Nationale Agenda Laadinfrastructuur

Charging Handbook for Transport Depots

A practical checklist for e-truck charging infrastructure

Sluit aan

Introduction

The world is rapidly changing and every area of work, including the transportation sector, is striving to become more sustainable. One way of increasing sustainability is to use electric trucks. There is a growing market for such e-vehicles, with several manufacturers already offering a number of models.

Governments are also encouraging the use of electric trucks by subsidising their purchase, for example.[1] The operation of (older) diesel vehicles will be further discouraged by implementing (and enlarging) environmental zones.

These and other developments have left the transportation industry facing the challenge of making the truck fleet more sustainable by converting to electric vehicles. The increasing use of such e-trucks, has of course raised numerous issues, especially with regard to charging these E-trucks.

This handbook will help answer important questions on this subject by offering practical information, guiding discussion, generating new insights and providing concrete tips. The focus will be on the charging of vehicles at transport depots, as research has revealed that 80% of future e-truck charging will take place at such locations.[2]

Who is this handbook for?

This document has been written for haulers and/or shipping agents who have questions about implementing more powerful electrical infrastructure at transport depots specifically intended for charging a fleet of heavy-duty e-trucks (categories N2/N3).[3] In addition, it can also be used for other heavy-duty EVs, such as waste collection vehicles.

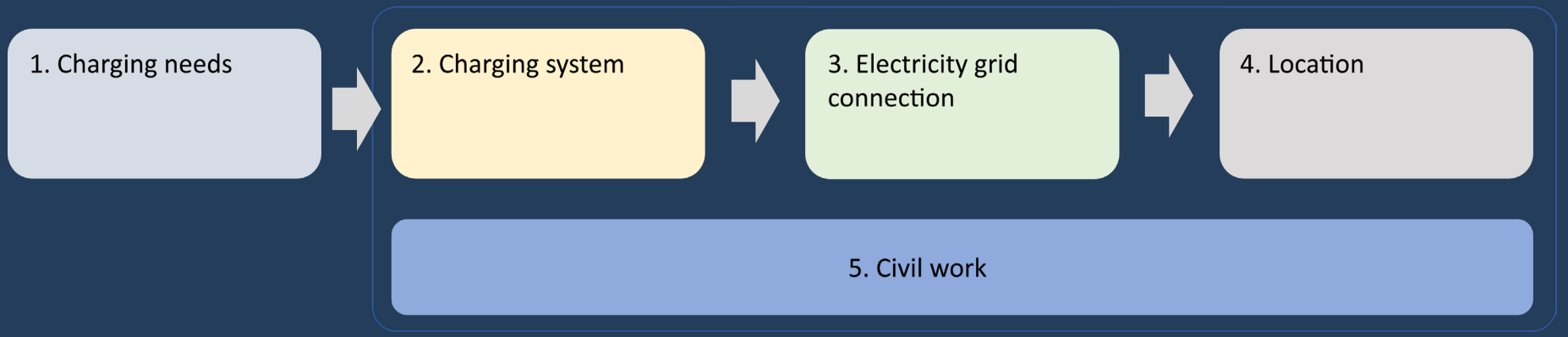
What is the scope of the document?

The handbook focuses exclusively on charging at transport depots and not fast EV charging along the highway or at other public locations. In addition, the discussion solely relates to charging infrastructure for e-trucks. They can be either battery-electric or plug-in hybrid vehicles. Hydrogen vehicles and infrastructure will not be discussed.

[1] https://www.rijksoverheid.nl/binaries/rijksoverheid/documents/kamerstukken/2021/12/14/regeling-aanschafsubsidie-zero-emissie-trucks-aanzet/regeling-aanschafsubsidie-zero-emissie-trucks-aanzet.pdf
[2] https://www.elaad.nl/uploads/files/20Q3_Elaad_Outlook_E-trucks_internationale_logistiek.pdf
[3] N2 and N3 vehicles are heavy commercial vehicles. A vehicle falls into the N2 category if it weighs between 3.5 and 12 tons and in the N3 category if it weighs more than 12 tons.v

How to read the handbook

The handbook covers several key topics involved in achieving appropriate charging infrastructure. They are shown in the flowchart below and listed in the table of contents. The topics or sections can be read in sequence or as stand-alone items. Use the checklist on page 4 to determine the information relevant to you.



We will start with the basic question: What are your **'Charging needs'** and how to determine them? All the important factors associated with charging stations are then discussed in the section on the **'Charging system'**. You can read how to organise a suitable electricity grid connection in the **'Electricity grid connection**' section. The section entitled **'Location**' discusses the points concerning the charging system's surroundings. Finally, the requirements for installing charging stations, network connections and setting up the site can be read in the **'Civil work'** section.

Disclaimer

The content of this handbook has been produced with the utmost care and developed to be applicable in various countries. Although national (energy) systems share many common features, differences undoubtedly occur. Since the authors have written the document in a manner to facilitate its use in multiple countries, some country-specific information may have been omitted. For this reason, the authors cannot be held liable for any inaccuracy or incompleteness in the information provided.

This is the first version of the **'Charging Handbook for Transport Depots'**. Due to the rapid developments occurring in the market, regular updates will be provided.

Checklist for EV charging at transport depots

- [x] **Charging needs**
- [ ] *I know how many kWh my electric trucks will need. If not, see 1.1 and 1.2.*
- [ ] *The ways in which electric trucks impact logistics processes are clear. If not, see 1.1*

- [x] **Charging System**
- [ ] *I have chosen the type and number of charging stations. If not, see 2.1 to 2.4*
- [ ] *I know the charging capacity that the charging stations should have. If not, see 2.3 and 2.4*
- [ ] *The method for financing the charging stations has been selected. If not, see 2.6*

- [x] **Electricity grid connection**
- [ ] *I have a clear understanding of the current connection and contracted capacity at my depot. If not, see 3.1*
- [ ] *I know whether my current grid connection needs to be upgraded and whether this can be done. If not, see 3.2*
- [ ] *My grid connection can be upgraded. I know how to arrange the upgrade of the network connection. If not, see 3.2*
- [ ] *My network connection cannot be upgraded. I know the various alternatives to meet my energy demand. If not, see 3.3*

- [x] **Location**
- [ ] *My depot is on private property. I am familiar with the various requirements for the construction of charging infrastructure. If not, see 4. 1*
- [ ] *My depot is not on private property. I know what to take into account when constructing charging infrastructure. If not, see 4.2*
- [ ] *I have prepared a plan detailing how the charging site will be set up. If not, see 4.3 to 4.8*

- [x] **Civil work**
- [ ] *I know what work needs to be done and which organisations I need to contact. If not, see 5.1*
- [ ] *The schedule for the infrastructure construction work has been drawn up. If not, see 5.2*
- [ ] *I am aware of the risks associated with the work. If not, see 5.3*
- [ ] *The cost estimate for the work has been made. If not, see 5.4*

Content

1. Charging needs

When implementing EV charging at transport depots, it is important to determine the amount of electricity that will be used for charging. This section describes the factors that influence the extent of the ´charging needs´ and how you determine it.

