THE ULTIMATE MAN GUIDE TO HEAVY DUTY TRUCK CHARGING.

Powered by MAN Transport Solutions.

CONTENTS

INTRODUCTION

We live in an era defined by sustainability and innovation, where transportation, and the way we think about it, is undergoing a profound transformation. For companies, sustainability is an important aspect that affects customer perceptions and buying decisions.

In the EU, heavy-duty vehicles account for around a quarter of all road transport emissions. While electric cars have become commonplace on our roads, the development of electric trucks, or eTrucks, has been limited not only by available battery capacity and technology but also by the availability of charging infrastructures. That’s now changing.

Recent progress in the development of battery and charging technology means that battery-electric trucks are well positioned to offer a credible replacement to diesel-engined vehicles and offer a solution for emission reduction. By 2024, long-haul eTrucks with daily ranges between 600 to 800 km capable of fully charging during a 45-minute driver break will be available in Europe. Furthermore, these vehicles will have a lower total cost of ownership (TCO) than diesel trucks for a broad range of transports, including long haulage.

While the EU is working on legislation that calls for networks of charging stations at regular intervals along major highways and roads, most eTruck users will also need their own charging infrastructures. Whether you run one vehicle or a large fleet of eTrucks, in this brochure we cover all the aspects of planning, implementing and running a charging infrastructure. We also show you how, through careful planning, you can reduce not only the initial investment, but also the daily running costs.

We hope you find all the information you need to get started in electrifying your fleet.

EXECUTIVE SUMMARY

The vehicle: Battery electric trucks are powered by lithium-ion batteries. The charging process and other factors lower the battery's capacity, limiting its life. Balancing aging with operational requirements is a trade-off: the less stress on the battery, e. g. through slower charging, the longer its lifetime. Factors such as annual mileage, temperature and battery usage strategy all have an effect on aging.

MAN's own cell technology is specially developed for heavy duty applications aimed at long lifetimes.

There are two common charging standards in use in Europe, Combined Charging System (CCS) and Megawatt Charging System (MCS). CCS is fast enough for longer duration charging such as overnight, while MCS enables long-haul traffic (charging time 45 minutes).

The charging infrastructure: Different types of charging station are available to meet all space and charging needs. These can be optionally controlled by a charging management system (CMS), a software-based solution for controlling and optimising the charging process. For smaller fleets, the eManager function in MAN trucks can be used in place of a CMS.

Factors that influence the type and extent of the infrastructure include fleet size and composition, route and range requirements, operating hours and the ability to charge vehicles during a tour, i. e. opportunity charging.

Operating scenarios: There are three basic scenarios for operators looking to charge commercial vehicles: depot where a vehicle returns at the end of a tour; destination e. g. logistics center where the vehicle can be charged while loading or unloading during a tour; and public, e. g. via a stand-alone public facility. When developed as an independent business opportunity by a site owner, these public facilities constitute a fourth scenario.

Site energy supply: Every situation is different. The amount of energy required is determined by the number of vehicles and the installed charging infrastructure. Higher loads require the installation of a transformer. The use of smart charging enabled by a charging management system (CMS) or on-site power generation can help reduce grid connection requirements.

Implementation: Typical project implementation can take up to 24 months depending on the scale and design of the infrastructure. Shorter timescales are possible if the existing grid connection is sufficient for the requirements. MAN 360° eMobility Consulting helps analyse and define the charging requirements. MAN's premium infrastructure partners are then available to support you with planning, design and installation.

Financial considerations: The initial investment in hardware and installation is defined by the scope of the project. These "cost up" factors include charging hardware and software together with any civil engineering work, for example foundations for a transformer. MAN's online Charging Infrastructure Calculator can provide a rough guide to costs. See page 39 for a link.

Cost optimisation: There are a number of ways to reduce or offset both the initial investment of the infrastructure and running costs - the so-called "cost down" factors. These include subsidies and tax breaks, on-site power generation, and intelligent charging using a CMS, to reduce higher tariffs.

Public charging: The public charging facilities needed to enable long-haul traffic are being driven rapidly forward across Europe. EU legislation calls for a minimum of at least one 350 kW eTruck charging station every 60 km on core routes and 120 km on extended networks by 2030. Plus, private organisations are actively working on building out charging networks to meet the anticipated demand.

