

VW Compendium – Fleet charging



in cooperation with:

THE MOBILITY HOUSE

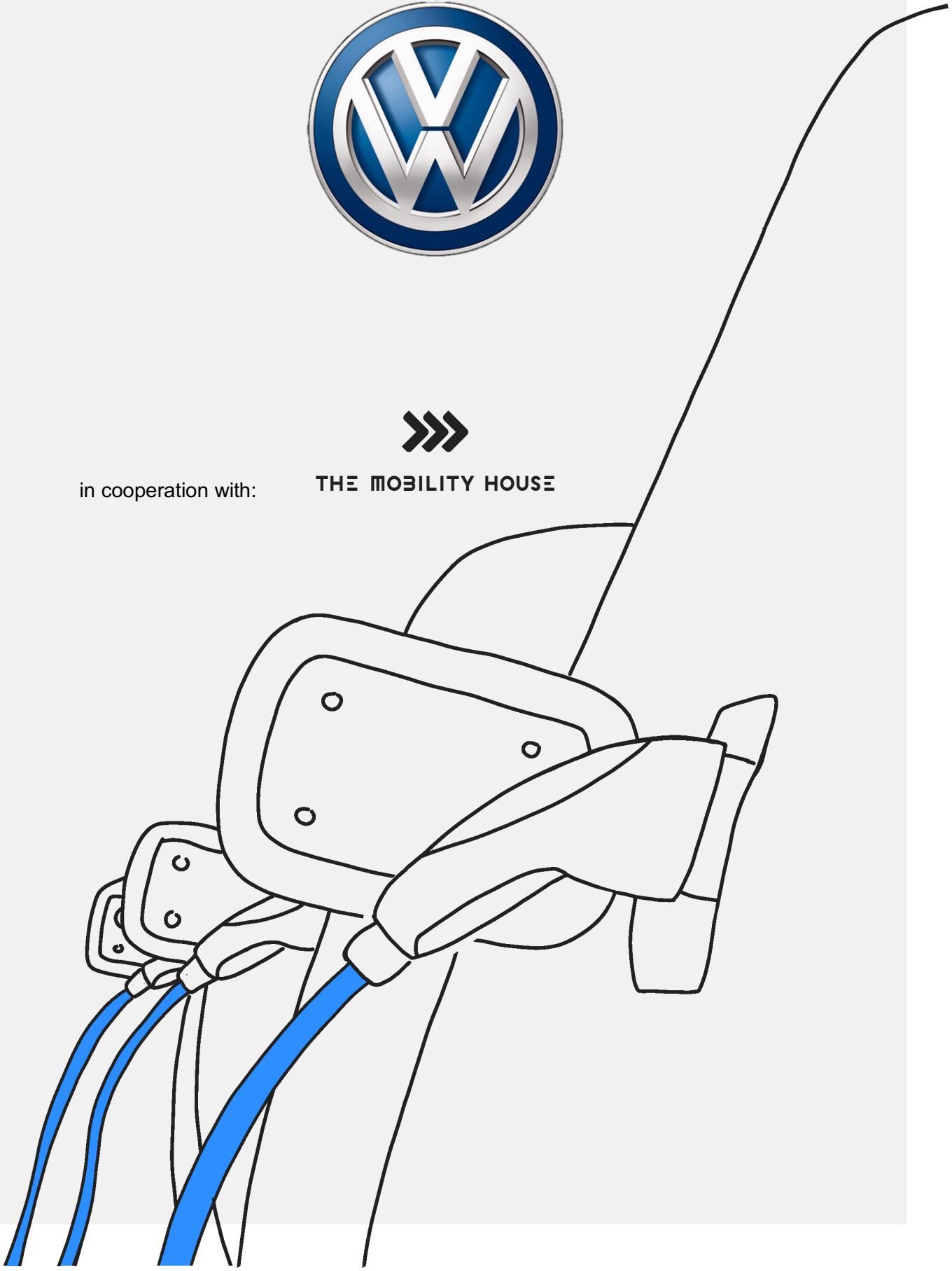


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1. Electric mobility basics – Questions and answers

The transition to electric mobility is not only a technical breakthrough, but also a change of routines: While drivers would previously drive to a gas station when they needed to fuel up, downtime is now the time for charging. This is practical: On the one hand, many vehicles are idle for up to 90% of the day. On the other hand, electricity is available everywhere – at least in urban areas. This means that, theoretically, charging can be done anywhere as long as the wheels aren't rolling.

Before we take a closer look at the requirements of the infrastructure needed for a fleet of electric vehicles, we would like to briefly answer some frequently asked questions on the topic of electric mobility.

- **Are electric cars even suitable for company fleets with their shorter range?**

This only appears to be a problem. For one, normal everyday use of fleet vehicles does not come close to the ranges of today's electric vehicles – not by a long shot. For another, inevitable downtime can conveniently be used for charging. For most requirement profiles, a suitable solution can be found by designing the operational charging infrastructure appropriately.

- **Isn't an electric fleet much more expensive than a conventional fleet?**

No. The specific advantages of electric mobility – favorable emission behavior, low energy and operating costs – have immediate benefits, especially given the high annual mileages of fleet vehicles. An electrified fleet can therefore significantly increase the efficiency of operational and environmental management.

- **Is enough electricity even generated for electric mobility?**

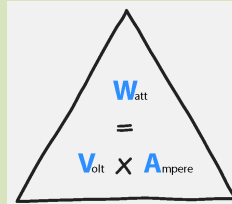
Yes – even if there are millions of electric cars on the road someday, the demand for electricity will only increase slightly. It is important for our energy supply to come increasingly from renewable sources; this is the only way for electric mobility to really make progress for climate protection. In the future, electric cars can even help to stabilize the power grid by acting as a buffer against volatile power inputs in their role as mobile electric storage devices.

- **What happens if everyone wants to charge their electric cars at the same time?**

If employees connect their electric cars to their charging stations as soon as they arrive at work, this could actually cause problems in the local low-voltage grid. The solution already in place for manufacturing industries is called **load management**: A maximum current is defined and made available for charging the vehicle fleet. The number of electric cars that can be charged at your location depends on the size and usage profile and has to be determined by a situation/needs analysis.

- **What happens if I have to charge my vehicle when I'm out and about? Is the extension of public charging infrastructure making any progress?**

Yes. The charging infrastructure in Europe is currently being massively expanded – by national governments as well as private suppliers. For example, the provider IONITY – a joint venture of car manufacturers BMW Group, Daimler AG, Ford Motor Company and the Volkswagen Group with Audi and Porsche – will install a total of 400 quick-charge charging stations with an output of 350 kW along European highways by 2020.



A **watt** or **kilowatt** (*W*, *kW*) is a unit of electric **output**. This is calculated by finding the product of the **voltage** (measured in **volts**) and **current** (measured in **amperes**). This output value describes how much energy is consumed or stored per unit of time. The energy you charge or consume is the product of electrical output and time and is measured in **watt hours** (*Wh*) or more commonly in **kilowatt hours** (*kWh*).

Example: A conventional domestic socket with 230 V and 16 A outputs 3.7 kW. A three-phase connection (400 V) outputs 6.4 kW.

- **Which is better for charging: direct current or alternating current?**

Many modern electric vehicles can be charged with three-phase alternating current (AC) as well as with direct current (DC). DC is quicker, but those charging stations are also significantly more expensive. Whether or not acquiring DC stations is useful for your purposes depends on the operational concept of your vehicle fleet.

- **What is the quickest way to charge the battery?**

As the name indicates, the quick-charge charging stations are the fastest. They currently use direct current (DC) with 50-150 kW, and in the coming years this should increase to 350 kW and more. Just 50 kW of charging power over 30 minutes can charge enough for a range of around 100 to 150 km.

- **Is it possible to charge at different charging stations operated by varying providers?**

Unfortunately this is not always possible yet, but cross-regional solutions have gradually gained acceptance: To avoid entering into charging contracts with every regional provider, roaming providers are being established – similar to what we know with from the mobile phone industry. These providers bundle access and billing for different charging stations across Europe. Nowadays, you can choose from a number of providers (e.g. Volkswagen Charge&Fuel Card). Many of the more than 100,000 charging stations in Europe already allowing for charging independently of the provider.

- **What are the different kinds of charging stations?**

Charging stations for electric vehicles come in two styles: free-standing charging columns and wallboxes. The choice of design depends on the location, the available space, and the technical equipment desired. In addition, some (premium) vehicles are able to charge using a wireless, inductive process via a charging plate that lies on the floor or is integrated into the floor.

- **Can the battery also be charged from a normal domestic socket?**

Yes. However, for the most part domestic sockets are not designed for sustained loads and should therefore be inspected by an electrician. The charging process also takes much longer because of the charging current, especially for purely electric vehicles.

- **What charging power is optimal for my fleet?**

The right power output for your stations depends primarily on the normal idle times of the vehicles. If there is not a lot of idle time, a correspondingly higher output will be needed. You also have to consider the battery capacity of the vehicles being used and the output capacity available from the local power connection.