1.1. Which factors determine the amount of electricity required?

The amount of electricity an electric truck needs depends on several factors. The vehicle itself constitutes a key element. For example, a heavy tractor-trailer combination with estimated electricity consumption of 2 kWh/km will consume more electricity than a light truck with estimated electricity consumption of 1 kWh/km. To determine an e-truck's charging needs, it is, however, especially important to identify the purposes for which the vehicle will be used.

Important components that affect the energy consumption are:

- **The length of the ride**. The more kilometres that must be driven, the more kWh the truck consumes and therefore the more kWh must be charged at the depot.

Tip – Overview of available trucks

For an overview of the range of available tucks, please go to the Zero Emission Technology Inventory tool.

- **The cargo**. The weight of the cargo has a great influence. The heavier a truck is loaded, the higher the consumption, as more energy (kWh) is then required to drive the truck. More electricity is also required If the cargo must be cooled during transport, causing electricity consumption per kilometre to increase.
- **The route**. In addition to the length of the route, the type of route also has an influence. When properly deployed, an e-truck in city traffic with a lot of stopping and starting can achieve relatively favourable energy consumption due to energy recovery during braking.

Tip – Selecting the right truck

Truck suppliers can help configure the electric truck and its charging infrastructure. Often, they have digital tools to create certain scenarios for truck and charging infrastructure based on monitoring data (of diesel trucks). In addition to truck suppliers, there are independent consulting agencies that can help in determining charging needs and strategy.

- **The driver**. The driving behaviour of the driver has a major impact on an e-truck's consumption. Accelerating quickly and driving fast increase the consumption in terms of kWh per km.
- **Ambient temperature**. A lower temperature has a negative influence on consumption and therefore also on the range of an electric truck. Experiences vary, but consumption can be up to 25% higher at low temperatures (winter) compared to regular temperatures. At very high temperatures (summer), consumption can also increase significantly, partly because of air conditioning, which also uses energy directly from the battery. The effect can also vary depending on truck model. It is advisable to consider this performance factor when choosing an electric truck.

1.2. Which factors influence the scheduling of charging time?

The previous section describes the factors that influence the vehicle's energy consumption. Logistics planning may have an influence on many of these factors, as well as the scheduling of charging time. It is important to take charging time into account in logistics planning in order not to waste valuable driver and truck operation time. It is also important to avoid inappropriate investments in charging infrastructure.

Research by ElaadNL has shown that 80% of an e-truck's charging time will occur at the transport depot[4]. Trucks that are stationary for long periods of time (e.g. at night) can then be recharged to 100%. Should this 100% not be sufficient for daily operations, it would be wise to quickly recharge in the interim as well, whenever the charging operation does not disrupt logistics planning.

The scheduling of charging time is not only subject to logistics planning but also to the availability and price of energy, which also constitute critical factors. Daytime charging may, for example, be less expensive because it uses energy from solar panels. Smart handling of fluctuating energy prices constitutes another example in this regard.

[4] https://www.elaad.nl/uploads/files/20Q3_Elaad_Outlook_E-trucks_internationale_logistiek.pdf

2. Charging system

Charging stations are a key part of transport depot charging infrastructure, and there are quite a few of them available on the market. They vary in terms of charging speed in particular, but also in terms of their quality and pricing. This section describes what to look for when choosing a charging station.

2.1. What types of charging stations are available?

Charging operations can be divided into regular and fast charging. Your choice depends on your charging needs. Regular charging requires longer charging time, while fast charging reduces the time requirement.

Regular charging

Slower chargers are used in regular charging and are applicable when trucks are not used for an extended period. Since these charging stations are less expensive, price is one of the advantages of regular charging. Both AC and DC regular charging stations are available.

- AC charging stations have the advantage that they are often cheaper than DC charging stations. To be able to use AC charging stations, an electric truck must have an 'onboard charger' (onboard inverter). These stations can generally charge with 11 or 22 kW. It is important to determine if trucks are stationary long enough to be fully charged with these types of stations.
- There are also several DC charging stations on the market that are well suited to regular charging. In fact, not all electric trucks come with AC charging as a standard option. DC chargers usually have capacities between 25 and 50 kW and are generally slightly pricier than AC chargers. The costs of various stations will be discussed later in this section.

Fast chargers

There are also fast chargers on the market specifically designed for trucks. Their use makes sense when the range on a full battery is too limited for the routes involved. Charging is then often combined with a rest stop and/or the loading and unloading of cargo. All fast chargers are DC, and their typical power rating is between 150- and 350 kW.

To illustrate, a truck with 200 kWh battery capacity can, at a fast charger and under optimal conditions, charge from 20% to 80% of its capacity in an average of 20 minutes. However, each electric vehicle has its own charging curve, and these can vary a lot from vehicle to vehicle. In general, vehicles will charge the upper and lower 20% of their battery capacity at a significantly slower rate in order to avoid the risk of damage to their batteries. Truck power capacity also plays a role. Since not every truck can handle the highest charging speeds, you should check with the truck supplier about the options available.

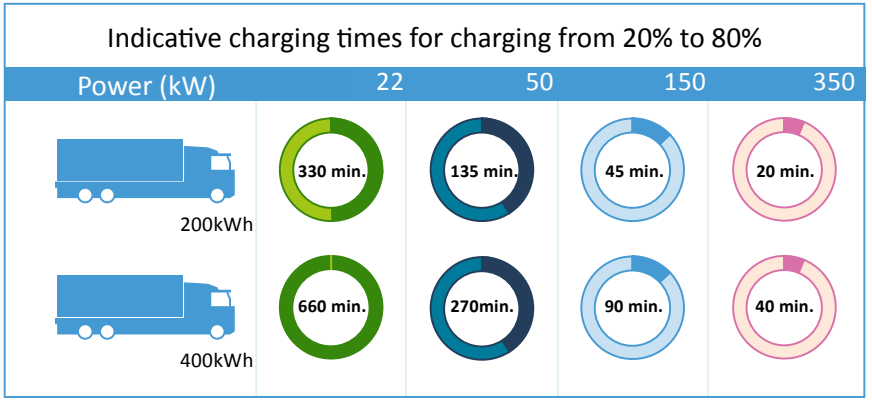


Figure 1 shows several representative charging times for an electric truck with a 200 and 400 kWh battery pack. Future developments relating to charging speeds are discussed briefly in §2.8.

2.2. Which type of charging station suits your organisation?

The right type of charging station depends on when and for how long your electric truck will or can be charged. This is also known as the 'charging strategy'. Two things are important in determining your own charging strategy: the range of the electric truck and the charging options.