Implementation checklist: As a reference, you'll find a useful checklist that covers all the main points of project planning and implementation on pages 46 - 47.

GETTING STARTED

Charging infrastructure – which scenario are you?

There are many factors to consider when planning a charging infrastructure for commercial electric vehicles. Before getting into the specific technicalities of the charging system, the first step is defining which of the four scenarios best fits your business requirements.

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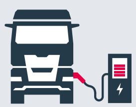

DEPOT CHARGING

Charging your own vehicles at a company depot where they return daily.

Considerations: optimise investment, ensure grid connection

2

DESTINATION CHARGING

Rapid charging of vehicles during loading or unloading, for example at a distribution center. Also with provision for charging and billing 3rd party vehicles.

Considerations: Manage charging process of other logistic companies via CMS

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PUBLIC CHARGING

You don't want to install your own infrastructure but are looking for a public charging-based solution for your fleet.

Considerations: Availability, reservations and pricing

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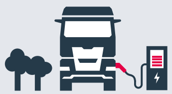


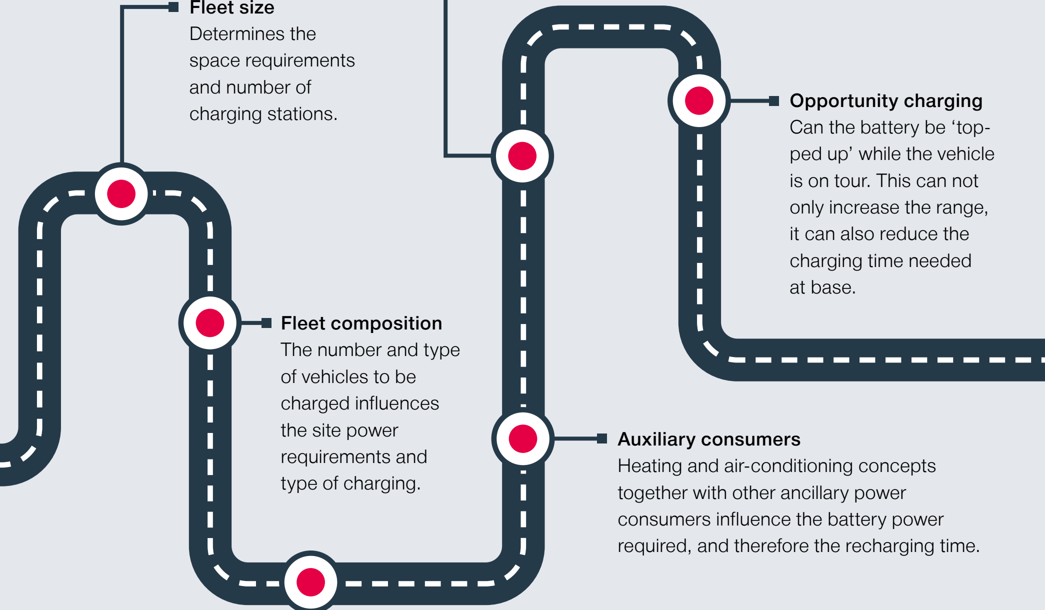
PROVIDER PUBLIC CHARGING INFRASTRUCTURE

You're looking to develop a public charging facility for commercial vehicles as a business opportunity.

Considerations: Business case, pricing and marketing of location

The route to electrification

Once the scenario has been defined, the type and extent of the infrastructure must be established. Here are just some of the factors that influence the requirements.



Fleet size
Determines the space requirements and number of charging stations.

Fleet composition
The number and type of vehicles to be charged influences the site power requirements and type of charging.

Route and range requirements
Light trucks driving in cities or short journeys don't need the same charging infrastructure as a long-distance truck driving across Europe.

Hours of operation
The amount of time available for charging and frequency with which vehicles return to base has an impact on the charging speed required.

Auxiliary consumers
Heating and air-conditioning concepts together with other ancillary power consumers influence the battery power required, and therefore the recharging time.

Opportunity charging
Can the battery be 'topped up' while the vehicle is on tour. This can not only increase the range, it can also reduce the charging time needed at base.

