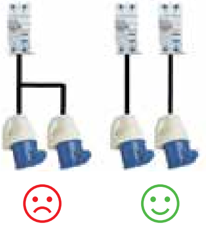
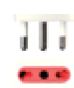
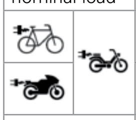
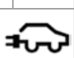
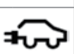
Getting connected
Electromobility and infrastructure

Tips & Recommendations



- Work on electrical installations must be performed only by qualified personnel!
- The existing electrical installation should be certified by an electrician or the electric power supplier (EPS) before it is used as a charging station.
- Caution: Risk of falling and mechanical overload of plugs and cables. Socket-outlets or charging infrastructure should be as close as possible to the electric vehicle.
- For each electric vehicle respectively socket-outlet/ connection an independent circuit-braker (CB) and an independent (RCD) should be used.
- If the power connection is used regularly to supply electric vehicles - including from third-parties, such as visitors, customers or guests, it is recommended to install a separate connection (CEE plug or Home Charge Device) for safety reasons.
- Commercial-quality travel adaptors are not suitable to charge electric vehicles.
- Adapter cables should only be used in exceptional situations, and for continuous operation, it should be protected with an 8 A fuse.
- The use of a cable reel is not appropriate due to the danger of overheating. If, in exceptional cases, it needs to be used, it must be completely unreeled.
- For vehicles with power rating over 2 kVA ≈ 2 kW, the socket-outlet and plug of the charging cable must be equivalent to at least CEE 16 A/230 V.
- Batteries should only be charged in ventilated and dry rooms.
- Some electric power suppliers and municipalities support electromobility. It is worth learning more about which conditions apply.
- In the event of a vehicle breakdown, never touch the electrical system. Leave the diagnosis and repair to professional personnel.

Characteristics of country-specific (domestic) socket-outlets and their suitability for charging

	Country-specific (domestic) socket-outlets							Industrial socket-outlets		Mode 3 socket-outlets	
IEC/National	Type 13	Type 23	CEE 7/5	CEE 7/4	BS 136	Afsnit	CEI 23	IEC 60309-2		IEC 62196-2	
International	Type J	(Type J)	Type E	Type F	Type G	Type K	Type L	CEE 16	CEE 16	Type2	Type 3
Socket-outlet											
Plug			CEE7/7								
Standardized and approved	CH / LI	CH / LI	F / B / MC / PL / CZ / SK	D / A / GR / L / MC / NL / N / S / SLO / ES / TR / RUS	GB / IR / M / CY	DK	I	Europe global	Europe global	Europe global	Europe global
Rated voltage (V)	230 (250)	230 (250)	230 (250)	230 (250)	230 (260)	230 (250)	230 (250)	230 (250)	400 (480)	400 (480)	230 (250)
Rated current (A)	10	16	16	16	13	13	10	16	16	32	16
Mechanical load	☹	☹	☹	☹	☹	☹	☹	☺	☺	☺	☺
Cont. oper. at nominal load	☹	😐	😐	😐	😐	😐	😐	☺	☺	☺	☺
	☺	☺	☺	☺	☺	☺	☺	😐	☹	☹	😐
	☹	😐	😐	😐	😐	😐	😐	☺	☺	😐	☺
PHEV 	☹	😐	😐	😐	😐	😐	😐	☺	☺	😐	☺
EV 	☹	😐	😐	😐	😐	😐	😐	☺	☺	☺	😐
	☹	☹	☹	☹	☹	☹	☹	😐	☺	☺	😐

Type of charging modes

The different types of charging methods are called «mode».

Mode 1

Alternating current (AC) charging using a standard domestic or industrial (CEE approved) socket-outlet. No communication between power output (socket-outlets) and vehicle.

Mode 2

Same as mode 1, but using an in-cable control box (ICCB) or also called «in-cable control and protection device» (IC-CPD). This ICCB is used to connect an electric vehicle, which is usually charged in mode 3, to a standard or CEE socket-outlet. Communication between the ICCB/IC-CPD and the vehicle, see page 12.

Mode 3

Charging with 1- or 3-phase alternating current (AC) is only possible with a dedicated type 2/type 3 socket-outlet or with a permanently installed mode 3 charging cable. Communication between the charging station (socket-outlet) and the vehicle. Fast charging using direct current (DC).

Mode 4

Fast charging using direct current (DC). Communication between the charging station and the vehicle.

«Communication», when referring to e-mobility, contains two separate processes. Mode 2, 3 or 4 include safety information regarding energy transfer, such as amperage or control of the earth conductor between the vehicle and the power outlet, etc. «High level communication», in addition to the mode signal, may include, for example, user information, identification, accounting/billing data and many more.

Typical power consumption of electric vehicles

The user groups have different requirements regarding the charging infrastructure and parking (storage space). Placing different charging stations in the same area might cause problems.

	Typical values				Cost of full charge at high tariff time (CHF)
User groups	Charging power [kW]	Charging current [A]	Voltage [V]	Battery capacitiy [kWh]	
E-bikes	up to 2	up to 8	up to 250	0,1 – 2,0	0.02 – 0.40
E-scooters	up to 3	up to 13	up to 250	1 – 3	0.10 – 0.80
E-motorcycles	up to 3	up to 16	up to 250	1 – 5	0.20 – 1.00
PHEV	up to 6	8 – 32	up to 250	1 – 10	0.20 – 2.00
Three & four-wheeled EV	2 – 22	8 – 32	up to 400	5 – 25	1.00 – 5.00

Types of car parking areas and possible charging options

Depending on the usage, the individual user groups have very different requirements regarding the charging infrastructure. A description of the different installation possibilities can be found in the «Architects, Electricians and Planners» Section.

Private – Access only with owner's permission. Private property.

Semi-private – Access to authorized persons. Underground garage in apartment buildings, garages in housing complexes, company parking lots, parking areas.