Charging strategies

Although specific charging strategies can vary endlessly from one organisation to another, two main strategies are:

- **Regular charging**. The truck is only charged at night without interim recharging times during the day. See Trip profile 1 in Figure 2.
- **Fast charging**. The truck must be charged during the day (at least once). A fast charger must almost always be used for interim recharging. See *Trip profile 2* and *Trip profile 3* in Figure 2. (For charging times, see Figure 1.) Fast charging is generally combined with regular charging, except when fast charging is exclusively used around the clock.

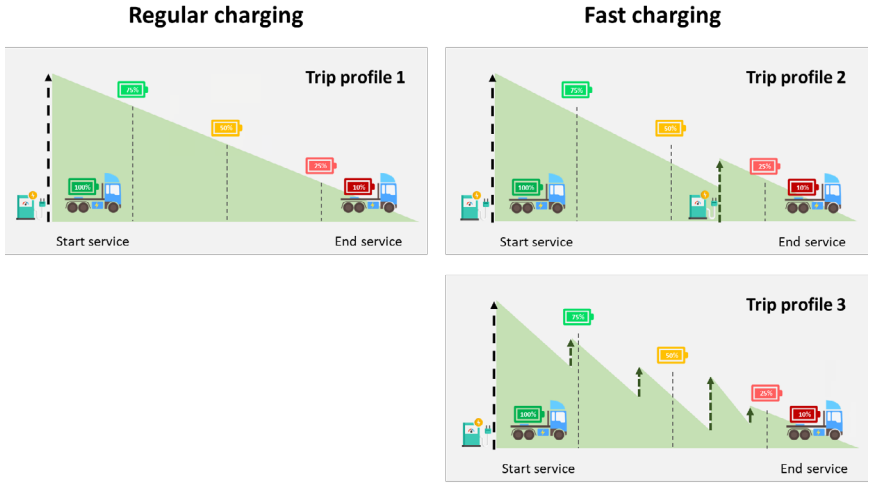


Figure 2: Charging strategies: regular charging and fast charging.

The charging strategy that best suits your organisation depends on your logistics planning. Fast charging should be used if the truck needs to drive more kilometres than the range of a full battery charge. If fewer kilometres are driven in a day, regular charging will suffice. Furthermore, an e-truck using regular charging according to profile 1 may, on another given day, still require interim fast charging due to several factors that affect the vehicle's range. For more information on the factors affecting an e-truck's energy consumption, see Section 1.

2.3. How many regular charging stations do you need and at what charging speed?

The most obvious time for charging is when the truck is not in use (e.g. at night). Since trucks cannot normally be interchanged at night in order to be charged in succession, a separate regular charger must be available for each vehicle.

Future plans should also be taken into account when determining the number of regular chargers. You would be wise to consider the number of electrical trucks you will incorporate in your feet over the coming years. Distribution System Operators (DSOs) generally look 10 to 15 years ahead when making plans about their electricity grids. You can include the different scenarios as a starting point when consulting potential suppliers. This future orientation is mainly important for grid connection and civil work. See Section 3 'Electricity grid connection' and Section 5 'Civil work'.

The speed of the chargers you wish to purchase mainly depends on the size of the truck's battery pack and the time when the vehicle can be charged. Taking this information into account, the most inexpensive option is to select the lowest charging speed that can charge the vehicle up to 100% during the charging session. A lower charging speed often means a less expensive charging station and the lowest impact on the grid connection. For more information about the grid connection. See Section 3 'Electricity grid connection'.

However, there are also alternatives where several trucks can be connected to and charged by a single charging system. These systems consist of charging stations with plug-in connections and a 'power cabinet' integrating the charging technology. There are two options in this design:

- Sequential charging. Full power can be made available at one of the charging points at any one time. The truck with the lowest residual battery charge can be given priority, for example.
- Dynamic charging. The power is distributed over the charging points. Whenever a vehicle reaches full charge, the resulting available power can be used to charge the remaining vehicles still charging. For further information see 'Smart charging' in Section 3 'Electricity grid connection'.

2.4. How many fast chargers do you need and at what charging speed?

Fast charges are used to rapidly recharge vehicles so that they can complete their routes for the day. These chargers are usually used for short periods on any given day, and several trucks can therefore make use of the same fast charging station. Importantly, logistics planning can be arranged to avoid queuing and to ensure that fast chargers are utilised as fully as possible. Fast charging can also be combined with rest stops and/or the loading and unloading of cargo in order to minimise the costs of inactive drivers due to unnecessary waiting. The number of charging stations therefore depends on the charging time requirement and the compatibility of this charging time with logistics planning.

Increasing a fast charger's power decreases the time required to recharge an e-truck, allowing it to drive more kilometres in a day. A fast charger with a higher power will therefore ensure more efficient use of an electric truck. Figure 1 displays estimates of charging time at different power outputs. Other important factors when selecting the desired charging capacity are:

- **Truck charging capacity**. Charging speed is not only determined by the charging station but also by the charging speed that an electric truck can handle. A charging station with 350 kW capacity will charge an e-truck that can handle maximum 200 kW at power not exceeding 200 kW.
- **Charging curve**. A battery cannot be charged at full power from 0% to 100%. The beginning and end of the charging process are slower. Interim fast charging often allows for partial charging of the battery so that the charging time remains as short as possible.

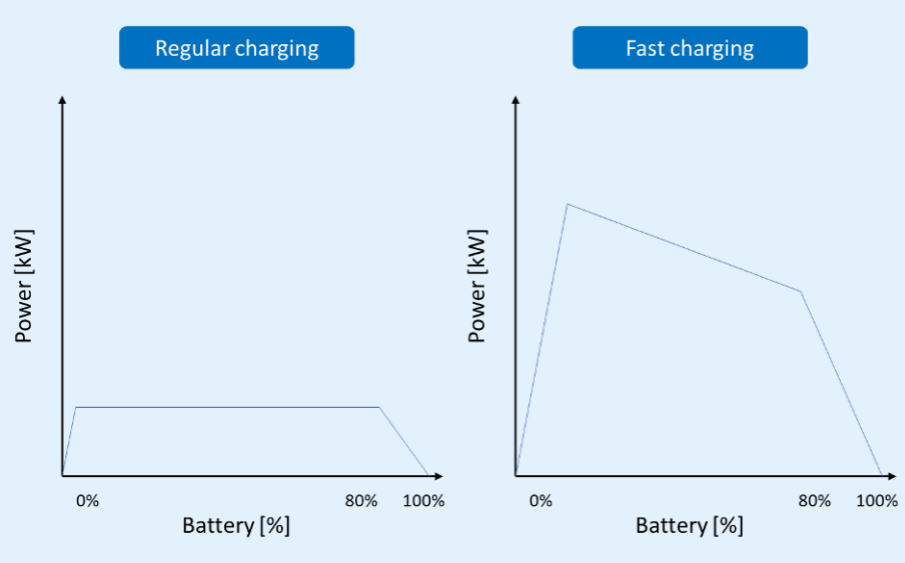


Figure 3: The charging curve of an AC and DC charging station.