- **Will the owner of my building agree to the installation of a charging station?**

Most likely yes. This is because installing charging stations increases the value of a building or property and prepares it for the future. In any case, building owners are legally required to do so for a new building or a complete renovation at the latest. A recent EU directive passed by the European Parliament on total energy efficiency of buildings specified that, starting in 2025, new or renovated residential buildings that have more than ten parking spaces must be equipped with the appropriate pre-cabling.

- **Can you also charge electric cars in underground garages?**

There are no restrictions on access in this case. The charging technology used in production models is safe, which means that it is impossible to damage the battery. Also, modern lithium-ion batteries do not emit any gases.

- **Is the magnetic field of electric cars harmful to health, especially for people with pacemakers or defibrillators?**

No. The electrical field that is generated during operation is very well shielded. As a matter of safety, people who are sensitive to electrical fields should not open the hood of operational vehicles, because strong electrical fields can be generated in the engine compartment. However, there isn't any risk when driving and charging.

- **Would I be at greater risk during an accident in an electric car?**

No more so than in any other modern vehicle. The battery has a stable casing which protects it during impacts. Even water penetrating the casing is not dangerous, because this would cause the battery cells to discharge immediately. Of course, water cannot reach the battery during everyday operation because it is encapsulated and waterproof. That means it won't short-circuit when it rains!

2. Charging the ecosystem

After a slow start, electric mobility has truly gained momentum: The typical confusion about new technological developments has mostly been sorted out, and binding standards have been established for all the essential components. Electric cars and charging stations have been produced in large series for years now, and the public charging infrastructure has been expanded. Fleet operators who would like to invest in sustainable mobility are therefore well advised to start electrifying their fleets now, because the lead time for setting up the necessary infrastructure can be a good six to twelve months or even longer, in part due to the reaction times of electricity suppliers or approval authorities, delivery times for desired equipment, and processing times for funding applications.

In this chapter, you will find out

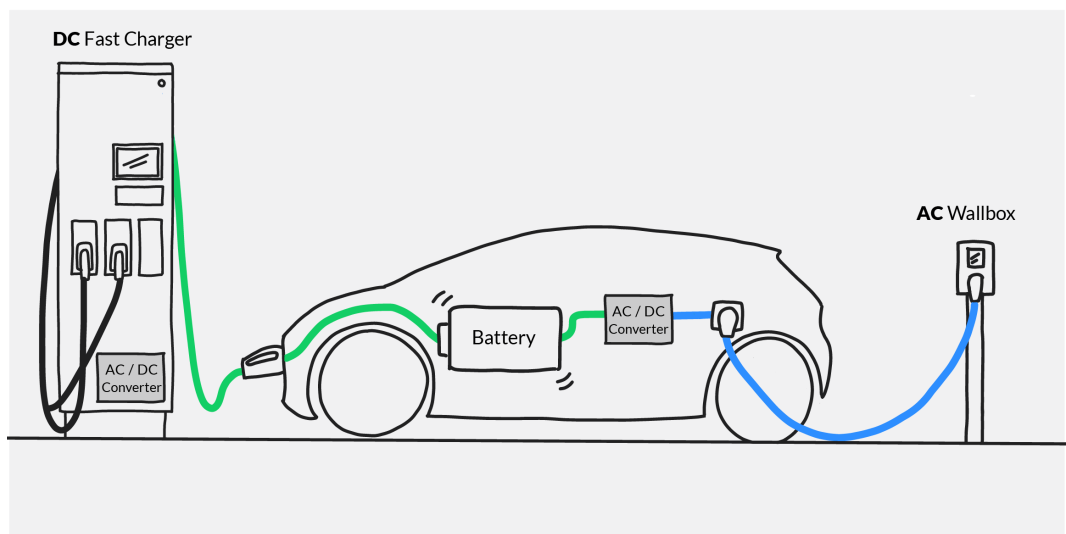
- what infrastructure you will need to charge your fleet,
- what you need to consider in terms of installation and operations costs, and
- what billing terms are reasonable depending on the vehicle usage scenario.

2.1. The basics of charging technology

▪ How can I charge?

In the future, your employees won't have to drive to the gas station anymore. Instead, they will be able to multi-task the filling-up process: in the company parking lot, the underground garage, or even at home – whenever they are parked. Today, there is a perfect charging infrastructure solution for every location and every conceivable usage scenario.

▪ Alternating current vs. direct current



In principle, electric vehicles can be charged with three-phase alternating current (AC) or with direct current (DC). For alternating-current (AC) charging, a rectifier installed in the vehicle converts the current from the public AC grid into the direct current (DC) needed for the battery; when charging with DC current, charging is regulated in the charging station.

	Alternating Current			Direct Current
VOLTAGE	AC (1-phase)	AC (1- to 3-phase)	AC (1- to 3-phase)	DC
MAX. AMPERAGE	10 A	13 A (1-phase) 16 A (1-phase) 16 A (2-phase) 32 A (3-phase)	32 A (1-phase) 16 A (2-phase) ² 32 A (2-phase) 32 A (3-phase)	up to 700 A
MAX. CHARGING POWER	2.3 kW	3 kW (1-phase) ¹ 3.7 kW (1-phase) 7.2 kW (2-phase) ² 22 kW (3-phase)	7.4 kW (1-phase) 7.2 kW (2-phase) ² 15 kW (2-phase) 22 kW (3-phase)	350 kW

1 is usually charged with 2.7 kW
2 common charging power, not a maximum

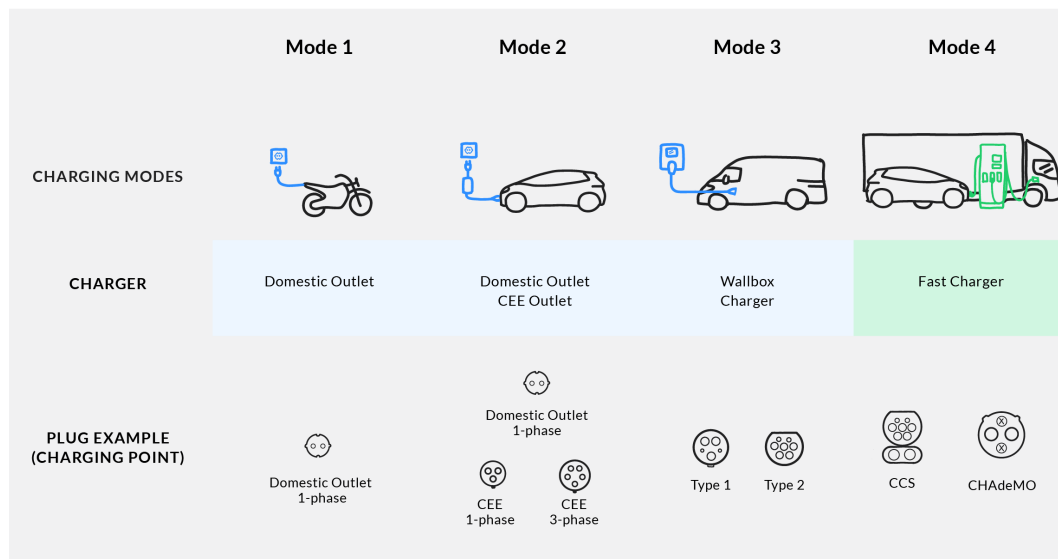
▪ Charging types and modes

Today, conductive charging is standard via a charging cable, which connects the charging station and the vehicle. Inductive/contactless charging via charging plates on the floor vehicle is available for individual (premium) vehicles as special equipment. An established standard has yet to be approved. Most modern electric installations can still be used for inductive technology as well.

There are four charging modes when using a cable: Charging Mode 1, which is not electrically secured, can only be used for small electric vehicles like e-bikes. In Charging Mode 2, a monitoring module in the charging cable (ICCB) ensures electrically secure charging. In Charging Modes 3 and 4, special sockets and cables have to be used.

Charging Modes 3 and 4 are the most common modes implemented in practice for fleet installations. With components specially designed for electric vehicles, they offer a high level of capacity and electrical safety. They also prevent accidental misuse and manipulation by third parties: The plugs are locked while charging, so they cannot be removed.

Important note: If your employees charge their electric cars at home or when on the road (at customer locations, at a hotel, etc.), a domestic socket (Schuko/CEE 7/4) is a short-term, convenient alternative. However, they shouldn't be a permanent solution. This is because the conventional electric installation of a house is not designed for charging an electric car over a period of multiple hours. A wallbox (a wall-mounted charging connection) should be installed if charging is regularly required at private locations.



- **Which connection is right?**

Over the years, different mutually incompatible plug and cable standards have developed. Thanks to advanced standardization, there are now only a few variants:

Type 2 (also known as a Mennekes plug): European standard for charging with alternating current (AC) in Charging Mode 3. Today, most European car models and most public charging stations are equipped with a type 2 socket.

CCS (Combined Charging System): like type 2, but with additional contacts for quick DC charging (Charging Mode 4). The Combo-2 plug is required for all public charging stations with a DC charging power of 22 kW or more.

CCS unifies AC and DC charging with high charging power (AC up to 43 kW, DC up to 150 or perspectival 350 kW and more) into one system and also includes control functions and communication protocols between the electric vehicles and charging stations (see Section 2.5). In Europe, CCS is recommended as a future-proof solution for new installations.