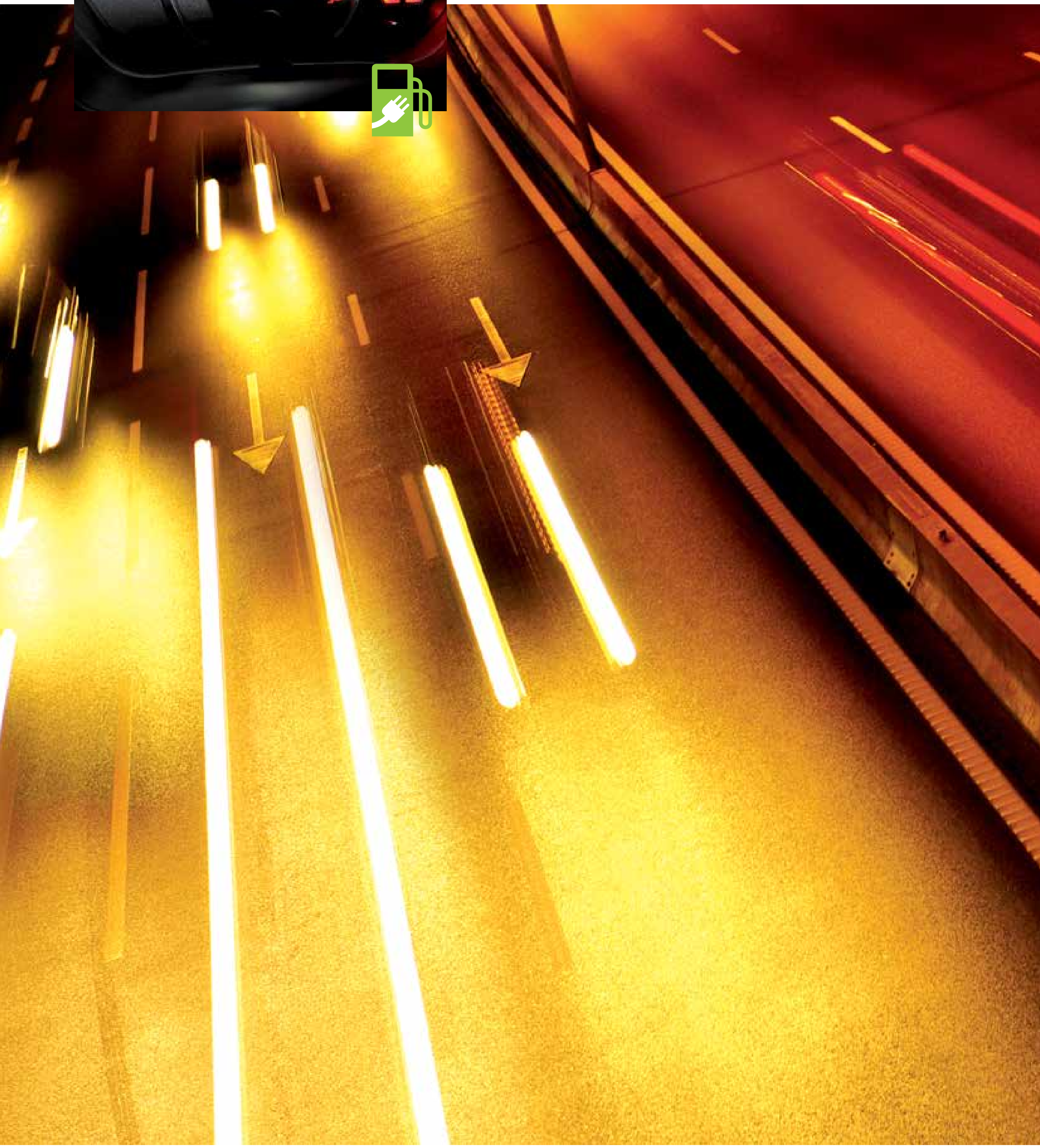
Semi-public – Access to customers. Parking lots at post offices, shops, shopping centres, managed areas, parking areas.

Public – Public access in general. Streets, squares, train stations.

Aspect	**private**	**semi-private**				**semi-public**		**public**	
Parking place	**Private person**	**Worker**	**Visitor**	**Fleet**	**Tennant**	**Customer**	**Free time**	**P&R commuter**	**Traveller**
Domestic socket-outlet	🙁	🙁	🙁	🙁	🙁	🙁	🙁	🙁	🙁
CEE socket-outlet	🙂	🙂	🙂	🙂	🙂	🙂	🙂	🙂	🙂
Mode 3	😐	😐	😐	😐	😐	🙂	😐	🙂	🙂
Home Charge Device (HCD) CEE	🙂	🙂	🙂	🙂	🙂	🙂	🙂	😐	😐
Home Charge Device (HCD) Mode 3	😐	😐	😐	😐	😐	🙂	🙂	😐	😐
Public charging station	🙁	😐	😐	🙁	😐	😐	😐	🙂	🙂
Fast charging station	🙁	🙁	😐	😐	🙁	😐	🙁	🙁	🙂
Parking duration (hours)	8 – 12	4 – 10	0,5 – 3	0,5 – 3	8 –12	0,5 – 3	1 – 8	4 – 10	> 2
Day	😐	🙂	🙂	😐	😐	🙂	🙂	🙂	🙂
Night	🙂	😐	😐	🙂	🙂	😐	🙂	😐	🙂
Range (km) / Day (typical values)	30 – 40	< 50	< 20	> 50	30 – 40	< 20	< 30	< 30	> 50

Contents

“Socket-outlets for charging electric vehicles are, in principle, available everywhere.”



Introduction

Electric vehicles (EVs) are gradually taking over individual transportation. Especially for commuters, there is a new environmentallyfriendly way to commute to/from work. The needs and requirements of EV users are multi-faceted, especially regarding the charging infrastructure – and so are the solution approaches. Although almost all buildings have multiple socket-outlets, not all of them are suitable for charging EV batteries.

The questions concerning the charging infrastructure are new for most stakeholders. Necessary international standards are currently being developed and technical harmonization and political lobbying is under way. As for the «plug» and the «right» connection, there are still many open questions.