- **Future charging speed requirements**. The development of electric trucks is proceeding rapidly, and the DC charging rate that trucks can handle is expected to increase at comparable pace. If 350 kW charging stations are currently unprofitable because current trucks can only handle 200 kW, circumstances may change within a year.

2.5. What is a back-office system and do you need it?

A back-office system is a digital platform linked to the charging stations. It is not absolutely necessary to integrate a back-office system into your charging hub, but such integration does have its advantages. For example, it allows you to control and monitor the charging stations, as well as to access their data. Most back-office systems communicate with the chargers via a local network or internet connection.

A back-office system can provide insight into the status of the charging station and charging transactions. A dysfunctional charging station can also often be reset.

Monitoring charging transactions is useful to properly register energy consumption per truck. A back-office system can even record charging transactions per truck, often by means of a charging card. Using a back-office system, possibly in combination with a charging card, allows you to better align logistics planning with actual consumption per transaction, truck and even individual driver.

Charging station manufacturers and charge point operator (CPOs) (see the discussion of the 'Charge Point Operator (CPO)' in Section 2.7) often offer their own back-office systems, but it is also possible to choose an external provider. The option to link a back-office system with other IT systems, for example internal planning systems, is an important consideration when making a choice. Proper alignment of the back-office system with internal planning will only become more important as you expand your fleet of electric trucks. The appropriate integration of back-office system, charging infrastructure and logistics planning will potentially increase efficiency.

2.6. What do charging stations cost?

The table below provides insight into the prices and costs of various charging stations. These figures are based on general, average figures. You would be wise to compare several brands and types of chargers.

Table 1: Charging station cost by capacity. Source: market research eGLM

22 kW AC	*+/- €2,000*	*+/- €2,000*	*+/- €500*	*€10,000*	*€1,000*
50 kW DC	*+/- €20,000*	*+/- €10,000*	*+/- €1,000*	*€40,000*	*€4,000*
175 kW DC	*+/- €50,000*	*+/- €35,000*	*+/- €3,000*	*€115,000*	*€11,500*
350 kW DC	*+/- €90,000*	*+/- €65,000*	*+/- 5,000*	*€205,000*	*€20,500*

Depreciation

How long you intend to use the charging station will obviously have a solid impact on annual (depreciation) costs. The quality of today's current charging stations is so high that they will still be operational in ten years' time. Depreciation costs for a charging station can also be calculated for a period of less than ten years, for example if technical developments in the market require earlier replacement.

Service and maintenance

Charging stations require maintenance, and charging stations with a higher power output generally have higher maintenance costs. The charging station manufacturer/supplier will always make recommendations concerning maintenance procedures and the parts that should be preventively replaced when servicing. Often these organisations also offer the maintenance. Legislation in your country may hold you, the installation owner, responsible for the installation and any liabilities associated with it.

It is also very common for software and/or firmware updates to be carried out during servicing. These updates are improvements to the charging station, and the charging station manufacturer/supplier therefore recommends that they are installed.

Agreements can also be reached regarding failures and incorporated in a Service Level Agreement (SLA). They often stipulate the period within which a repairman must be on site and/or the period within which the charging station shall return to operation.

2.7. How can you finance the charging stations?

As with any other investment, there are several options for financing charging infrastructure. This handbook will discuss the four forms below.

Ownership

Owning the charging infrastructure (paid from equity or external capital) puts you in control. However, ownership also means that you need to cover the risks yourself by concluding appropriate contracts with suppliers and service providers. You may also take full advantage of any subsidies, allowances and tax benefits that governments may choose to offer.

Operational lease

It is also possible to finance charging stations by entering into an 'operational lease'. In such arrangements, your instalments cover the costs of all relevant matters, including maintenance. Ownership of the charging stations will of course remain with the financier. Charging station manufacturers or suppliers often offer such leases. Under them, you have to run the operation entirely yourself and ensure proper integration with logistics planning, as well as monitoring of charging activities.

Shared charging

You can also use charging infrastructure jointly with other business operators and thus share costs. Such an arrangement may be particularly attractive when it comes to fast chargers. The advantage is that the usage rate of the charging station is high and the costs per business are therefore lower. The downside is that charging sessions can be more difficult to schedule. Although shared charging can mean joint investment, the most obvious solution involves one business investing in charging stations and others using them for a fee.
The following (legal) issues are important in shared charging:

- **Liability**. Appropriate agreements should be reached regarding the liability for damages to or caused by the charging infrastructure.
- **Sharing of costs**. Appropriate agreements must also be concluded regarding the variable and fixed costs of the charging infrastructure. Examples include maintenance, expansion of the grid connection, costs for software and electricity. In the case of one investor and several users, a fixed minimal usage fee can also be agreed.
- **Location of the charging infrastructure**. The co-owners and/or users must agree where the charging infrastructure will be located. This can be in public space or on private property. Often a private site is preferred because it does not entail any extra costs, although access must then be arranged for all fellow users.

Charge Point Operator (CPO)

A CPO can take the installation and operation of the charging infrastructure completely out of your hands. The extent to which you wish to outsource the work will depend on what your own organisation is able and willing to do with regard to this process. You can discuss the options and associated costs with the CPO. Obviously, outsourcing (part of) the construction and operation unburdens your organisation, allowing it to focus on its core business.

Another big advantage is that you can, for example, shift responsibility for the risk involved in charging station failure by making stipulations in a contract (e.g. an SLA). Such contractual provisions may include agreements on the period within which the charging stations must be operational again, possibly including a penalty payment if this is not achieved.

The role of CPO can be fulfilled by many different companies. The latest development, for example, involves truck manufacturers also assuming this role.

2.8. What will the future of charging infrastructure bring?

Charging technologies have greatly improved in recent years, and a high standard has been developed for plugs and charging systems. Such improvements are expected to continue. Although it is difficult to predict the technology that will play a major role, we can state in all certainty that power and charging voltages will increase.

Specifically in the area of plug-in charging, work is underway on the new Megawatt Charging System (MCS), a new plug that has been specifically developed for vehicles with larger batteries, such as trucks and buses, but also ships and airplanes. The standard is expected to deliver between 1 and 4.5 MW. For the road transport sector, this means that truck charging time can be significantly reduced, providing the truck can handle the higher power output. This technology is expected to be mainly used in long-haul transport, where charging may take place at a public location along a highway belonging to a transport corridor. The high power output will have a major impact on the electricity grid and will initially be too expensive to be implemented at transport depots.

3. Electricity grid connection

After determining the charging needs, the type and number of charging stations, you must ensure that you have an adequate grid connection. Electric trucks require a lot of electricity (kWh) and possibly also a lot of power (kW). This section describes the ways to determine whether the existing grid connection is sufficient and how a possible upgrade can be achieved.