A HELPING HAND: Although there are many user scenarios, each with diverse factors that need to be taken into consideration, a tailored solution can always be found. Our MAN 360º eMobility Consulting together with our premium charging infrastructure partners are there to support you and provide the expertise you need.

2 CHARGING: THE VEHICLE

VEHICLE CHARGING BASICS

Getting to the heart of the matter

Made up of thousands of lithium-ion cells, the battery pack is at the core of every battery-electric truck. In addition to battery cells, it includes a thermal management system.

There's a unique trade-off between the battery and charging infrastructure. While battery capacity and required recharging time define the method of charging, optimised charging can reduce the number of battery packs required by a given vehicle.

Common battery types used in electric vehicles

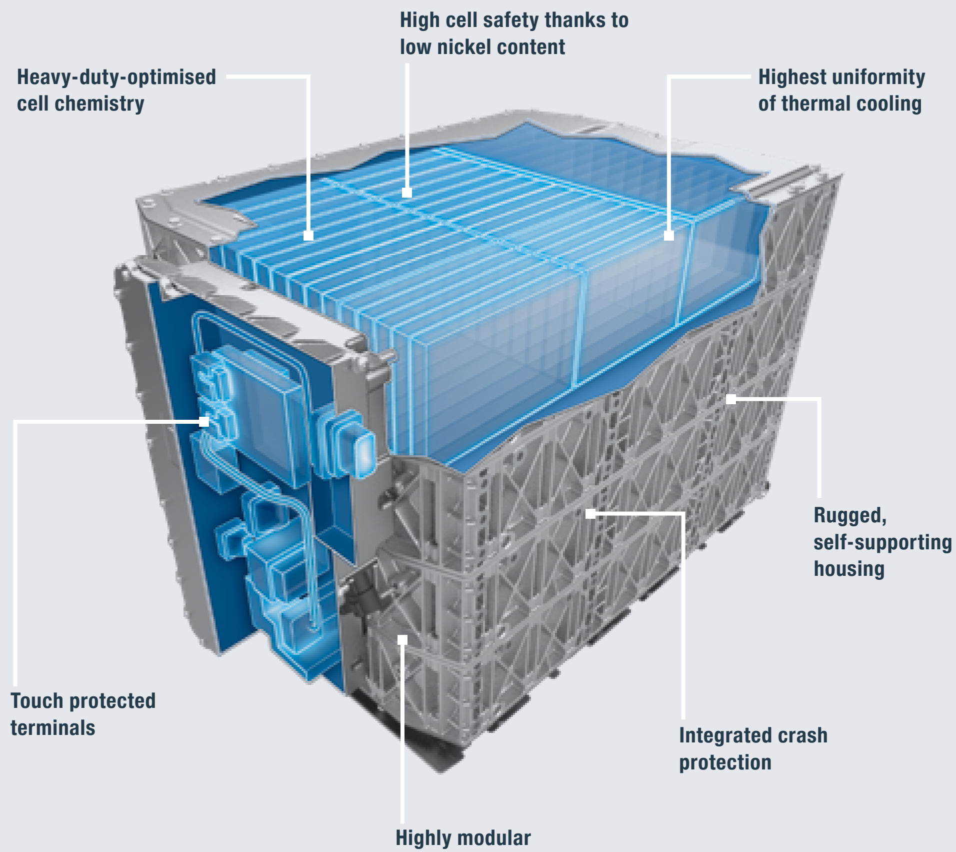
	NCA Nickel Cobalt Aluminum Oxide	**LFP** Lithium-Iron Phosphate	**NMC** Nickel Magnesium Cobalt
Energy density	++	–	+
Lifetime	–	+	+
Safety	–	+	+

NMC batteries used in MAN eTrucks offer good specific energy and specific power density needed. Solid-state and sodium-ion batteries are currently under development but can't yet meet the demands of eTrucks.

GOING THE DISTANCE: MAN has developed its own cell technology to meet the needs of eTrucks. Unlike the technology often used in electric car batteries, it meets high-voltage charging needs and is suitable for lifetimes in excess of up to 1 million km and more.