This brochure discusses today's key issues for Switzerland. The emphasis is on electric cars, including extended range and plugin hybrid vehicles. One chapter is dedicated to two-wheeled electric vehicles.

This informative document results from the work of subject-matter experts from relevant Swiss associations and organizations. They can be contacted for further information and advice regarding electric mobility and, particularly, the charging infrastructure.

Swiss Association for Electric and Efficient Vehicles, e'mobile

Swiss Electricity Industry Association (SEA)

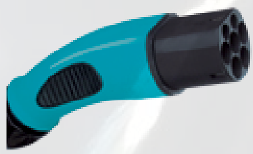
Electrosuisse Association for Electrical Engineering, Power and Information Technologies

> Switching to electric vehicles requires, mainly, a new way of thinking about fuelling.

Vehicle-connectors
for mode 3 AC &
mode 4 DC

Type 1
AC vehicle-connector

Type 2
AC vehicle-connector



CHΛdeMO™
DC vehicle-connector
mode 4

System CCS
DC vehicle-connector
mode 4 CCS Type 1

DC vehicle-connector
mode 4 CCS Type 2

Overview | EV drivers

Vehicle-inlets
(Commen connections on vehicles)

Type 1
AC vehicle-inlet

Type 2
AC vehicle-inlet

System CHΛdeMO™
DC vehicle-inlet
mode 4

System CCS
DC vehicle-inlet
mode 4 CCS Type 1

DC vehicle-inlet
mode 4 Type 2

Individual drivers usually travel around 30 to 40 km per day. Only around 2 % of commuters travel over 100 km daily. This means that, in most cases, a battery that provides a ramge of 100 km is suitable for daily requirements.

Charging process
In order to use electricity from electric power suppliers (EPS) to charge electric vehicles, alternating current (AC) must be converted into direct current (DC). This is done through a charging unit. For four-wheel electric vehicles, the charger is usually built into the vehicle (on-board charging). The charging electronics (Battery Management System – BMS) controls and monitors the charging process based on temperature, state of charge (SOC), and voltage of the battery.

Depending on the type of vehicle, there are different power requirements. Two-wheeled vehicles, such as e-bikes, e-scooters and e-motorcycles, have different requirements compared to three or four-wheeled vehicles (see front cover flap).

Often EV traction batteries are recharged either at home and/or at work. Charging during working hours extends the travel range. So today 80 % of the population could use electric vehicles to cover their daily commute on 80 % of the days. Fast charging allows using electric vehicles to travel longer distances by greatly reducing charging times.

Charging times
Depending on the battery's capacity, charging times vary greatly. On average, it takes 6 to 8 hours to go from zero charge to full charge. Batteries, however, seldom reach zero charge. With an average travel distance of approximately 40 km per day, it should not take more than 3 or 4 hours to charge the battery.

EV energy consumption may increase significantly when additional electric or electronic devices, such as air conditioning, heating etc., are used.

Electric vehicles can be charged anytime during the day. It may be more cost-effective to charge EVs overnight, provided adequate control measures are used. Simultaneously charging a large number of vehicles however might lead to power consumption peaks. Utility companies are responsible for implementing the necessary regulatory actions.

Electrical connections
Electric mobility is in its infancy. Today EVs can only be used by people with access to a parking space with an electrical outlet that can be used to charge vehicles.

The charging cable
The charging cable for mode 1, mode 2 and mode 3 connections in Europe comes as standard vehicle equipment. It can be built into the vehicle (case A) or it can be provided as a separate cable (case B).

Two cables are necessary: one for mode 1 and 2, and one for mode 3. The charging cable for mode 4 connections (fast charging) is always part of the charging station equipment (case C). In the US and other countries, «levels» 1, 2 and 3 are used rather than «modes» 1, 2, 3 and 4.

Common built-in EV connectors
Depending on the type and model of vehicle, EVs and plug-in hybrid vehicles (PHEVs) use different connections for plugging in the charging cables. Basically, there are two types of connections built into vehicles (vehicle inlets): mode 1 or 3 for AC (alternate current) and mode 4 (direct current). There are also «combo vehicle inlets», i.e. combined AC/DC connectors (see pictures on page 4 and 5).

Public charging infrastructure
Public charging infrastructure is currently being developed. So is the process of influencing political and economic opinion-makers regarding the need for public charging infrastructure. Interoperability between individual providers varies greatly. A standardized access and billing system is yet to be developed.

EV drivers who wish to drive longer distances can find a European-wide list of public charging points at www.lemnet.org.

In the event of a vehicle breakdown, never touch the electrical system!

In Switzerland, there are many roadside assistance providers that are qualified to deal with electric vehicle specific problems. They are trained in the new technology and are able to provide competent help.

Property owners and administrators

For property owners, administrators or landlords, new questions arise: What type of charging infrastructure can or needs to be built? What investments are required? How can users be billed for the service? What are the expected maintenance and running costs?

Parking space for electric vehicles

When car parks (parking spaces) are equipped with electric vehicle infrastructure, they need to be clearly marked, signalled, and reserved. This can make EVs more attractive, stimulates EV usage and adds value to car parks.

Parking garage

Parking garages for electric vehicles only make sense if there are specific, reserved spaces for EVs and if EV drivers may use the same special access to the building (as long-term tenants or suppliers). This way, EVs would not have to get in line with other vehicles. The access system needs to be capable of registering electric vehicles separately to avoid misdirecting drivers to wrong parking spaces.

Rented parking spaces

A lump sum amount charged for power and infrastructure costs is the easiest and most cost-effective way to bill the cost of rented parking spaces. For a public charging station, parking would be charged on an individual basis (see table on page 6, 7 and front cover flap).

Twenty-four-hour car parks (day/night) in semi-public areas can offer an alternative to EV owners who do not have their own parking spaces.

Rental contracts

The leaflet «Installation of Electric Charging Stations for Tenants», issued by the Swiss Homeowner Association (HEV), describes different approaches for rental agreements when installing an electric charging station. The HEV provides a sample agreement «Permission to Build Electric Vehicle Charging Station». This can be used as an amendment to existing rental contracts for parking spaces.