3.1. How to find out what kind of grid connection you currently have?

To find out whether the current connection is large enough, you first need to find out what the desired charging power of your electric fleet is. See Chapter 1 'Charging needs' and Chapter 2 'Charging system' for more information on this topic. The next step involves finding out the type of grid connection that you currently have and ascertaining your current electricity consumption.

- Finding out the contracted capacity. This term refers to the maximum power for which you have signed a contract. This figure can often be found on the invoice of either your energy supplier or DSO.
- **Determining current power consumption**. Mapping current consumption allows you to determine whether and at what time of day, there is a surplus of power under the current contract. This can often be examined by the technical service provider.
-

Tip – Contacting your Distribution System Operator (DSO)

- **If you have an account manager with your DSO, it is best to directly contact the account manager.**
- **If you don't have an account manager, you can contact your DSO via the 'contact for business users' page on the site of your DSO.**

If there is sufficient power capacity remaining within your current contracted capacity when you start using the charging infrastructure, there is no need to adjust the current contract. If you do not have sufficient power remaining, the next step is to find out what the maximum connection capacity is without upgrading the physical grid connection.

- **Finding out the maximum connection capacity**. This term refers to the maximum power that the existing physical grid connection can handle. Consumption under your current contract may have not yet reached this maximum connection capacity. Information regarding this capacity can be requested from the DSO.

Increasing contracted capacity

Any increase in capacity must first be requested from the DSO, which will then indicate if this is possible. You then only need to inform the energy supplier that more use is possible and the energy supplier will adjust the contract.

3.2. How to upgrade your electricity grid connection?

If the maximum connection capacity is not sufficient for the expected electricity consumption (meaning the current electricity consumption plus the charging stations), the next step is to explore the options for upgrading the electricity grid connection.

If you wish to increase the maximum connection capacity, the DSO will have to provide a new installation. A separate organisation may also have to install new 'metering' equipment. In addition, in some cases the energy supplier must be informed about the infrastructural changes.

Upgrading the grid connection

To upgrade the grid connection, follow the steps below.

- **Step 1**. Submit a request for an upgrade of the grid connection to the DSO. If you already have an account manager with the DSO, you can contact this person. Otherwise, there are often online request forms on the website of your DSO by means of which you can submit a request.
- **Step 2**. The DSO will contact you to discuss the request and may make an initial assessment of the options for upgrading the grid connection. To properly assess the request and estimate the costs, the DSO will likely ask about the location where you wish the grid connection to be installed. Usually, a site map is requested. In addition, the DSO will inquire about your expected energy consumption during this phase. It could be that a new location for the electricity grid connection needs to be determined. It would be wise to coordinate the positioning of the new grid connection with the layout of the charging infrastructure. See Chapter 4 'Location' for more information on the layout of the charging stations/charging hub.
- **Step 3**. The DSO will assess whether the grid connection can be upgraded, estimate the cost and the lead time of this upgrade and prepare a quotation.
- Approved. The request is officially approved once the quotation has been signed, and the upgraded electricity grid connection can be provided. See Chapter 5 'Civil work' for a detailed explanation of the civil work required for the installation of the grid connection.

Statutory provisions of a particular country may require a DSO to complete a new grid connection within a specified period. In addition, lead times may depend on the specific region and the DSO itself, but also on the complexity and size of the connection. Please be aware that the lead time for a new grid connection can extend to months or even years. This lead time depends on the specific location, and can differ between regions and countries. Your DSO can inform you about your specific case.

3.3. What are the alternatives to upgrading the electricity grid connection?

Unnecessary simultaneous charging requires a larger and therefore more expensive grid connection than is strictly necessary. In addition, the electricity grids in some countries have to deal with 'grid congestion', which means that upgrading the connection capacity may require a significant period of time before it can occur. Fortunately, there are alternatives such as those discussed below.

Smart charging

Smart charging ensures that electric vehicles in the process of charging do not require more power than there is available. The peak demand due to charging is better distributed, and less power is required from the electricity grid. This process can make a difference in terms of costs. Smart charging goes a step further than 'load management'. With 'load management', the entire charging capacity of the fleet is simply reduced, while smart charging makes it possible to prioritise vehicles when charging. Both techniques are aimed at making better use of the contracted capacity.

Smart charging technology includes a range of functionalities to deal more intelligently with the question of which vehicle to charge and when. Such functionality in the charging infrastructure can ensure that vehicles with a lower State of Charge (SoC) are given priority over vehicles with a higher SoC. That way, the entire fleet can drive away with a full battery at the start of a shift.

At the time of writing, smart charging is not yet a standard product. 'Load management' is relatively mature, but other smart charging functionalities are currently often customised add-ons. You can contact the charging station supplier, charge point operator (CPO), back-office system owner or your technical service provider to inquire about the form of smart charging that can provide added value in your circumstance.

Local energy production

Local energy production can take numerous forms, such as wind turbines and solar panels. Solar panels are most commonly used and are generally most suitable for industrial estates. The energy they produce can be used directly for charging electric trucks, but also for other internal processes. Both wind and solar energy are not equally available throughout the day. For this reason, it is important to check with your solar panel or wind turbine supplier in order to properly calculate how their output might meet the charging needs of your electric trucks. These suppliers can of course not make any guarantees.

Battery Storage

If your current contracted power and/or grid connection cannot be increased, you can always use stationary battery storage to meet your charging needs. Such battery storage functions as a buffer, as it is charged slowly when there is a surplus of energy available and can supply this energy during peak demand. Battery storage is not yet being used on a large scale, but there are pilot projects in various locations. This technology offers a lot of potential, especially in combination with solar panels and wind turbines. The current costs for stationary battery storage are between € 500 and € 1,000 per kWh of storage capacity. This high price currently makes it difficult to recover costs. However, it is expected that the price per kWh will continue to fall. It is also important to know that in some countries, special regulations apply with batteries inside or close to a building.

Example calculation

A battery system can provide a high level of power during a brief period when power from the grid system is not enough. For example, a battery with a capacity 150 kWh can be fully charged in 3 hours by a 50 kW connection and then be able to provide 300 kW to the charging stations for 30 minutes.

Charging at the neighbours

In addition to the above-mentioned alternatives for the installation of charging infrastructure on site, it is also possible to gather information about the plans of other companies in your vicinity. You can read more about this in Chapter 4 ‘Location’ under the heading ‘How can collaboration with other companies help?’.

Example I

A project in Rotterdam, the Netherlands, posed the challenge of providing suitable charging infrastructure for an electric truck. To enable fast charging of this truck and also to anticipate future requirements, the idea was to create a dedicated charging hub with two fast chargers. It quickly became apparent that the current capacity of the electric connection was not sufficient for this set-up. A technical service provider (TSP) was called in to investigate the possibilities of upgrading the electrical connection and making the best use of the existing connection.