Further standards: Most public charging stations also offer the **CHAdeMO** DC quick-charging standard, which is used primarily in Asian vehicle models. Especially in Japanese and American vehicles, there are also the **type 1** plug and the **Tesla plug**, a modified type 2 plug that Tesla uses in its Supercharger quick-charging charging stations. Only Tesla vehicles can be charged with direct current using these plugs.

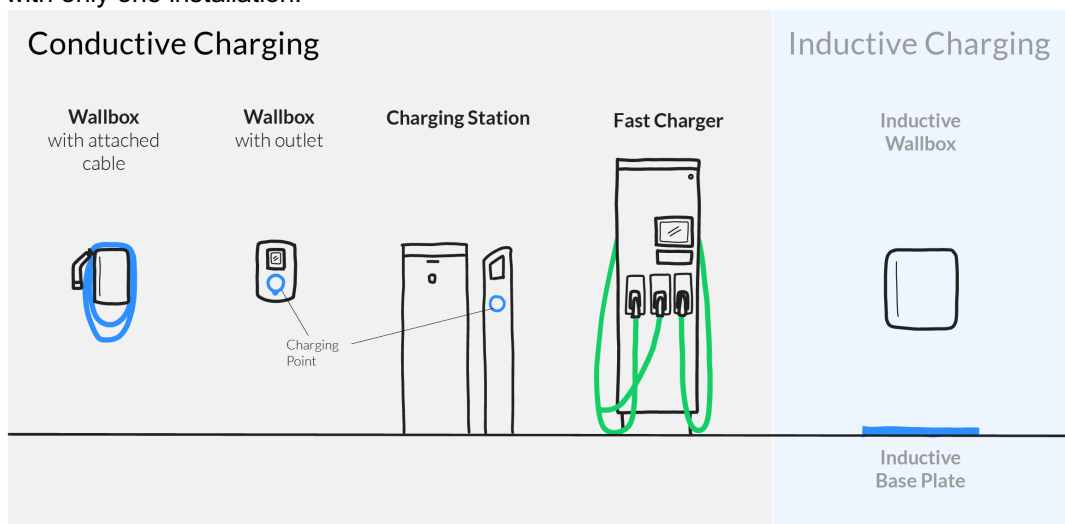
- **Which standard for which vehicle?**

Most current vehicle models allow AC charging with at least 7.4 kW. An AC charging option with 11 kW and/or a DC charging option with 50 kW or more are often offered as special features. The choice of vehicle therefore plays a decisive role in planning your charging infrastructure.

- **Charging station or wallbox?**

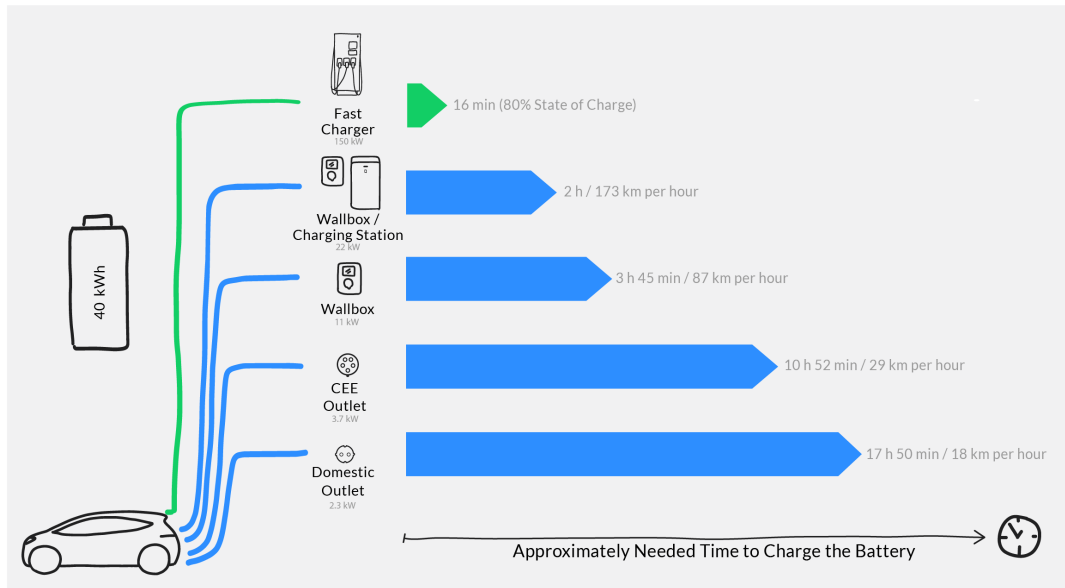
Charging stations for electric vehicles come in two styles: free-standing charging columns and wallboxes for installation on a wall or on a column. The column design provides more space for connections and may include additional components, such as RCD circuit breakers, overvoltage protection, and an energy meter. Both designs are also available in versions with an attached (fastened) cable or socket – in the case of sockets, the right cable has to be carried along in the vehicle. For charging homogenous fleets, versions with fastened type 2 cables are recommended for their conveniences, but sockets with different standards would be better for employee parking spaces. The variant with a fastened cable is standard for DC charging.

A charging station or wallbox may have several (usually two) separate connections (charging points) or decentralized satellites. This way, several vehicles can be charged at once with only one installation.



- **How much output do I need?**

The simplest principle of electric mobility is: The greater the charging power, the quicker the battery will fully charge. On the other hand, (expensive) high output is not a goal in itself. To find the best solution, you really should ask yourself the following question: How much time is available to fully charge my vehicles? This might be the entire time an employee is at work or it might only be a few hours, for instance when fleet vehicles are used for many trips every day. The battery capacity and maximum charging power of the vehicles must also be included in the calculation along with the available power connection capacity at that location. You can find details on designing and optimizing charging power for your fleet in Sections 2.3 and 2.4.

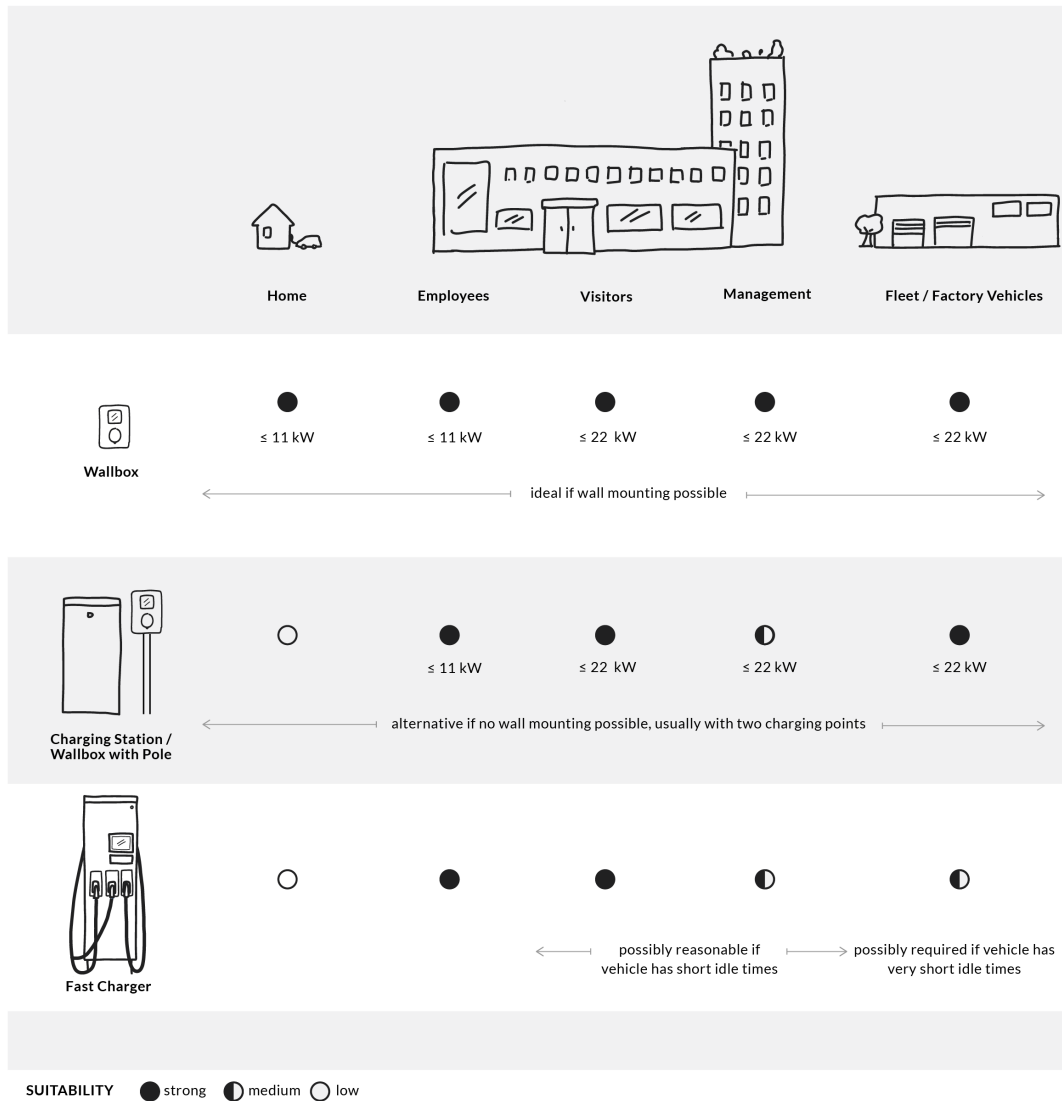


Calculatory Value; Depending on Age, Temperature & State of Charge of the Battery

2.2. Location

- **Where should I charge?**

In principle, the same locations used for combustion vehicles are suitable for electric vehicles. Setting up charging stations requires no extra space, or only a little, depending on the spatial conditions.