Customers and visitors

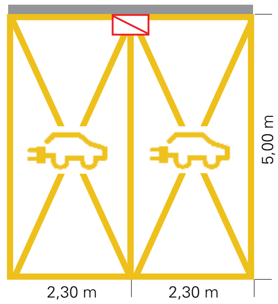
EV charging systems following all safety requirements are available at shops, restaurants or companies for customers and visitors driving an electric vehicle. For new connections, a home charge device or a public charging station with multiple socket-outlet types would be an option.

Billing

The individual assessment and billing of energy costs using an accounting model results in additional expenditure. Furthermore, there is no prevailing standard (see «Billing» section, p. 17).

The «Investment & Maintenance» table below provides a general view of the specific energy costs. The values between different vehicle groups overlap. There are applications in all groups that are partially outside the typical ranges.

Correct placement of the plug.



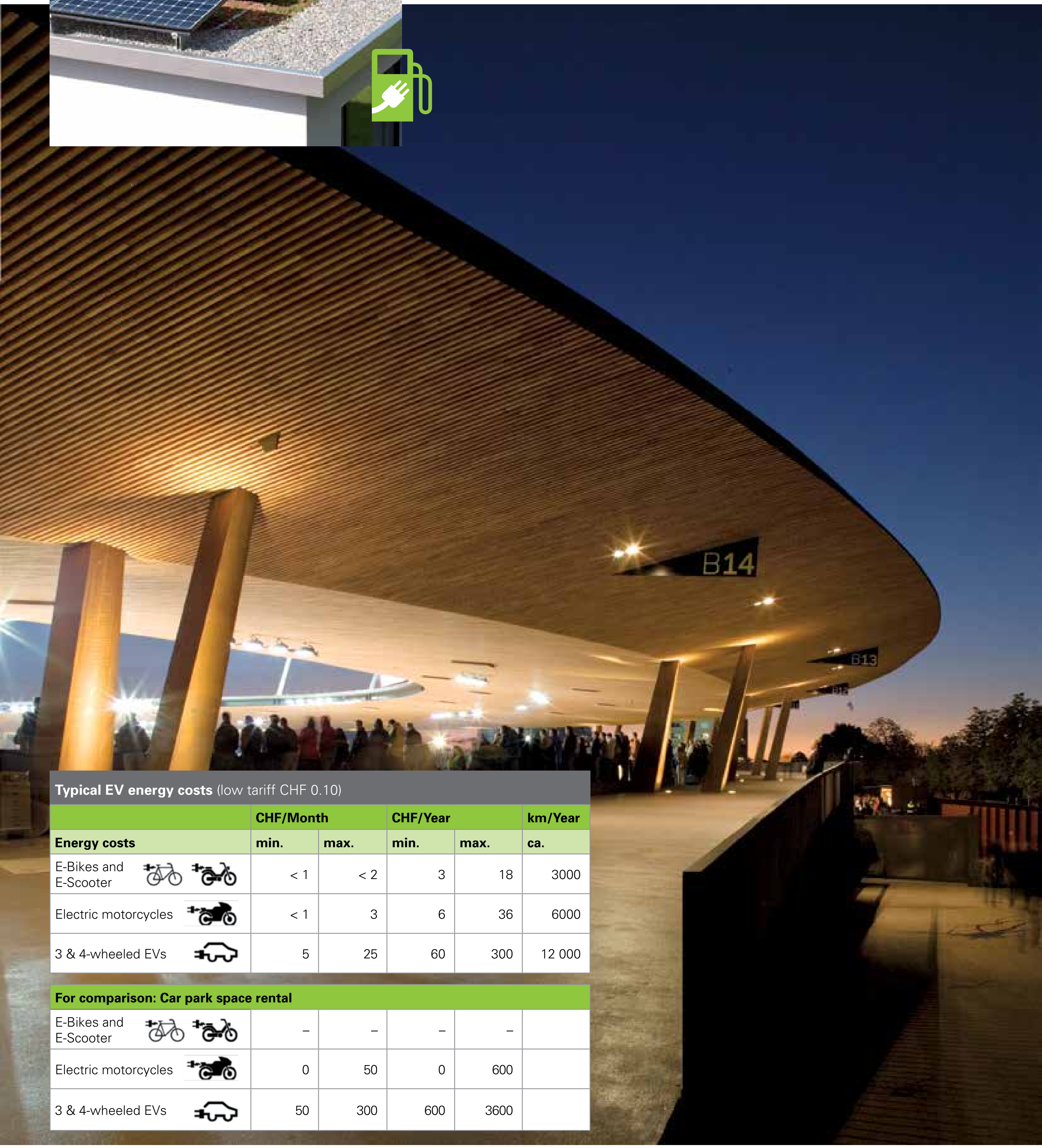
Investment & Maintenance

Usage	CEE socket-outlet	Home Charge Device	Public charging station	Fast charging station
Typical charging time	> 4 h	> 4 h	30 min to 4 h	Approx. 30 min
Type of charge	Normal charge	Normal charge	Normal charge	Fast charge*
Key aspect	Allows charging	Allows charging	Allows charging	Speed of charging time
Required investment (without installation) approx. CHF[1]	100 – 600	500 – 3,000	1,500 –15,000	30,000 – 80,000
Energy cost for a partial load approx. CHF[2]	0.50 – 3.00	0.50 – 3.00	0.50 – 3.00	4.00 –10.00
Operating and maintenance cost per year approx.CHF	0	0 – 50	20 – 2,000	200 – 2,000
Billing	Fixed price (flat rate) or meter	Fixed price (flat rate) or meter	Fixed price (flat rate) or meter	Billing per event
Possible location	Single and multifamily homes, retail shops, companies, restaurants	Single and multifamily homes, retail shops, companies, restaurants	Multifamily homes, companies, public buildings, parking lots, restaurants	Gas stations, rest areas on highways, restaurants

[1] The length and installation method of the supply cable may have a significant impact on the investment cost.
[2] For smaller vehicles these costs are significantly lower (see «Typical Energy Costs» table)
* The first fast charging stations are currently built.