The investigation found that the higher investment in a more powerful electrical connection was unnecessary. Better use of the existing connection could be achieved in combination with the existing 500 solar panels located on the roof. The TSP drew up a power balance sheet clearly showing the power that was available for the charging stations at various times.

It is therefore always advisable to conduct a thorough investigation instead of drawing a hasty conclusion. The table below contains an example that shows the yield of the available solar panels, the consumption of the electrical system on the property and the incoming power from the grid. This results in a calculation of residual power available for the charge stations expressed in amps and converted to kW in the last line of the table.

Three different scenarios were used, each occurring between 6:00 AM and 9 PM and considered in combination with the varying yield of the solar panels. The yield of the solar panels differs due to differences in weather condition and seasons. The bottom line of the table indicates how much charging power (kW) is available at what time and in which scenario.

Electricity production and consumption	**Yield of solar panels**				
	0%	30%	60%	100%	0%
	00:00 - 6:00	6:00 - 21:00	00:00 - 6:00	6:00 - 21:00	21:00 - 00:00
Electricity production solar system 1 [A]	0	12	24	40	0
Electricity production solar system 2 [A]	0	12	24	40	0
Utilisation of installation in property [A]	-18	-160	-160	-160	-18
Available power of the grid [A]	250	250	250	250	250
Remaining power available for charging infrastructure [A]	232	114	138	170	232
Available power for charging infrastructure [kW]	**145**	**71**	**86**	**106**	**145**

3.4. What are the costs associated with the grid connection?

To supplement Section 2, which deals with the costs of purchasing, installing and maintaining charging stations, and Section 5, which discusses the costs of other civil work, this section will describe the costs of the grid connection and electricity.

One-time costs

- **Grid connection costs.** Comprising one-time costs for the construction and installation of the grid connection (work that the DSO must perform), these amounts depend on the size and location of this connection. The DSO will provide a quotation the required work.
- **Energy systems (hardware).** These additional non-recurring costs are for acquiring the necessary energy equipment, such as a transformer substation, a low-voltage distributor and possibly a consumer substation. They also include the costs of solar panels and/or battery storage.

Recurring costs

- **Electricity costs.** These amounts vary and depend on the contract with your energy supplier, whether you are a high-use or low-use consumer and whether you generate your own renewable energy. In addition, smart charging allows you to take advantage of a lower price per kWh by shifting charging operations to off-peak hours.
- **Electricity grid management costs.** The recurring costs for the grid connection can consist of fixed and/or variable costs. Both these costs can vary based on the total amount of energy used and the maximum contracted capacity.
- **Charging infrastructure management costs.** The costs for managing the charging infrastructure via a back-office system consist of fixed monthly amounts. For more information, see Section 2 ‘Charging’.

Other costs. It is possible that other costs may exist in your country in addition to the ones indicated above. As described earlier in Section 3, an electricity grid connection can require that you have metering equipment possibly giving rise to additional costs, such as rental and surcharges for servicing the energy meter. If the contracted capacity set by agreement is exceeded due to, for example, an unexpected peak load, the DSO may impose a higher fee. Since this differs between countries and DSO's, please make sure your DSO and energy supplier inform you about all relevant and potentially relevant costs.

4. Location

When installing a charging station at your transport depot, it is important to consider a number of factors, such as laws and regulations. Account should also be taken of the differences between installation on your own site or on the property of another owner. This section will additionally provide information about the physical layout of the location and ways in which you might share the charging hub.

4.1. What are the requirements for installing charging infrastructure on your own site?

Depending on the applicable laws and regulations, several permits and/or 'requests/notifications' could be required. Of course, this varies between countries, locations and scenarios.

Obligations

Please be aware that you might have to follow certain procedures, each of which may take time. Discussing plans at an early stage with, for example, a business contact officer from the municipality, DSO or technical service provider may help you to identify any permit obligations well in advance. Examples might include the notification requirement for the presence of a public gas pipeline or excavation in a drinking water catchment area.

Local authorities

Local and regional authorities also regularly play a role during the preparation of a large charging hub with a high-use connection. Their concerns may extend to obligations involving environmental permits that may affect the colour of a new transformer station, for example. It is therefore wise to involve these authorities in you plans at an early stage, through a business contact officer or other means. In addition, these authorities can also inform you about current initiatives in the region that you can join and mobility plans that may impact on your situation.

Insurance

It is also important to check the requirements that an insurance company might set for the installation of a charging station, such as those relating to potential fire risk. Charging stations may often not be located within a certain distance of a building, but this can differ between insurance companies. We recommend that you contact your insurer and take account of the requirements before you start constructing the charging location.

4.2. What is important when the proposed location is owned by someone else?

If you rent office space or a building, you need to develop your plans jointly with the property owner. You must, of course, consult with and obtain permission for any charging infrastructure that you wish to construct. It is furthermore very important to take a long-term view of any such investment.

Property owner

The owner will primarily be interested in the safety of the technical installations. Many property owners have a contracted technical service provider responsible for all technical systems. Since the installation of a charging station for electric trucks is something only trained personnel can carry out, a separate technical service provider may have to be engaged in order to undertake the installation work. It would, nevertheless be wise and prudent to coordinate with the contracted technical service provider. This organisation is responsible for onsite installations and will have knowledge about the proposed location that may be useful.

Long-term view

Charging infrastructure is normally constructed for a longer period of use (5 to 10 years). You can discuss options with the property owner and draw up an agreement for the use of the site on which the charging equipment will be located. These arrangements may, for that matter, be incorporated into the existing lease. When drawing up any such agreement, it is advisable to take additional account of the rights in rem being established. What happens, for example, if the property owner of the location goes bankrupt?

Example II

Albert Heijn, a major Dutch supermarket chain, sited and installed fast chargers at its regional distribution centre in Delfgauw. The charging hub began operating on 7 October 2020 to service the first all-electric truck from Mercedes-Benz in the Netherlands. This eActros has been used since the end of July 2021 by regular carrier Simon Loos to supply Albert Heijn supermarkets.

The high power demand makes the construction of fast charger infrastructure into a challenging endeavour involving multiple, complex perspectives. For this reason, project managers, engineers and specialists from ABB, Albert Heijn, Daimler, Simon Loos, Van Ooijen Gouda BV (the contractor) and Batenburg Installatietechniek jointly designed the charging hub in detail and continuously interacted with each other during construction.

Simon Loos will be testing the eActros. The truck is used for supermarket distribution at Albert Heijn, which in turn is responsible for the route planning and the required charging facility. The electric eActros has performed intensive shifts, making several daily trips to such locations as Rotterdam, The Hague and Delft. The fast chargers now make it possible for Albert Heijn to plan longer trips. Since, on return to the distribution centre, the truck's battery can now be recharged in a shorter time, there is no longer much waiting time between trips. This rapid turnaround achieves an important goal, namely the scheduling of electric trucks in the most effective manner possible.