▪ Charging station placement

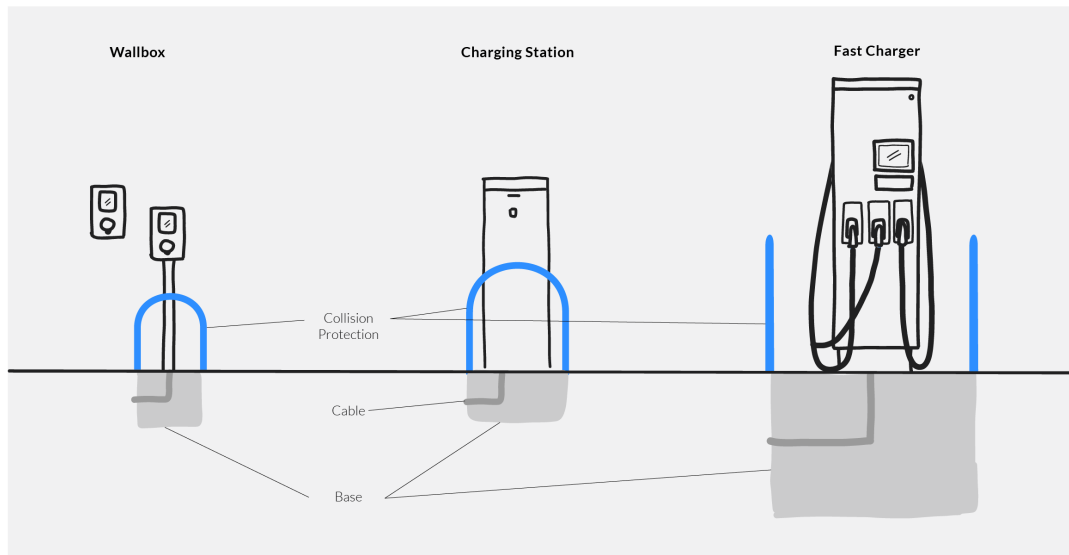
If wall mounting is possible, wallboxes are usually the most cost-effective solution. Placing charging columns in the open requires more space and additional construction (foundations). In terms of spatial placement, one charging station normally provides two places to charge, and one vehicle can be charged at each place. The charging stations should be installed or placed so that they don't pose an obstacle when parking or getting in or out of the vehicles.

Important note: The charging cables should be long enough for the vehicles to be conveniently charged in all possible positions – even if the charging socket is on the opposite side.

Charging stations are usually placed in the corners of parking spaces or between two spaces. Another option is positioning the charging infrastructure in an open area between two parking spaces. Having clearly visible markings is recommended so that the charging spaces cannot be taken up by other kinds of vehicles.

▪ Caution when parking in reverse: Bumper buffer

If there isn't a separate installation area (niche or strip) planned for installing the charging stations, this has to be allowed for within the parking spaces (typical dimensions: 50 cm x 50 cm for an AC charging column and 100 cm x 100 cm for a DC charging station)



A bumper buffer – e.g. protective brackets, wrap-around protective bands like for gasoline pumps, bollards, or raised approach boards – might also be a good idea for free-standing or wallboxes mounted on columns.

- **Cabling and power connection**

When placing charging stations, you also have to consider the route of the power supply cable from the power connection or transformer to the charging stations. All power supply cables have to be installed in pipes or cable ducts. The path from the power connection/transformer to your charging infrastructure should be as short as possible. If long distances cannot be avoided, subdistribution boards may be needed near the parking spaces.




Important note: Even if lower charging power is specified in the first phase of electrification, all cable cross-sections should be designed for 22 kW from the beginning and a power connection cable should also be laid for system control. Then there won't be any new installation costs later when the fleet grows or requirements increase.

- **Communication network**

A charging station should not only provide power, but also be able to communicate. This is necessary for load management, monitoring, and/or for billing (see Section 2.4). Therefore, you should also plan for a connection to a communication network (LAN or Wi-Fi) from the beginning. Far-away charging stations can also be connected to the mobile phone network with a SIM card. A Wi-Fi connection also provides other advantages: Software updates for the vehicle can be installed, and the drivers can use the internet connection while waiting. If third parties have access to your charging infrastructure, you can also connect surveillance cameras to prevent vandalism.

- **What will that cost me? Construction and installation costs**

Depending on the requirements placed on the charging technology and the on-site prerequisites, the construction and installation costs may differ significantly. If extensive excavation work or wall penetrations, for example, are needed for laying power lines, costs can quickly go up. This makes it even more advisable to conduct careful analysis of the location, to use any existing cable ducts and to avoid new installations.

	Wallbox	Charging Station	Fast Charger
			
Construction / Installation / Connection	€ 200 - € 2.000	€ 1.500 - € 3.000	€ 16.000 - € 40.000
Hardware	€ 300 - € 1.500	€ 3.000 - € 8.000	€ 20.000 - € 75.000
Operating Cost per Year	€ 0 - € 350	€ 0 - € 600	€ 900 - € 2.000

2.3. Connection and operational costs

“The more, the better” is not usually a useful approach when designing charging infrastructure. This is because electrical energy is very expensive, especially at peak load. The charging

Important note: *Keep the final extended capacity of your fleet in mind: All installations should be scaled so that they are viable for the future.*

infrastructure for a larger fleet should therefore be able to regulate output demand intelligently. This can significantly reduce costs without restricting the availability of the electric vehicles. The following factors influence the dimensioning of connection capacity:

- the number of vehicles at the location,
- the charging power of the vehicles that need to be connected,
- the expected average parking time, and
- the charging needs of the vehicle users.

Generally, not all of the vehicles are being charged at full output capacity at the same time, meaning that the necessary total output is less than the sum of the maximum charging powers. In this case, we also speak of a “simultaneity factor”, which is usually significantly lower than 1 (corresponding to 100%) in practice. An analysis of usage behavior, possibly with the help of simulation software, provides a realistic estimate for the connection capacity that is actually needed.

Important note: *Maximum necessary connection capacity (kW) = max. charging power per vehicle x number of vehicle x simultaneity factor*

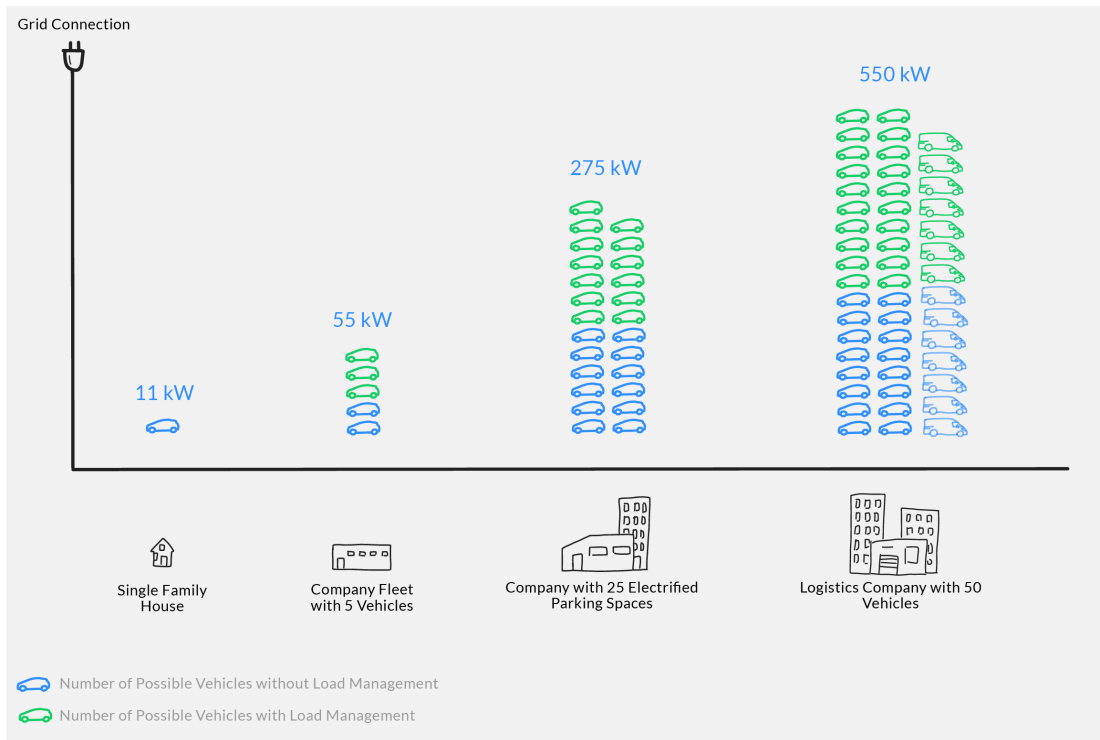
▪ Keeping an overview of current energy costs

A flexible charging strategy using load and energy management with a lower simultaneity factor helps prevent expensive peak loads, thereby reducing electricity bills. There are further savings options if charging times can be shifted to times with less expensive rates (e.g. lower night rates). For industrial customers, dynamic rates oriented around spot market prices are also common, making even more savings possible due to flexible charging times.