The listed prices are estimated and may vary significantly on a case-by-case basis.

> Parking spaces with infrastructure for electric vehicles will be used if they are easily accessible, available and clearly marked as such.



Typical EV energy costs (low tariff CHF 0.10)

	CHF/Month		CHF/Year		km/Year
Energy costs	**min.**	**max.**	**min.**	**max.**	**ca.**
E-Bikes and E-Scooter	< 1	< 2	3	18	3000
Electric motorcycles	< 1	3	6	36	6000
3 & 4-wheeled EVs	5	25	60	300	12 000
For comparison: Car park space rental					
E-Bikes and E-Scooter	–	–	–	–	
Electric motorcycles	0	50	0	600	
3 & 4-wheeled EVs	50	300	600	3600	

Architects, Electricians and Planners

Work on electrical installations may only be performed by electricians holding a specific license. Existing installations used to charge electric vehicles must be regularly inspected.

Before installation, electricians must submit a connection request and an installation notice to the electric power supplier (EPS).

Most electric mobility standards are still being developed. Therefore, it makes sense to plan for additional capacity and space to deal with the expected changes.

Types of charging infrastructure

Country-specific & CEE socket-outlets:
Country-specific (domestic) socket-outlets are neither mechanically nor thermally resilient. On the other hand, industrial socket-outlets, the so-called «CEE socket-outlets» offer higher resilience. They are suitable for permanent use over multiple hours and are specifically designed for charging electric cars and electric motorcycles.

Home charge device (HCD):
An HCD provides more comfort for users and additionally it is set up to meet the power output limit of the existing grid infrastructure. An optional built-in «power meter» provides power consumption information. Other control equipment, such as time switches, tariff control equipment, combined with an override push-button for use during the day, allows timely charging batteries at off-peak tariffs.

Public charging stations:
Public charging stations make sense in high traffic areas. Access to these systems is possible using keys, cards or coins. For public charging stations in large areas around buildings, shopping centres, public areas, etc., Ø 80 mm cable conduits should be used.

Fast charging stations:
The electric power supplier (EPS) should be involved in the planning and installation of fast charging stations. The use of a battery backup system should be considered.

New & refurbished buildings
For new and refurbished buildings, it is recommended that a sufficient number of empty conduits (M 25 to Ø 80 mm conduit diameter) be available for installation in appropriate places. In public areas, Ø 80 mm conduits are recommended. By including an appropriate number of cable conduits, cable ducts and foundations during planning, additional costs will be avoided. A standard foundation for a charging station can be found at www.opi2020.com.

The cable connecting the electric vehicle should be as short as possible and have the appropriate dimensions to avoid significant voltage drop at maximum charge. For cables over 50 m long, it is advisable to increase the cable cross-section. It can be assumed that the simultaneity factor of a connection (connecting points) for a single electric vehicle can be set to 1.

The existing residential mains might overload even when few EVs are connected. If necessary, the electric power supplier will initiate the required improvements based on the electrician's connection request and installation notice (see also EPS «residential connections» chapter).

Socket-outlet installation
The connection points must be installed as close as possible to the vehicle to be charged. Passageways or gangways between the electrical socket-outlet and the electric vehicle must be avoided. Ideally, it should be installed between 1 m and 1.5 m from the ground. The usual length of the connecting cable supplied by the car manufacturer is approximately 5 to 7 m.

Each socket-outlet (connecting point) needs to be protected with a fuse/circuit braker (CB) and a residual current device (RCD) or with a combination of both (RCBO). In order to switch a tripped combined circuit breaker (CB/RCD) back on without external help it should be installed as close as possible to the socket-outlet. Plugs should be subject to minimum traction and torsional forces (fatigue and contact problems). At least, ingress protection grade IP 44 should be used.

Home Charge Device (HCD)

> The right connection at the right place benefits all stakeholders.