4.3. What are important points to consider when designing the charging location?

The following considerations are important when designing the charging location at your transport depot:

- truck position,
- cable lengths,
- pipelines and other obstacles,
- driver preferences,
- prevention of potential damage.

Changing the layout of a charging location will involve a lot of work and, consequentially, costs. It is therefore important to carefully plan the layout of charging infrastructure with all stakeholders involved.

Truck position

It takes time for a truck to charge and moving the truck during charging can be time consuming. The charging position has a direct influence on the logistics process and accessibility at the location. It must also be easy for the driver of the electric truck to park near the charging station, but also for drivers of other vehicles to pass. Specific fire regulations may also apply to parking and (un)loading the trucks. In addition, the turning circle of the various vehicles at the depot must be considered, so that reversing can be a far as possible avoided. The rest of the site should also be kept easily accessible in order to avoid damage.

Cable lengths

Since longer cables can increase the costs of the installation, cable distances from transformer to the charging stations and, if applicable, on DC circuits should be kept as short as possible.

Pipelines and other obstacles

Drawings and designs often need to indicate of whether account must be taken of any obstacles in the ground or on the site, such as any cables and pipelines present in the ground. The technical service provider and civil contractor can provide support for such purposes.

Tip – 'Call before you dig'
In most countries it is mandatory (obligated by law) to be properly informed about what lays in the ground where you are planning to dig. These so called 'one-call service providers' can give you information about where there are cables and pipelines.

Driver preference(s)

It is prudent to involve drivers at this stage. Their participation prevents frustration from arising among end users with regard to very practical issues. Often, small adjustments provide a lot of satisfaction and convenience during use. Examples of such issues include providing driver canteens, toilets, waste bins, etc. at loading locations where there are no nearby facilities.

Prevention of damage to the charging infrastructure

Repairing damage to the charging infrastructure is often expensive and can disrupt the logistics process. Small modifications, such as clear lines, crash barriers and curbs, can prevent a lot of damage. Such adjustments should be taken into account in the design, and discussed with the civil contractor.

The plugs and cables of the charging equipment can be fragile and easily damaged. It is therefore important that the end-users get proper instructions or training and that they correctly connect and disconnect the vehicles from the charging station. Facilities should also be provided for easily and safely storing unused plugs, although they are also often integrated into the charging stations themselves.

Periodic maintenance can also play a role in preventing damage to the equipment and ensuring safety. It should be given appropriate consideration in the provisions of the charging station's maintenance contract.

Example III

In Helsinborg, a city in Sweden, a transport company was looking for a charging solution without hindering the day-to-day operation. To not disturb the process, backing the truck up to position for charging was the only option. As explained in §4.3, this can more easily lead to damages, which are costly.

The Danish installation company, GodEnergi A/S, made sure of this by designing the so called 'puck solution'. The puck solution is a specific developed platform which stands loose on the ground. The charger is placed on the platform.

On the sides of the platform bumpers are placed in the same height as the bumpers on the trucks. This means that if a truck hits the platform the two parts will simply just bump away from each other. The energy supply for the charger was made flexible meaning that if a truck hits the charger, they could just use a forklift to get it back into place. See the picture below for the example.

This examples shows one of the many possibilities that can reduce the number of damages, of the impact of them.

This example was provided by GodEnergi A/S, a Danish installation company which designed and implemented this charger.

4.4. What impact does the location of the vehicle inlet have?

The port for the charging cable on the truck is called the vehicle inlet. The location of this is important, as charging cables are quite expensive, and longer cables are more prone to damage. In the most efficient scenario, the vehicle inlet is situated close to the parked truck's charging station. If the vehicle inlet is a fair distance away from the charging station, you may, in consultation with the charging station supplier, opt for a cable management system to prevent charging cables from lying loose on the ground. There are various solutions available to serve this purpose.

4.5. What are points to consider when determining the location of the transformer substation?

A transformer substation is required if the electrical connection has to be changed from a low-voltage connection to a medium- or high-voltage connection. The DSO will then wish to install a medium-voltage distributor in a technically suitable space that must usually be accessible from the public way (on the property boundary).

Transporting electricity at low voltages (400 V) can be very costly when large capacities are involved. It may sometimes be more economical to install a consumer substation containing DSO equipment on the property boundary and use medium voltage (10,000 to 23,000 V) to bridge the distance to the charging infrastructure and locate the transformer substation next to the charging points. You should become properly informed about the most sensible option (e.g. by the technical service provider).

4.6. How to future-proof the layout?

When designing charging infrastructure, it is prudent to take possible expansion into account. Consider laying casing pipes for future chargers at locations where electric trucks may be charged.

Similarly, oversizing breaker panels will provide less expensive options for later expansion. Discuss the possibilities with the technical service provider in order to be prepared for possible further upscaling.

4.7. How can collaboration with other companies help?

Collaborating with other companies to share costs and challenges can be very rewarding. There are several conceivable arrangements in this regard. The most obvious option is for one party to undertake the investments and make agreements with a second party on the joint use of the charging infrastructure, including the fee for using it. Since the costs are then shared, both parties benefit. For more information on shared charging see §2.7.

Communicating early plans for installing charging infrastructure to other companies in an industrial estate will facilitate the exchange of knowledge and potential collaboration. Most industrial estates have an umbrella association, which might provide a good platform for sharing plans.

Continuity of operation is obviously important. It would be inefficient to have always to wait for another truck when it is charging. Agreements must therefore be reached on charging times. Such arrangements will enable each party to charge and deploy vehicles when needed. A reservation system is often of added value. Ideally, such a system would be linked to the back office and logistics planning.

The price for the energy consumed can be tracked and settled, as each party uses its own card at the charging station to start and stop the charging process. The charging station must then be connected to a back-office system (see §2.5). Pricing for the use of the charging infrastructure should not only take energy costs into account, but also other costs such as depreciation, maintenance, tax-related issues, etc.

5. Civil work

The preceding sections have enabled you to draw up a plan for charging at your transport depot covering the charging needs, the number of charging stations, the capacity of the charging stations as well as their location on the depot. This plan is recorded in the (basic) design. Implementing this design requires a lot of civil work, for example routing electrical cables in the ground, laying pavers and installation of charging stations. This section will tell you what is involved in these activities and how you can coordinate the process properly.

5.1. How to prepare the work?

Depending on the complexity and the extent to which you wish to retain control of the process, you can (partly) outsource the management of the civil work to an (electrical / technical) service provider or the charging station supplier. In the event of partial outsourcing, it is always wise to have the final design and planning of the charging infrastructure checked by a technical service provider.

A charging-infrastructure design covers various topics. Of course, there are a few basic principles to consider, such as the existing electricity grid connection, the contracted and available capacity, and the possibility of upgrading the grid connection.

Site plan

A proper site plan of the proposed charging infrastructure must be prepared. This drawing of the spatial layout often starts as a sketch, which is then elaborated into a digital drawing. The existing cables and pipes can be subsequently added as well.