Energy costs can be reduced not only by cheaply “purchasing” energy, but also by using self-generated electricity from a photovoltaic system, possibly in connection with appropriately dimensioned stationary storage. Fleet charging can significantly increase a company’s own use of solar energy produced on site. As we all know, the sun does not send an invoice.

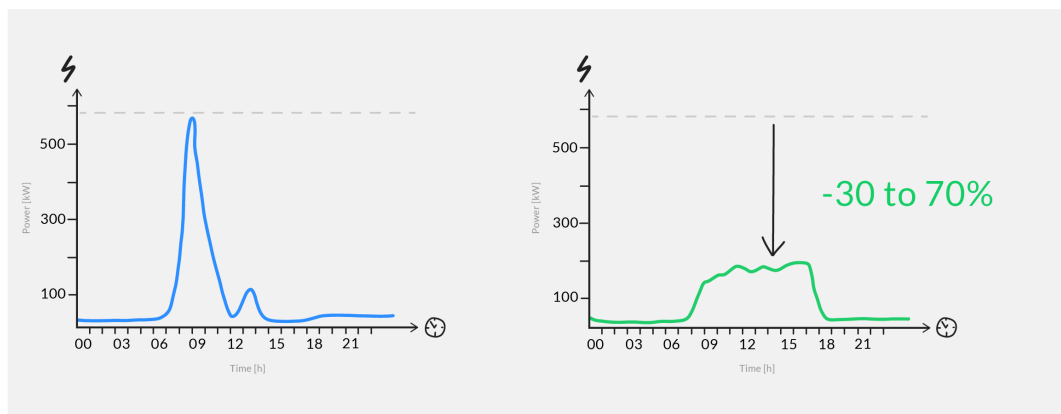
2.4. Load and energy management

With a load strategy adapted to the usage scenario of your fleet, you can gain significant savings in electricity costs. Using charging stations with an output of 11 kW results in the peak loads shown in the image below for the respective vehicle fleet.



▪ Smart charging: Load management

Load management is about distributing the available charging power flexibly based on demand. With intelligent charging instead of “static” charging, you can reduce your one-time and regular electricity costs (power connection, output remuneration) by 30 to 70%.



Especially for larger fleets, load management quickly pays dividends by smoothing out expensive peak loads (“peak shaving”). The electric installation is prevented from overloading when charging several vehicles at the same time. In practice, load management is achieved by networking the charging stations. You can then define rules for charging your fleet by using management software. If the output demand of the vehicles currently being charged exceeds a certain threshold, regulation kicks in. The following levels are possible:

- consistent distribution of the installed output for all vehicles,
- prioritization of vehicles for individual (VIP) users or a certain user group,
- scheduled charging times (e.g. for logistics operations), and

- coordination of charging times with the current energy demand of the building (e.g. reduction of charging power when cooking is underway in the cafeteria).

Example:

Company B installs 20 charging stations with an output capacity of 22 kW each in the underground garage to charge their own electric car fleet reliably. A connection capacity of 440 kW is required to fully utilize all the charging stations. However, the underground garage only has a max. 100 kW connection. With intelligent load and energy management, Company B can avoid having to increase the output of the connection, resulting in one-time cost savings of around €30,000. In addition, Company B saves up to €27,000 in service charges by avoiding a higher peak load.

- **Keeping an eye on everything: Monitoring charging status**

Controlling charging processes in larger fleets can be a complex issue, especially if load management is being used. It is important to have an overview here: Backend systems with the corresponding software make real-time monitoring possible for the entire installation. As the fleet manager, you can monitor the status and assignment of all the charging stations, check the load distribution over time and process malfunction reports. The system also allows for extensive statistical analyses.

Important note: *During everyday operation, the system regulates itself – manual intervention is only needed in the case of malfunctions, expansions, or when assigning charging priorities.*

Another possible added feature is to regulate your company's internal energy system, for example, to integrate specific energy prices/rates, energy currents from a PV system, or energy storage into your load and energy management. In the online portal, you can see how much PV electricity is generated and how high the company's own consumption currently is when charging your fleet.

2.5. Billing models

Who has used how much electricity and when? This question may come up if your employees occasionally want to charge when they are out and about or at home, if you set up visitor parking spaces, or if you make your charging stations public. Depending on the usage scenario for the charging infrastructure, various billing models are available.

- **User authentication process**

The user is authenticated before any possible billing. Nowadays, this is usually done with the following processes:

- RFID card (or a corresponding function on the employee ID)
- Smartphone app or web-based access (QR code)

The upcoming Plug & Charge process, which automatically carries out authentication between the vehicle and charging station, is even more convenient.

- **Charging at Work**

In the company parking lot or in the underground garage at the office, employees can either freely access charging stations or they can authenticate themselves with an RFID card. If necessary, third parties can be given access with a QR code. In this context there are easy-to-integrate procedures, such as Interchange Direct from Hubeit, that enable payment right at the station.

- **Charging at home**

At home, employees can charge at a wallbox (which may be financed by the company). If he or she is presumably the sole user, authentication is not necessary. If you want to carry out authentication, this can be done with an RFID card, for example.

- **Charging at public stations**

If your employees need to charge up while they're out and about, appropriate usage contracts will have to be concluded with public charging station providers. There are regional offers with city works and cross-regional offers with various providers and car manufacturers. Consider the eRoaming option so that stations of various providers can be used. There are combined charging/fuel cards for hybrid vehicles and mixed fleets (Charge&Fuel).

- **From free charging to differentiated usage models**

You can approach the implementation of a suitable authentication and billing model step by step, while also building up your electric fleet. In the early phase, you can provide your employees and visitors open access to the charging stations, and then introduce differentiated access authorization later on.

In any case, your charging stations should allow for expansion and connection to backend software. This provides the basis for different billing models, from simple export of usage data to automated invoicing. A detailed cost allocation can also be provided considering aspects of accounting and tax law, for example, if electricity is also supplied to private employee vehicles or if a company photovoltaic system is integrated to supply power.

Example:

Company C installs eight charging stations each with 11 kW in its employee parking lot. Initially, the charging stations should be available for use by all employees free of charge. In the future, however, Company C would like to keep the option open of billing employees for charging.

When choosing the charging station, the following points were considered:

- *future-proof charging power that allows larger batteries to be fully charged during idle times*
- *the charging station network connection, including backend software to visualize the charging processes and charging costs.*
- *the possibility of using software for future invoicing*

Important note: *What is eRoaming?*

Similar to roaming with mobile telephones, electric car drivers can use different operators' charging stations on eRoaming and then receive a collective invoice from their own provider. In Europe, there are already several providers of these roaming platforms (e.g. Hubject, ladenetz.de, e-clearing.net). The outlook: In the future, users of electric vehicles should be able to charge and pay conveniently at any charging station in Europe.

- **How is the electricity paid for?**

There are several options for invoicing: free charging, flat rate invoicing, and consumption-dependent invoicing. This last option can be based on kWh charged or on time. You can find all of these variants at public charging stations today. For fleet charging, you should decide on one or two options to make usage more transparent. Your country's calibration regulations may also need to be taken into account for publicly accessible charging stations.

Important note: *What has to be taken into account for billing?*

- *If your fleet is only available to a limited user group, user authentication may not be necessary.*
- *If you don't want to permanently provide your electricity free of charge, you should implement appropriately equipped or expandable charging stations when you start building your e-fleet.*
- *If necessary, make an eRoaming contract for your fleet's users.*

2.6. Legal framework conditions and funding opportunities

Before installing new charging infrastructure, different legal requirements will have to be examined, including relevant EU guidelines, national regulations on construction and planning rights, and the provisions of property ownership and rental law. Fire protection systems may also play a role. You must familiarize yourself far enough in advance that you can obtain any necessary approvals on time.

- **Use possible subsidies**

There are many possible subsidies at the European and national levels when building charging infrastructure. In some circumstances there are also regional subsidies, for instance from your energy provider. It's best to contact your provider directly to find out if there is a suitable subsidy for your project.