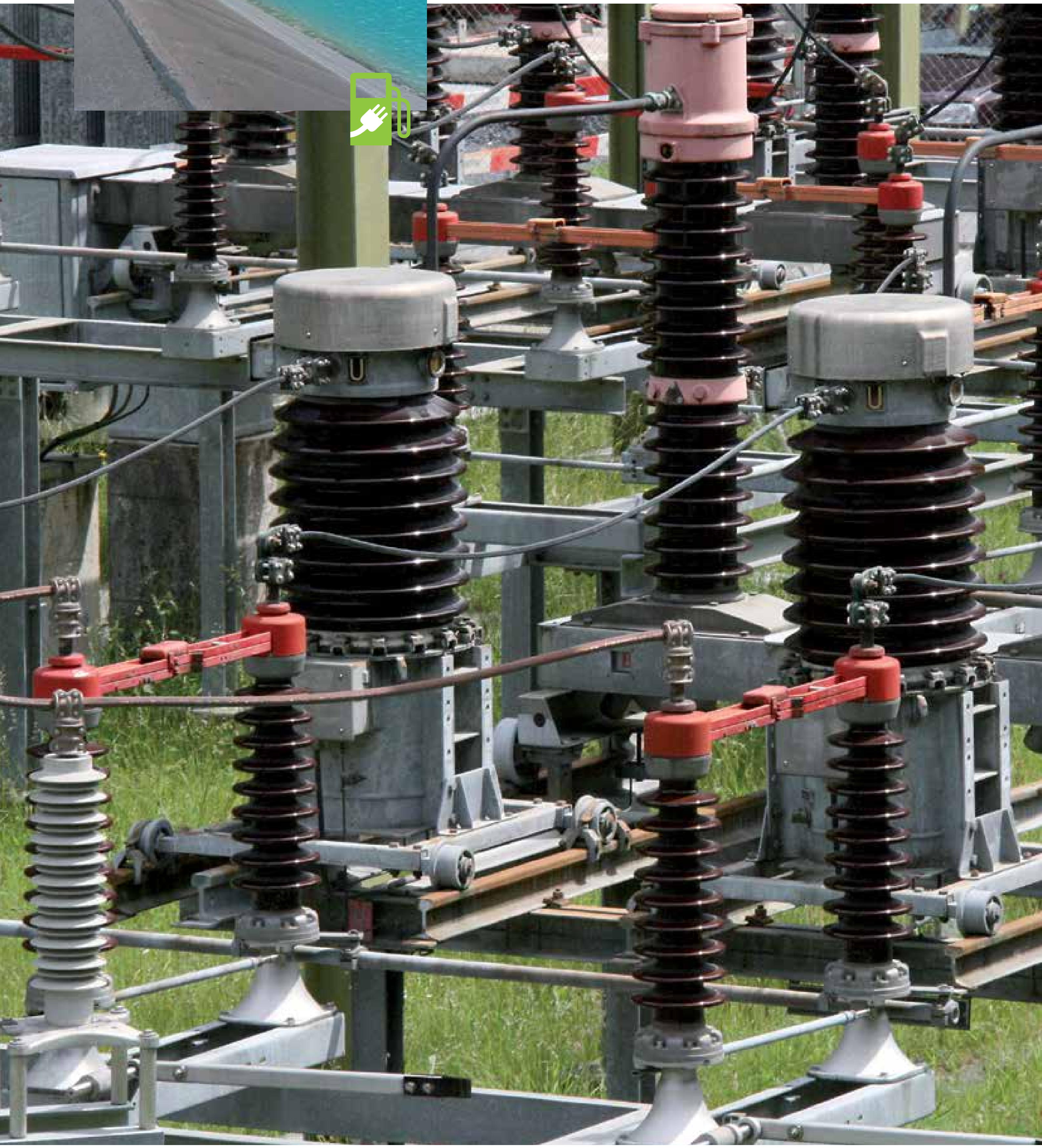
Charging current and mains symmetry

In large buildings/properties with multiple connection points for electric vehicles, it is essential to consider a symmetric mains load (using phase rotation). The necessary actions must be coordinated with the electric power supplier (EPS).

Parking garages

For covered parking lots, the electrical connection for electric vehicles should be installed using a conductor rail, cable tray or cable duct. This way it is possible to modify existing connection points or install additional points at any time. Supporting 6 to 10 connections, a conductor rail is a more flexible and cost-effective solution. The basic structure needs to be installed only once. It can be easily expanded, changed or removed. Installing conduits and cable tray systems with the corresponding socket-outlets and safety systems in easily accessible public areas make it easier to carry out maintenance and repairs in case of failures.

“Proper control of the charging infrastructure allows for a smooth interaction between the EPS and consumers.”



Electric Power Suppliers (EPS)

Electric power suppliers are facing new and complex challenges with the increasing number of electric vehicles. They ask, for example, «how can we supply enough energy to the different charging stations»? «What can we expect in terms of (new) energy peaks»? «How can we best handle these peaks»? «How can we bill the user for the power consumed»? These are only some of the many questions.

Access to the grid

In Switzerland we have a well-built electrical grid. Electric energy is available practically everywhere. Since EVs are parked for long time, we already have the ideal infrastructure to charge batteries using low current over a long period of time. On working days, the existing grid infrastructure is sufficient to charge batteries to provide an electric autonomy of around 40 km. However, problems would arise if a large number of EV drivers wanted to «fast charge» their batteries at the same time, requiring a high «charging current» possibly at peak times. If 10 % of all existing licenced vehicles were electric vehicles charging at 3 kW or more, even well-established grids might reach their load limits.

Avoiding charging peaks

During the night, there is plenty of time and power available to charge EVs and have them ready for the next day. Slow charging during the night puts less strain on the grid, helps to avoid load peaks, and is easier on the budget due to the reduced off-peak energy cost. Load peaks can be avoided using intelligent solutions, such as home charge devices (HCD) or simple timers. EPS may in the future restrict charging during peak times.

Fast charging stations providing higher charging current are desirable at high traffic areas. With increasingly decentralized energy production, decentralized energy storage becomes an important requirement. A fast charging station with a battery backup (500 kWh) is a possible solution to increase grid quality and stability.

Key connection & infrastructure aspects

All appliances that require energy must be connected in such a way that the load is distributed as symmetrically as possible among phases; see Swiss technical connection requirements (WV 8.12) wiring rules.

Instead of thermally and mechanically resilient cables and socket-outlets, such as CEE socket-outlets or HCDs, should be used.

Influence on grid quality and stability

EV chargers are devices that change the frequency (WV 8.31) and can absorb more electricity than average household appliances. Therefore, connection requests are mandatory for connections ≥ 2 kVa ≈ 2 kW. For higher electrical loads, ≥ 3,6 kVA ≈ 3,7 kW, only 3-phase connections are allowed (WV 8.13). Some vehicles are charged from the power grid using 1-phase, 32 A type 2 sockets. An increase in the number of EVs will influence grid quality and grid stability. The use of EVs should help to increase grid quality and stability in the future (multi-quadrant electronics as used for renewable power sources).

House connections and supply cables that bring power from the grid are usually designed and sized considering a simultaneity factor of 0,2 to 0,3, i.e. 20 % to 30 % of the installed nominal electric power. Totally installed nominal electric power in a building is therefore much higher than the one available from the grid. The capacity of a house connection may already be exhausted when few EVs are connected. It may be necessary to increase the capacity of the electric circuit or install a separate branch circuit to supply energy to the EV. EPSs obtain the necessary information from the connection request submitted by the electrician.

“ Electric vehicles require new specific knowledge acquisition. ”

Different mode 2 charging cables with ICCB

ISO-voltage classes:

A < 30 Volt AC or
< 60 Volt DC.

B ≥ 30 Volt AC to
1,000 Volt AC or
≥ 60 Volt DC to
1,500 Volt DC

Car Manufacturers | Dealers

Electric and hybrid vehicles require highly-trained repair professionals. The infrastructure in repair shops must also be adapted to handle «high voltage systems» (ISO-voltage class B).

