low-Voltage Main Distribution

M

MID	Measuring Instruments Directive
MQTT	Message Queue Telemetry Transport (standard protocol for IoT applications)

N

NFC	Near Field Communication
-----	--------------------------

O

OCPP	Open Charge Point Protocol
on-board charger	Charger located in the vehicle
off-board charger	Charger located outside of the vehicle

P

PE	Protective Earth
PHEV	Plug-in Hybrid Electric Vehicle
PP	Proximity Pilot
PV	Photovoltaic
PWM	Pulse Width Modulation

R

RCCB	Residual Current Operated Circuit-Breaker
RCBO	Residual Current Operated Circuit-Breaker with Overcurrent Protection
RCD	Residual Current Device
RFID	Radio-Frequency Identification

S

SaaS	Software as a Service
SPD	Surge Protection Device

T

THD	Total Harmonic Distortion
TIA	Totally Integrated Automation
TIP	Totally Integrated Power

U

UMTS	Universal Mobile Telecommunications System (mobile communication standard)
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8.2 Bibliography

No.	Publishers / Authors	Year	Title
1	BMWi.de	2011	Regierungsprogramm Elektromobilität; mehrere Bundesministerien (German governmental program for electromobility; various Federal Ministries)
2	de.statistika.com	2022	Business Data Platform – Insights und Fakten aus 170 Branchen und 150+ Ländern (insights and facts across 170 industries and 150+ countries)
3	ev-volumes.com	2022	The Electrical Vehicle World Sales Database
4	BMWi.de		Rahmenbedingungen und Anreize für Elektrofahrzeuge und Ladeinfrastruktur (framework conditions and incentives for electric vehicles and charging infrastructure)
5	BDEW / DKE / ZVEH / VDE FNN	2022	Leitfaden Elektromobilität, Version 3 (German electromobility guideline, version 3)
6	Dehn company	2020	White Paper: Blitz- und Überspannungsschutz für die Elektromobilität (lightning and surge protection for electromobility)
7	VDA	2021	Verband der Automobilindustrie (German association of the automotive industry)

8.3 Siemens Close to You

For further project support in the planning and dimensioning of power distribution systems for infrastructure and industrial buildings, the TIP Consultant Support from Siemens is at your disposal with professional expertise.

Totally Integrated Power provides comprehensive support for electrical planners in the different planning phases with

- Software tools
- Revit files Building Information Modeling (BIM)
- Tender specification texts

Integrated planning increases cost-efficiency, safety and reliability of power distribution systems. Totally Integrated Power offers assistance for the conception of consistent power supply solutions for applications in infrastructure, buildings and industry – also for critical power supplies as required, for example, in hospitals and data centers. Efficiency considerations and energy management complete the consulting portfolio.



- Planning and application manuals.

Professional consulting as well as training offers, performed by technical experts from different countries, round off the support services from TIP.

Please use the personal contact also to learn more about the SIMARIS planning tools that were used as a basis for dimensioning the configuration examples shown in Chapter 7.

[siemens.com/tip](https://www.siemens.com/tip)

SIMARIS planning tools – for efficient planning support

Planning the electric power distribution for industrial plants, infrastructure and buildings is becoming more and more complex. The innovative SIMARIS planning tools effectively support you as an electrical planner to enable you to continue working efficiently under the given conditions. Within the SIMARIS Suite you can obtain the latest Information on all available planning tools, which you can access easily and quickly.

[siemens.com/simaris](https://www.siemens.com/simaris)



BIM for electrical planning

BIM (Building Information Modeling) for easy exchange of all relevant building data ensures the quality, and saves both time and money. Totally Integrated Power provides BIM-capable objects, data and tools for power distribution, such as Revit files for low-voltage switchboards and medium-voltage switchgear, busbar trunking systems, and transformers.

[siemens.com/bim-eplanning](https://www.siemens.com/bim-eplanning)



Tender specification texts

TIP provides tender specification texts from the Siemens product portfolio. They comprise products and systems of building technology, electrical power distribution, industrial switching technology, drive technology, automation technology, as well as safety technology. The texts can be exported in the formats .TXT, .RTF, .DOCX, and .GAEB.

[siemens.com/specifications](https://www.siemens.com/specifications)



Trainings and events

Benefit from the comprehensive technical knowledge and the project expertise of our lecturers. Within the scope of face-to-face events as well as in digital formats, Totally Integrated Power offers trainings, knowledge exchange, or even practice-oriented workshops around the planning of electric power distribution.

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