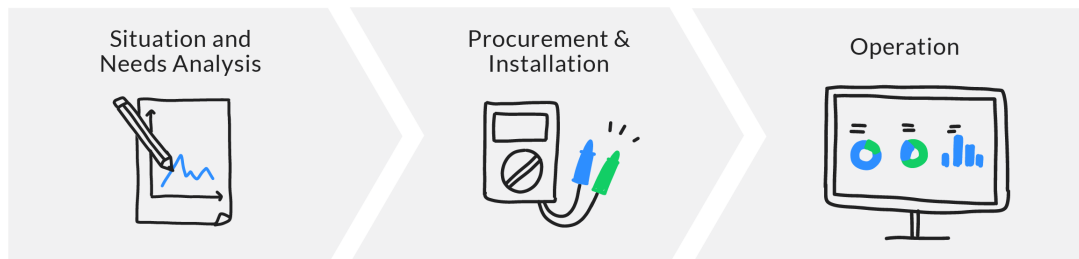
3. Step by step towards your own charging infrastructure

The success of converting or expanding your vehicle fleet to battery-powered electric vehicles or plug-in hybrids depends on careful planning. The following checklists include the steps relevant for that process and all the stakeholders that you need to involve in the implementation phase.

Important note: Begin preliminary planning early. The design and implementation of charging infrastructure for an electric fleet can easily take 6 - 18 months.

3.1 Concept phase: Situation and needs analysis, Planning charging infrastructure

<When the decision is made to expand or electrify your fleet, a precise setup of your current situation will make it easier to determine the demand for charging infrastructure on your company's property or at other locations. The concept derived from this analysis can also help you write the tender for acquiring and operating your charging infrastructure – the procurement criteria are already pre-formulated for this. The concept includes a schedule for the implementation and operation of your charging infrastructure that puts all the necessary steps in the right order.



Important note: Depending on the complexity of your requirements, bringing in a specialized service provider may be recommended for the situation and needs analysis as well as concept creation. Various charging scenarios can also be compared to identify the cost-optimized, customer-specific solution.

3.1.1 Usage profile analysis

Fleet usage profile

What does the fleet usage profile look like? What distances are driven with the electric car on an average day? How high is the annual mileage? How many trips do the vehicles take on a daily basis and how far are the trips? Are there fixed routes and driving times or are the vehicles used irregularly? When, where, and how long are the vehicles idle, allowing time for charging?

Important note: If you don't have enough detailed usage data, you can, for example, evaluate the driving logs of your existing fleet over a relevant time period (e.g. one or two weeks) or record the appropriate log information with an app.

Operational processes

What do the operational processes look like? Are there fixed maintenance or service intervals that restrict flexible charging hours?

Charging locations

Can/should employees also charge when they are out and about or at home? Is it necessary to procure charging cards or apps for charging at public charging stations?

Vehicle types

Has the decision already been made regarding the type and number of electric cars or plug-in hybrids? If yes, which charging standard(s) and charging power capacities are supported by these vehicles? How long do these vehicles take to charge? What is their battery capacity and specific consumption rate? Should employees also be able to charge electric scooters or bicycles (pedelecs, e-bikes)? Does your fleet also have larger electric vehicles, such as buses or transport vehicles?

3.1.2 Location and energy profile analysis

Important note: Vehicle requirements can be derived from the usage profile (e.g. battery size/range, maximum charging time). These also involve requirements for the charging infrastructure (e.g. plug type, charging power, number of charging stations). Simulation software can be used to model and evaluate your usage profile in detail. Various charging scenarios can also be analyzed and assessed during this process.

Location

Where will the electric vehicles normally be parked or charged? Is there enough space for the charging infrastructure at the planned location? What is the distance between the charging stations and the transformer or power grid connection?

Power connection

How high is the available power network connection at the location? Is expansion possible if needed, and what would the costs be? Will the charging stations be on the same connection as the office building?

Electricity rates

Is it cheaper to expand the existing electricity supply contract (possibly cheaper volume rates) or to enter into a separate contract to provide charging infrastructure, perhaps with another energy supplier? (Tip: If you decide to conclude a new contract, the electricity should come from renewable sources. This will help you to improve your company's ecological assessment, which is also beneficial for your public image.)

Renewable energy

Is there a PV system, a wind turbine, or a cogeneration plant on your property that can be used for charging? Would it be worth investing in stationary storage?

3.1.3 Designing and planning the charging infrastructure

Important note: You may be able to start the conversion to electric mobility with a small number of vehicles to gain some initial experience. In the process, you should also make sure that your charging infrastructure has room to grow. Pipes, cabling, and load management should be designed so that new (quick-charge) charging stations and other plug systems can be added. In the end, you'll want to be as independent as possible from the charging infrastructure provider.

Number of charging stations on the property

How many electric cars and/or plug-in hybrids should be included in your fleet? What does their usage profile look like? Have you also considered foreseeable expansions to your fleet or the subsequent purchase of more powerful vehicles when designing your charging structure?

Location of charging stations

Have you considered easy access and short cable distances to the power connection?

Charging station equipment

Important note: When choosing charging technology, also remember that future vehicles will most likely have larger batteries, and allow room in your calculations for the charging power that needs to be installed – it shouldn't be less than 11 kW per charging station. You may also need one or two direct-current (DC) charging stations for short-notice vehicle use.

- **Charging power**

What charging power will be needed? Should charging be carried out with alternating or direct current? Do short-notice trips come up often?

- **Connection / plug type**

Do the charging station capacities and connections selected correspond to the chosen vehicle models?

- **Communication capabilities**

Do the chosen charging stations support a connection to your company network via LAN or Wi-Fi? Was this considered during installation planning?

Important note: You should always choose future-proof standards: Your stations should at least have standardized type 2 and perhaps CCS plugs/connections for quick DC charging, and they should support the OCPP communication standard and prepare for the upcoming ISO 15118 (Edition 2) standard.

- **Access protection**

If the charging infrastructure is only supposed to be used by authenticated individuals, you should make sure to purchase charging stations with the appropriate access protection (e.g. RFID).

- **Protective devices**

Every electric car charging station has to have its own power circuit that is secured with a circuit breaker and a residual current circuit breaker (a type B RCD or a direct current sensor has to be used for a multi-phase connection). A residual current circuit breaker and/or a direct current sensor is already integrated in some charging stations, which can significantly reduce upcoming installation costs.

Accessories

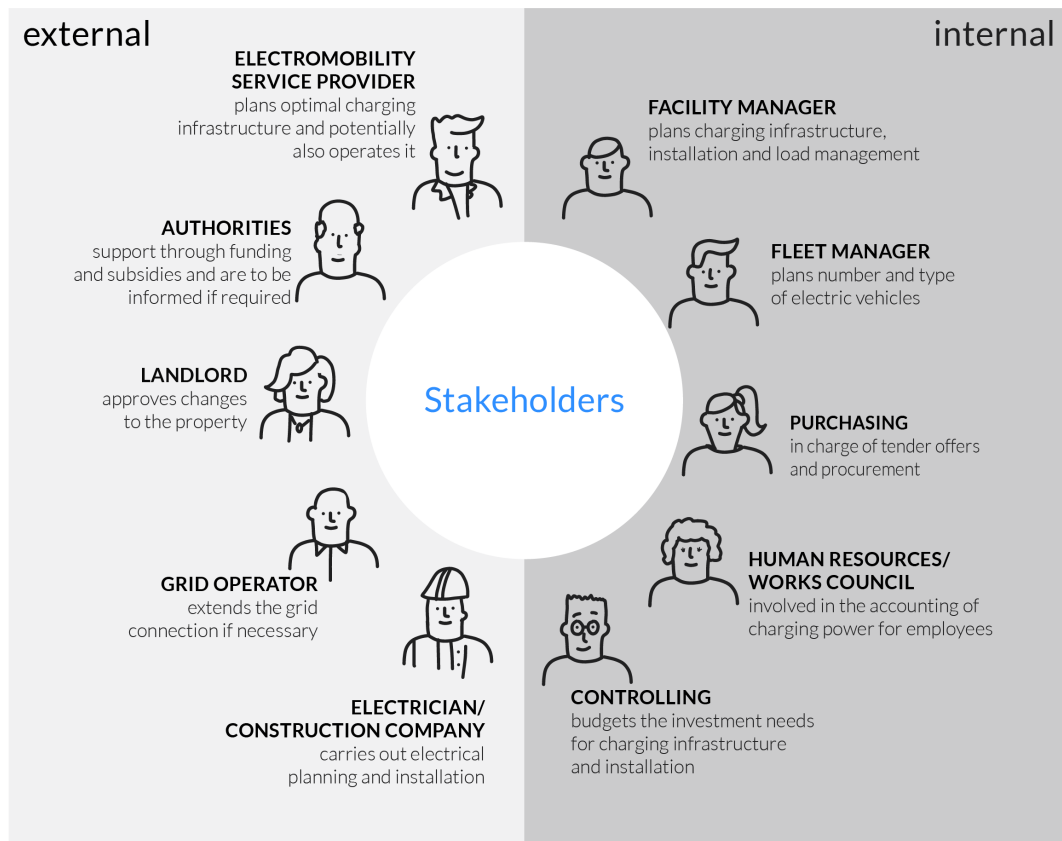
Will any additional accessories, such as columns, wall brackets, mounting brackets, adapters, RFID cards, mobile charging cables, surveillance cameras etc., be needed?

Additional services

Do you need additional services like load management, monitoring, or a billing module? See Sections 2.4 and 3.1.2 for those topics.