EV traction battery
Electric and hybrid vehicle batteries are industrial batteries. For passenger cars, they support from 100 to 400 V supply. Work on equipment or installations at such high voltage range must only be performed by qualified personnel!

In case of accident, the battery connections are disconnected automatically.

Charging cable
For each electric vehicle there is an individual charging cable. Charging cables can be quite different and are not interchangeable. These cables should be inspected when the vehicle is being serviced. It is especially important to check whether the ground wire between the plug and the vehicle is working properly, whether the cable insulation is damaged, and whether there are visible or perceptible cracks or deformation points.

Adaptor cable
Adapter cables should only be used in exceptional situations, always with an 8 A fuse. If adapter cables are frequently used in the same location, converting the existing connection point to one that meets the intended use is advisable for safety reasons (for example, using a CEE socket-outlet). The adapter cable should exhibit a warning sign «Use with 8 Ampere only, reduce charging device capacity using vehicle control system!»

Adapter
Commercial-quality travel adapters are not suitable to be used for electric mobility!

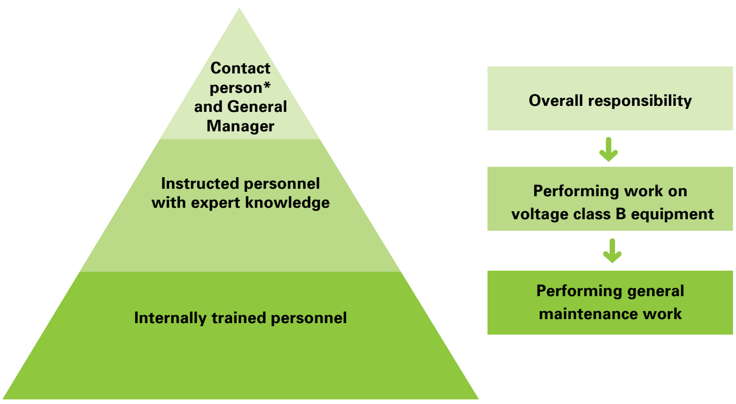
Socket-outlets
Vendors should urge EV buyers to have an electrician check the socket-outlets they regularly use to charge their vehicles. Users should only use proven connections that are safe and appropriate for their vehicles. Standard domestic socket-outlets in Switzerland should be used only in exceptional cases.

Repair equipment for vehicle repair shops
Some EV manufacturers demand the use of specific charging infrastructure and special tools in repair shops, showrooms and customer parking spaces.

Repair shops must have electrically insulated gloves, safety glasses, insulated cover material, eyewash station, fire extinguishers, and warning signs. It is imperative that special equipment for diagnosis, repair and service as per manufacturer's specifications is used.

Organization & responsibility
Clear organization and defined responsibilities in repair shops are essential, as working on EVs and PHEVs may expose people and property to a high level of danger. At least, internal guidelines should be in place for guiding professionals that perform general work on EVs and PHEVs. Those performing work on voltage class B devices and installations are required to have specific professional knowledge and to be trained at a qualified training institute.

Minimum requirements for garages/ repair shops that perform work on EVs and PHEVs



* Contact person for workplace safety

> Shelters with charge boxes allow off-board batteries to be easily charged.

Infrastructure for E-Scooters and E-Bikes

Charging units for E-Bikes and E-Scooters are usually off-board. These provided units are mainly suitable for indoor use, since they are not protected against water and/or dust. They are marked «IP21 – Indoor Use Only» or exhibit the symbol . Devices marked in such a way should not be kept inside closed compartments, such as helmet boxes, saddlebags or similar, as they may overheat. They should not be used outdoors, since they are not protected against humidity. Charging devices should not be kept inside the vehicle during the charging process! Two-wheeled EVs are usually equipped with a domestic plug. Devices with the blue CEE plug are seldom seen. Only CEE plugs should be used for devices with charging current ≥ 8 A (≥ 2 kVA, ≈ 2 kW).

«EnergyBus™»
An increasing number of manufacturers is using a uniform charging method with standardized plugs, the so-called EnergyBus™ connector (www.energybus.org). Two-wheeled vehicles that do not conform to EnergyBus™ standards must be charged using the chargers supplied by the manufacturer.

Using the wrong charger may cause damage to or destruction of the battery. When charging or overcharging, a flammable electrolyte or oxyhydrogen (mixture of oxygen and hydrogen) may be produced. Fire caused by, for example, a spark at the light switch in a closed, unventilated room may cause an explosion!

Safely charging off-board batteries
Charge cables supplied by manufacturers are usually short (approx. 1.5 m). In apartment buildings or public areas, batteries should be recharged in protected, fire-safe areas (off-board), for example in combination with covered shelters and lockable charging bays, separate lockers equipped with standard socket-outlets and a CB/RCD or a residual current operated circuit-breaker with integral overcurrent protection (RCBO, see picture on page 14).

Charging infrastructure requirements
The charging device should be installed in ventilated and dry locations. Separate lockable charge boxes may be installed to allow charging by multiple users.

Socket-outlets should be installed as close as possible to the shelf housing of the charger to avoid mechanical overload of the socket-outlet resulting from traction.

For e-bikes and e-scooters, a 6 A fuse is sufficient.

Billing
Energy consumption by e-bikes and e-scooters and the resulting costs are minimal. Investment in power consumption measurement and billing systems are not likely to pay off (see table on page 7).

EnergyBus™
DC vehicle plug

DC vehicle socket

“Shared use of parking lots enables efficient use of the charging infrastructure.”

Access and billing

The energy cost of electric vehicles is very low compared to the investment necessary to implement a billing system. Making charging stations accessible to the public in general, allowing shared use, may allow for higher amortization of the costs.

Private & semi-private

When a parking space is reserved for a specific vehicle or tenant, complex billing systems are not necessary. The simplest solution is a flat rate including energy costs, amortization of the installation, and maintenance costs; this flat rate may be included in the parking fee, for example (see table on page 7).

For power consumption measurement, an uncalibrated class 2 meter is sufficient. If an electric vehicle is charged using a shared meter on a property with multiple tenants, a control meter can be used to measure power consumption. This allows measuring power consumption by each individual tenant and eliminates other tenants' concerns.