Budget

The budget is an essential element. It must clearly indicate the costs of installing the charging infrastructure based on the assumptions and data included in the design.

Do not forget the expected, recurring costs and potential revenues. It is advisable to draw up a schedule indicating which products and services have a long lead or delivery time.

Furthermore, even smaller materials are no longer always deliverable from inventory. Properly mapping the delivery times of products allows you to set priorities. Your technical service provider can help in the respect. The products and services with short delivery times (e.g. low voltage cabling and civil works) can be carried out first. Good planning ensures an efficient process but also, of course, appropriate expectations regarding the deployment of electric trucks.

Stakeholder management

Various stakeholders are involved in the installation of charging infrastructure. For this reason, appropriate agreements should be made with each other. Importantly, the responsibilities of the various stakeholders should be specified in writing. Drawing up a demarcation list (see tip in the green box) allows you to discuss and agree on any overlap in activities in advance. A good plan also includes a risk analysis. This topic will be covered later in this section.

Tip – demarcation

Drawing up a demarcation list provides you, with a complete overview of responsibilities among different stakeholders in an easy-to-read figure.

5.2. How to plan the work?

Every installation process is (slightly) different. Stakeholders, environmental factors, availability of resources and planning of the integration of the electric trucks can all have an impact on the process.

Moreover, the process can also be partially iterative. The most important planning steps are indicated below.

- **Request an upgraded grid connection** (optional). You request this from the DSO. It is important to start early because lead times to implementation can run into months. Consult with the DSO in advance and then complete the actual application. Usually this is a digital application. Only the site owner may submit this application. See Section 3 'Electricity grid connection'.
- **Instruct metering company to install meters** (optional). This installation is required in the event of a change in the grid connection. It is a small but important step, which is sometimes forgotten in practice. See chapter 3 'Electricity grid connection'.
- **Order a transformer substation** (optional). This order placement can be performed directly or through a third party, such as a technical service provider. Delivery times can again be lengthy. See Section 4 'Location'.
- **Order the charging station(s)**. This can also be done directly or via another party (such as the electric truck supplier). Make clear agreements about delivery times and terms of delivery (such as transport costs). For more information, see Section 2 'Charging'.
- **Place the order for the installation work.** The site can be prepared prior to the delivery of the charging infrastructure and grid connection upgrade. Such pre-delivery installation work will shorten the lead time. For more information, see Section 2 'Charging'.
- **Engage a civil contractor for the modifications to the site**. This contracted civil work includes (partial) demolition of existing pavement, digging of cable trenches, construction of foundations for the charging and energy facilities, constructing a foundation under the paving to prevent subsidence and laying out the charging hub by creating the physical charging bays. Preparatory can also be carried out in this regard in order to shorten the lead time. See Section 4 'Location' for more information.
- **Commission the grid connection.** Once the grid connection has been upgraded, it must be commissioned by the energy supplier in collaboration with the DSO. During commissioning, final tests are carried out in the presence of the energy user's designated system manager. See Chapter 3 'Electricity grid connection'.
- **Commission the charging station.** This activity includes the delivery, installation, 'commissioning' and explanation of the charging stations. After installing a charge station, the technical service provider will also commission it. The charging station supplier will also often have someone present for the final checks. For more information, see Section 2 'Charging'. The charging-station end user should be provided with clear explanations during this step, making it possible to test if the charging station works properly and if any unclarity exists. See Section 4 'Location' for more information.
- **Service and maintenance**. Once the charging stations are tested and operational, it is also important to keep them operational by carrying out timely service and maintenance on the entire system. In principle, this work essentially concerns all electrical hardware, i.e. not only the charging stations but also the transformer. For more information, see Section 2 'Charging'.

5.3. What are the risks and how to cover them?

There are various risks involved in the preparation and installation of charging infrastructure. Below is a summary of the various risks, including tips on how best to deal with them.

- **Contaminated soil.** It may be important to have a clean soil certificate, as work in contaminated soil may require a different approach at a different cost. This requirement differs between countries, locations and type of activities. If any doubt exists about such matters, a soil survey should be ordered in advance. A civil contractor can often carry out such a survey. It will reveal whether a clean soil certificate can be issued or whether additional measures are needed.
- **Ground subsidence.** Another risk is subsidence of installations and charging stations. A cone penetration test (CPT) should be carried out as a preventive measure. On the basis of this test, the technical service provider and/or civil contractor can implement other measures to prevent subsidence.

- **Cables and pipes.** There is a risk of damage to existing cables and pipes during civil work. For this reason, it is necessary to contact the so called 'One-call service providers'. They will be able to give you information about where there are cables and pipelines. If in doubt, dig test trenches.
- **Dimensions that are too small or inefficient design**. Such constraints may disrupt logistics flows at the depot and possibly result in damage. If a great deal of movement occurs at the depot or if space is very tight, it is always prudent to have the plan checked by a transport expert.
- **Transport hindrance.** Of course, the transport operation often continues while the charging infrastructure is being installed, the installation and construction work potentially causing disruption at the depot. Ensure therefore that site managers are involved in the planning so that any operational hindrance is minimised.
- **Future developments.** To avoid duplication of work during further expansion, possible future developments should be taken into account at the time of initial installation. How is my electric vehicle fleet going to develop? What other facilities will I possibly wish to add to this location in the future? The costs of an extra casing are relatively low, and can save you greater costs in the future.
- **Malfunctions**. It is important for the end user of the charging infrastructure to have a well-functioning system, in which trucks can be charged without any problems. It may therefore be useful to place the responsibility of the entire system (or parts of it) with one organisation. Such delegation of responsibility will, as far as possible, enable you to avoid any finger-pointing in the event of failures, shifting responsibility for a solution to someone else. It is also important to take account of any such allocation of responsibility during the procurement phase. For more information, see discussion of the 'Charge Point Operator (CPO)' in Section 2.

5.4. What are the costs of the work?

Section 2 discussed the costs of purchasing, installing, and maintaining the charging stations. Section 3 dealt with the costs of the grid connection and the electricity itself. This section will now inform you about the costs of the work.

These costs are of course dependent on the quantity of work and the number of required modifications. Basically, you have to take the following cost components into account:

- installation work,
- length of the cables,
- civil work,
- project costs (engineering, supervision, and preparation).

To check whether you are making the right choices in terms of costs, it is important to present potential suppliers with the basic design. They may be able to suggest alternatives that would reduce costs. Of course, you can also request different quotes for the sake of comparison.

6. In closing

This document has been compiled in collaboration with charging infrastructure experts, experienced professionals and other parties from the logistics sector in order to produce a readable and instructive handbook.

Abbreviations

AC - Alternating current
CPO - Charge point operator
DC - Direct current
ICE - Internal combustion engine
kW - Kilowatt
kWh - Kilowatt hour
MCS - Megawatt charging system
MW - Megawatt
OEM - Original equipment manufacturer
SoC - State of Charge

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