3.1.4 Stakeholders: Who needs to be notified?

The more precisely you plan the acquisition and installation of your future charging infrastructure, the smoother your transition to electric mobility will be. Many of the parties involved have to be informed and integrated. Coordinate with the responsible authorities in advance to learn what structural requirements might need to be fulfilled. Your energy provider is also one of your most important partners. And your neighbor might be, too: The business next door might even be interested in sharing the costs and access to the power connection and charging stations with you.



3.2 Procurement and installation

3.2.1 Procurement criteria

The essential procurement criteria for charging infrastructure are:

- Total Cost of Ownership (TCO)
- Technical reliability
- Functionality
- Future viability (compatible, scalable)

Purchasing or leasing the charging infrastructure?

Would you like to buy or lease the charging stations? For leasing, check whether the installation can be leased along with the hardware. For purchasing, you can request various financing options.

Observe technical requirements

Make sure the charging stations conform to your country's national regulations and consider any subsidy options offered for the equipment. Before making a purchase, it is worth contacting a qualified installation company with relevant experience in building charging infrastructure.

Operator model

Who is responsible for operating the charging stations? If an external service provider takes over operation of the charging infrastructure, this reduces the effort your company needs to put in.

Possible components of the tender

- Charging stations
- Charging accessories (mobile charging cables, adapters, columns...)
- Laying connection cables (excavation work)
- Laying foundations
- Bumper buffers for charging columns
- Signage on charging stations (also for access routes)
- Additional illumination

- Access protection (barriers, gates)
- Load management setup
- Backend (monitoring software) for surveillance
- Billing system (if needed); administration of charging cards/charging app (smartphone) if required; online portal setup with FAQs and option to reserve pool vehicles and usage of charging stations; ordering new charging cards, etc.
- Operator model

3.2.2 Installation and approval

Finally, your charging infrastructure is coming! The requirements are:

- detailed planning for the electric installation and – if necessary – for preliminary building construction and excavation
- (when building on rented areas) approval from your landlord for all planned works;
- approval from your distribution system operator for providing the intended services;
- (if relevant) positive assessments from the responsible construction authorities and your operational accident insurance.
- Qualified specialist companies have been chosen and commissioned to implement the construction and electrotechnical installations.

Preparations for construction

- Existing buildings: Are wall penetrations necessary for cable ducts? Can existing pipes be used?
- New buildings: Were short paths to the power connection considered when laying the cable ducts?
- Have the walls been inspected to see whether they are suitable for wallbox installation? Have foundations been planned for charging columns?

Arrangement of charging spaces

- Has enough space been planned to install the charging stations? This might include bumper buffers like metal brackets, posts, or a higher curb edge. Are the charging cables long enough?
- Is clear signage planned for the charging spaces, possibly including information on the maximum idle time/charging time? Has the route to the charging stations been labelled?
- Do outdoor parking spaces need additional lighting or protection from the rain? Is the text on the column display legible in direct sunlight? Even though conventional charging stations are usually protected against spraying water (IP 54), a roof or similar cover may be recommended for this reason.
- Is camera surveillance needed?
- Do the charging stations require access protection (barriers, gates) that stays closed after business hours?

Electric installation and installing the charging stations

The commissioned electrician will lay the cables and install subdistribution boards if necessary. The electrician will mount the charging stations or wallboxes that have been delivered according to the manufacturer's installation instructions. Then the electrician will inspect the entire installation for functionality and create a corresponding inspection protocol. Lastly, you will be instructed how to operate the charging stations.

Informing the landlord

If you are not the owner of the company building or property, inform your landlord about the completion of installation work. He or she should be given the opportunity of having the building electrician inspect the work for proper installation.

Registering the charging station with the energy provider

In some European countries, new charging stations with a certain minimum charging power or higher have to be registered with or approved by the responsible provider. Did the electrician take care of this registration during installation?

Commissioning

The charging infrastructure is handed over from the builder to the fleet operator when it is ready for operation. This includes handing over the relevant documentation and inspection logs.

Employee training

Remember that some of your employees don't have any experience with electric vehicles yet and they might even be a bit skeptical of them. When a vehicle is handed over, there should also be training about the particularities of driving, charging, and maintaining electric cars.

3.3 Operation

Monitoring ongoing operations is very important. Define the scope and distribution of responsibilities when monitoring your electric mobility. Recommendation:

Access to the charging stations

To better monitor your charging infrastructure, the charging process should be authenticated. This way, you can assign power quantities to individual consumers or vehicles and analyze them, or make use of marketing options in case of overcapacities. For different electric vehicles in the fleet, a consumption evaluation can provide useful conclusions for future investments.

Access to external charging stations

For your external employees, you should choose a contract with a roaming provider that offers coverage of the desired area. Drivers of plug-in hybrid vehicles should receive an extended fuel card that they can use to pay for normal fuel as well as for electricity (Charge & Fuel).

Charging infrastructure repair and maintenance

Appoint an employee at your company to be responsible for the regular maintenance of your charging stations, or commission an external service provider with this responsibility.

Monitoring the charging infrastructure

Is load management working? What is the load of the charging stations? Do any adjustments need to be made? Do all the charging stations in all the locations work? Are there any necessary updates for the charging infrastructure or vehicles that should be installed?

Malfunction management

What happens if there is a malfunction? Who can employees contact or call (hotline) if a charging station is malfunctioning? Define the service level agreement with your internal or external malfunction management. Who should a driver contact if there are problems with the vehicle on the road or an external charging station?

Important note: Specify who is allowed to use the charging stations and how the current is activated. Operating the charging infrastructure involves long-term cooperation and responsibilities. Therefore, you have to appoint persons responsible for maintenance and for malfunctions. When an electric car is handed over to an employee, they should be given instruction/training in how to use the charging stations.

Liability for damage

Operating charging infrastructure generally does not present any particular risks. However, as with every electric installation, the chance of malfunctions or possible damage cannot be completely eliminated. The following applies in principle in terms of liability:

- If damage can be traced back to faulty installation, the electrician is liable.
- If damage can be traced back to the electric car or the charging station, the respective manufacturer is liable.
- If it is an error in use, you are liable as the owner or operator of the system.

3.4 Outlook: Your charging infrastructure today and tomorrow

If you have observed all the points listed, nothing stands in the way of successful acquisition and smooth operation of your electric fleet. In the future, you can pursue your business with your fleet in an environmentally friendly way with low emissions. Electric mobility offers your employees comfortable driving and an image boost for your company. Electric vehicles are more energy efficient, they are emissions-free when driven locally, and they reduce noise pollution with their quiet engines. In addition, the operating costs are significantly lower in comparison to combustion engines.

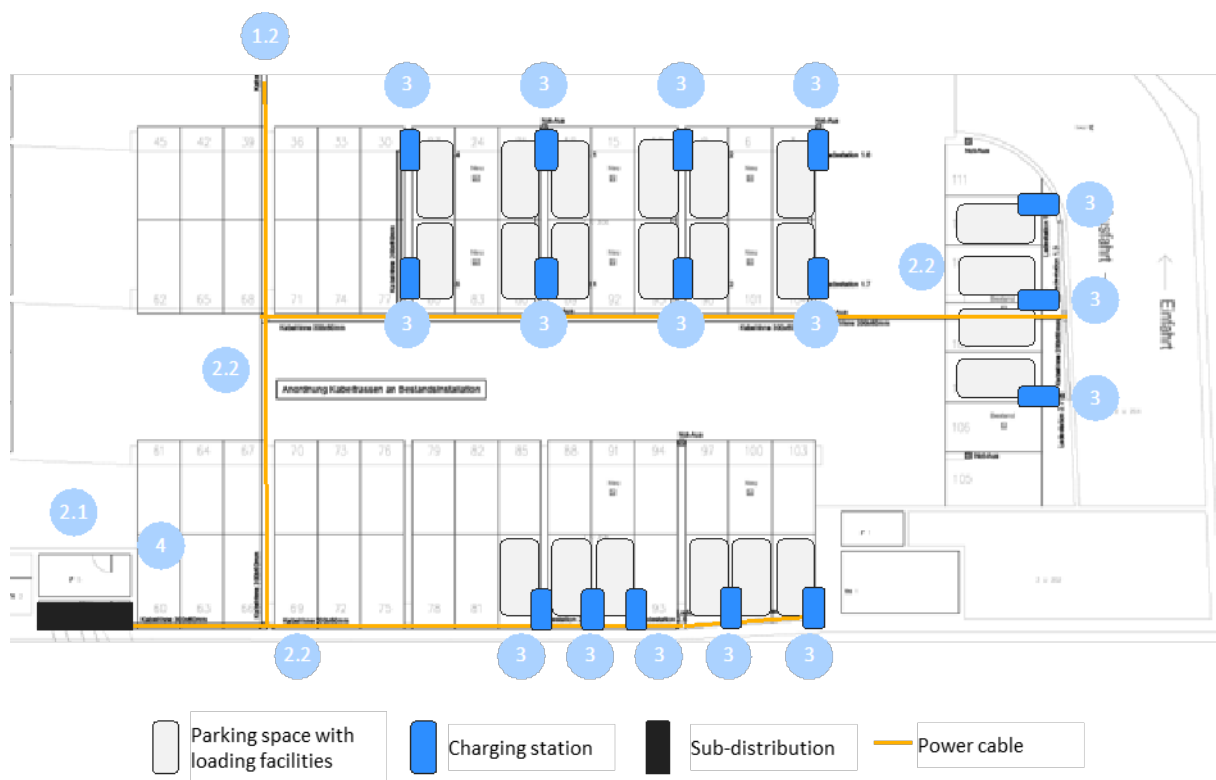
At the same time, the current electric mobility standard guarantees that you won't have to "redo everything" in five years. Your fleet can grow with the company's needs, and new technologies – subsequently available systems for super-quick or inductive charging, for example – can be integrated into the existing charging infrastructure. Intelligent linking of other energy systems, such as a PV or energy storage system, will also result in new opportunities to optimize operational energy management. In the future, electricity won't be limited to flowing only in the direction of vehicles: instead, depending on demand, electricity will also flow back to the business or the public power grid (Vehicle to Grid/V2G). This is a way to better utilize your charging infrastructure and profitably market energy surpluses.