Using home charging stations with time control allows users to charge their EVs at off-peak hours, taking advantage of the lower energy costs.

Employers may offer free EV charging to employees as a benefit, clearly identifying it as such in employees' pay checks.

Semi-public

If the parking space is not reserved for a specific vehicle or tenant, it may be necessary to adopt the same complex billing systems used in public charging stations. In this case, the simplest solution would also be a flat rate including energy costs and amortisation of the investment, charged together with the parking fee, for example.

Public

In public areas, depending on the region, there may be different access and billing systems, which may not be compatible. Efforts to standardize these systems are under way. Higher investments will be required to allow measurement of the power consumed by individual vehicles. Please refer to the table on page 6 «Investments and Maintenance».

Access and billing systems

In the future, access and billing systems will need to offer a wide range of functions, such as identification, authorization, unified billing systems, etc.

- Open access: connectors are accessible at any time and to anyone. Usually, at least mode 1 or 2 is possible. No billing.
- Key access: connectors are stored in a special case, which can be opened with a key. Power consumption billed at a flat rate.
- Prepaid access: connectors and power supply are accessible upon payment in cash or chips, electronic keys, disposable RFID cards, etc. Service is paid in advance. Such systems may also be accessed by tourists and require relatively high maintenance.
- Credit card access: connectors and power supply are accessible upon payment at credit card terminals or at conventional gas stations. Credit card billing. This solution may demand relatively high investment costs for small sites. Recurring costs for small amounts exceed the transaction amount.
- RFID card access: connectors and power supply are accessible upon identification and authorization of RFID cards. Application for and payment of RFID cards must be made in advance.
- Mobile phone access: connectors and power supply are accessible upon activation of an SMS clearing or oral agreement. Billing via phone bill.

Please go to www.lemnet.org for an up-to-date overview of publicly accessible stations in Switzerland and information on access and billing systems.

> Economic and political leaders must reach an international consensus to boost electric mobility.

Outlook | Perspectives

With the increasing demand for electric vehicles, e-mobility is gaining importance. Two-wheeled vehicles are specially favoured by customers. An increasing demand is gradually becoming apparent towards full electric cars or hybrid cars. E-cars are increasingly becoming part of the product portfolio of major car makers. Established brands have at least one EV and/or hybrid car in their portfolio. Even so, we cannot consider it an EV «boom» or a «hype» yet. It will take time until e-cars are produced in large numbers. Their development is heavily influenced by commodity prices (battery manufacturing/electronics).

Social and technical challenges
It is essential that electric vehicles can be parked next to the power supply point. A basic question that arises, regarding parking spaces in public areas, especially in the cities, is whether enough spaces will be reserved for electric cars when parking spots are redistributed. In addition, the increased energy demand on the power grid needs to be carefully considered.

Switzerland in the international scenario
In Switzerland, there is (still) no political or economic consensus regarding electric mobility. Although, for many years, a lot of effort has been dedicated to electric mobility, and several companies and people are promoting it worldwide, the topic has not received enough political and economic attention to accelerate its use.

Conductive charging (charging with a cable)
Development of standard connectors for electric vehicles and the associated infrastructure and power distribution system is still under way. Different groups continue to work to find suitable solutions.

Standardization
Key standards and rules regulating e-mobility are currently been developed. All stakeholders are working hard to standardize plugs and socket-outlets, fast charging stations, wireless power transfer and light electric vehicles as well as access and billing.

Inductive charging (wireless charging)
Inductive (wireless) power transfer may become a suitable alternative to mode 1 to 3 charging by mid-2015. Inductive or wireless transfer of power (WPT) could be interesting for public areas with restrict space. Furthermore, inductive charging (WPT)can open new operation possibilities. Intensive work on these applications is also under way.

Swapping the battery
Swapping batteries helps to solve the problem of the long charging time required for EV batteries. Battery swap, however, requires a high degree of standardization. Battery swap for e-cars can only become a reality in the long run, due to the different existing concepts and, mainly, car makers' desire for brand differentiation.

Battery swap not only for two-wheeled EVs (e-bikes, e-scooters, etc.), but also for trucks and buses, is already an important alternative.

Glossary

E-Bike	Electric bicycle
E-Scooter	Electric scooter
PHEV	Plug-in Hybrid Electric Vehicle
REX	Range Extended Vehicle
A	Ampere; unit for electric current intensity
V	Volt; unit for electromotive force
kW	Kilowatt; unit for power demand
kWh	Kilowatt/hour; unit for electric energy
kVA	Kilovolt ampere; unit for apparent power
EPS	Electric Power Supplier
AC	Alternating Current
DC	Direct Current
CB	Circuit Breaker
RCD	Residual Current Device; electrical switch used for protection of people and property
RCBO	Residual Current operated Circuit-Breaker with integral overcurrent protectionr
WV	Swiss-German factory regulations (TAB) 2009 (recommendation from the Swiss-German WV workgroup, 2009 VSE release)
M25 / Ø 80	Diameter of a conduit in mm
off-board	Designation of a «charging unit» that is not built into the vehicle
on-board	Designation of a «charging unit» that is built into the vehicle
EnergyBus™	Trade name of a DC «charging unit» for < 60 V DC two-wheeled vehicles.
CHΛdeMO™	CHΛdeMO is the trade name of a mode 4 «charging method» and a possible «quick charging device» for all vehicles with a specific connector.
CCS	Combined Charging System
HCD	Home Charge Device
ICCB	In-Cable-Control Box; a device built into the charging cable to provide safety and communication functions.
ISO	International Organization for Standardization

Publishing Information

Further Information
The following organizations provide information about various aspects of electromobility and about charging electric vehicles:
www.swiss-emobility.ch
www.infovel.ch
www.lemnet.org
www.opi2020.com

The following professional associations will gladly provide further details about electromobility:
www.agvs.ch
www.electrosuisse.ch
www.e-mobile.ch
www.strom.ch
www.vsei.ch

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