4. Practical example

Charging infrastructure for an underground garage with 200 parking spaces

- In an underground garage for fleet and employee vehicles, 22 of the total 200 parking spaces were equipped with charging infrastructure. Planning included a future expansion of the charging infrastructure.
- To meet future charging requirements, charging power of 22 kW was planned for each charging station. The vehicles are connected conveniently with a type 2 cable or flexibly with a type 2 plug.
- Because of the limited capacity of the power connection, load management was installed to intelligently distribute the available capacity to the charging stations.
- The charging processes are approved by presenting identification via an RFID card. The data can be viewed and managed in a monitoring system.
- A billing service was not requested, but this can be retrofitted in the future.

Installation and layout



	Components	Comments
1	Power connection	
1.1	Transformer	Expansion not necessary in this case
1.2	Connection capacity	2 x 100 kW
2	Installation	
2.1	Electrical distribution	2 subdistribution boards, 1 network cabinet
2.2	Electric installation	150 m of cable ducting, 700 m of cable, and 700 m of network cable
3	Charging infrastructure	6 wallboxes (2 charging stations of 22 kW), 10 wallboxes (1 charging station of 22 kW)
4	Load management	Dynamic distribution of the existing power cable of 200 kW to the charging stations being used (max. peak load without load management: 22 x 22 kW = 484 kW)
5	Systems access control	possible via RFID reader in the charging station
6	Monitoring	possible via charging station network connection; representation of charging processes
7	Billing	Not desired at this time but possible in the future with the charging station network connection
8	Operation	Continuous function monitoring of the charging stations with a backend connection; regular inspection of the charging infrastructure

Integration of a load management system

- With the current number of 22 charging stations, in the worst case scenario an additional load peak can occur when charging 22 electric cars at 22 kW (22 x 22 kW = 484 kW).
- This would exceed the existing connected load of 200 kW by more than twice its capacity.
- To cover the peak load, the connected load could be increased by network expansion. This would not result in significant costs.
- By using load management, the costs of a network expansion can be avoided, because the current connection load is distributed across all the charging stations.
- With future load management, approximately eight more parking spaces can also be electrified without having to expand the network. It is also possible to consider the building load.

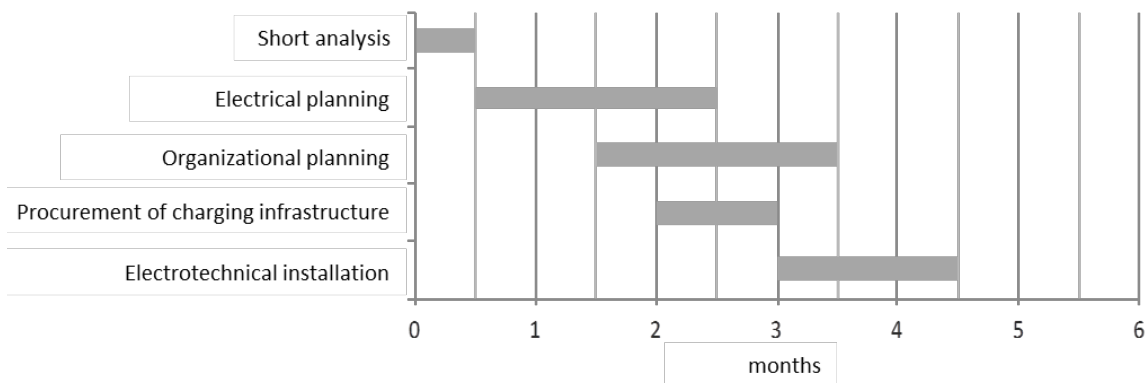
Overview of investment and operating costs

Investment costs	
Charging & infrastructure concept	€7,000
Electrotechnical planning	€13,000
Network connection expansion, including transformer	€0
Electric installation, construction	€50,000
Charging infrastructure	€33,000
Load management	€2,000
Systems access control	integrated into the charging station
Monitoring	integrated into load management
Billing	not requested
Total	€105,000

Monthly operating costs	
Load management	€100
Systems access control	integrated into the charging station
Monitoring	integrated into load management
Billing	not requested
Electrotechnical maintenance (in acc. with DGUV (German Social Accident Insurance) V3)	€150
Service in operation (24/7, hotline)	carried out by in-house electrician
Total	€250

Project schedule

Project phase	Person responsible	Description	Duration (months)
Concise analysis	External consultants	Development of a charging concept for fleets and car parks	0.5
Electrotechnical planning	Installation partners / external consultants	Planning the electrotechnical construction (distributors, cable routing, charging stations)	2
Organizational planning	Person responsible for e-mobility / customer	Obtaining approvals, placing orders, applying for subsidies	2
Purchasing the charging infrastructure	Person responsible for e-mobility / Purchasing	Selection of charging stations, taking delivery times into account	1
Electrotechnical installation	Installation partners	Installation of charging stations, Laying and connecting cables	1.5



5. Glossary

AC charging	Charging with alternating current
Battery	Used in the field of electric mobility as a synonym for the term “re-chargeable battery” (secondary cells)
Ampere	Unit of strength of an electric current (A)
Backend	Functions of a program are defined here; in contrast to the customer-centered frontend set up here, the backend is the system side of the software
Battery	Energy storage for the vehicle; batteries can be rechargeable (secondary cells; installed in the vehicle) or non-rechargeable (primary cells)
CCS	Combined Charging System; quick-charging system for AC and DC charging (type 2 plug expanded with two additional direct-current plug pins)
CHAdeMO system	Standard Japanese plug; DC
CPO	Charge Point Operator; charging infrastructure operator
DC charging	Charging with direct current
ESP	E-Mobility Service Provider; access provider for charging infrastructure
Energy density	Amount of energy that can be stored per unit of mass (of the battery)
Residual current circuit breaker	or RCD (residual current detector); protection against electric shock
ICCB	In-Cable-Control-Box; control device integrated in the cable, responsible for communicating with the vehicle in Mode 2
Inductive charging	Contactless, wireless battery charging using electromagnetic induction
IP	International Protection; labelling of the protection type of the charging column housing; minimum requirement: IP44
ISO/ISO 15118	International Organization for Standardization; responsible for defining standards; in the future, ISO 15118 should become one of the most important standards for the communication between EV and LIS, and defines standards for V2G
Kilowatt	Unit of measure for (electrical) output (kW); decisive for the vehicle charging time
Kilowatt-hour	Unit of measure for (electrical) energy volume (kWh); battery capacities are specified using this measurement; decisive for the vehicle’s range
Conductive charging	Charging with a cable
Charging power	Electrical output that is used to charge the vehicle; can be limited by the charging station or by the vehicle itself
Charging station	Device that supplies electric vehicles with energy
Load and energy management (system)	System that handles the charging ecosystem; may possess hardware and software components; e.g. possibility of integrating stationary storage systems or load management
Load management	IT system for the (intelligent) regulation of one or more (parallel) charging processes; part of load and energy management;
SoC	State of Charge; amount of stored energy; expressed as a percentage of battery capacity
MSP	Mobility Service Provider; access provider for charging infrastructure

OCPP	Open Charge Point Protocol; communication standard that describes the data exchange and operations between a charging station and a backend system
Peak shaving	This describes reducing and smoothing out load peaks
PV	Photovoltaic (system)
RFID	Radio Frequency Identification; conventional technology for identification at the charging station
Roaming	Enables charging of electric vehicles with different providers
Schuko plug	Plug for the common domestic socket; used for Mode 1 charging
TCO	Total Cost of Ownership; total cost (for a vehicle) over the entire usage period
Type 2 plug	Standard plug for Europe
Wallbox	Charging station usually mounted on a wall
Watt	General unit for the physical magnitude of (electrical) Output (W)
Watt hours	Unit of measure for the volume of (electrical) energy (Wh)
Volt	Unit of measure for (electrical) voltage (V)

Although many people have worked to prepare this compendium to be comprehensive and correct, mistakes may have crept in or new information may have come to light that we'd like to include in the next edition. If you have found something or if there is anything we should add, please send an email to: info@mobilityhouse.com.



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