Battery System Construction

A battery system for commercial BEVs contains multiple components, such as battery cells and thermal management. Cells are typically combined into modules and packs with a pack weighing around 500 kg. Depending on load and range requirements, MAN eTrucks can have up to six battery pack systems.



Safety first

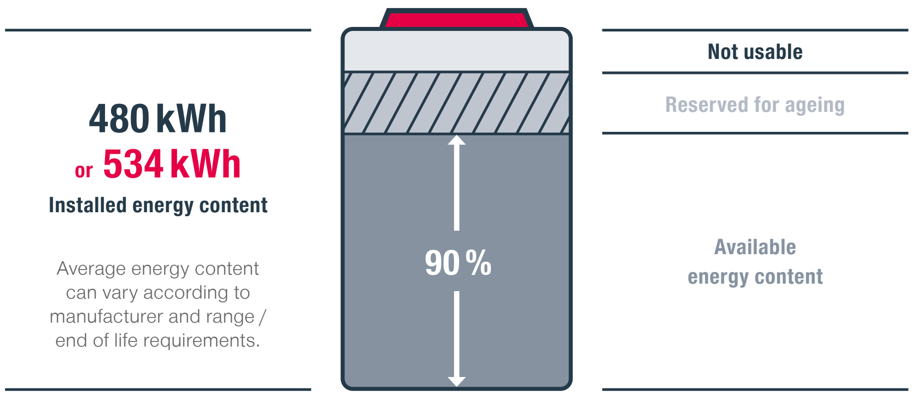
MAN eTruck batteries are designed to the highest safety standards and subjected to electrical, thermal, mechanical and passive safety tests.

Staying healthy longer: Usable battery capacity

The charging process together with other factors such as climate have an effect on the battery, lowering its capacity and limiting its life. Balancing battery aging with operational requirements is a trade-off.

The less stress on the battery, the longer its lifetime. A slower charging rate, for example, is less detrimental than rapid charging. Annual mileage, temperature, battery usage strategy and depth of discharge (DOD) all have an effect on battery aging.

Battery capacity

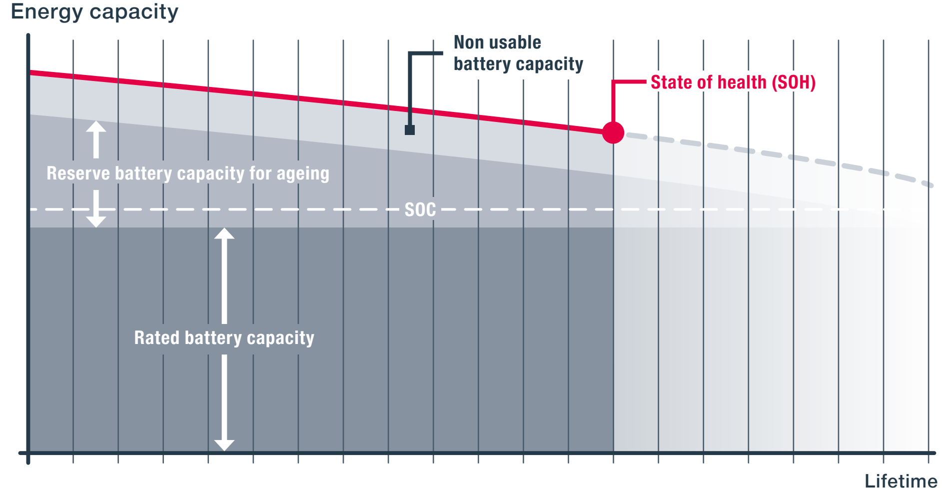


Manufacturers build a reserve capacity into their batteries to allow for the aging process. A MAN eTruck with 6 battery packs has a theoretical capacity of 534 kWh and a usable amount of 480 kWh. This assures a constant range in all operating conditions throughout the battery's service life.

OUTSTANDING LIFETIME: MAN eTruck batteries are designed to last for a lifetime of up to 1 million km.

Battery lifetime

Over time, the state of health deteriorates until it reaches a point where the reliable range falls below the vehicle operating requirements and must be replaced (end of lifetime). After this point, the old battery can be used for battery storage systems (second life).



The target is to achieve a high DOD level for maximum energy and range. MAN provides up to 90 % DOD. A lower DOD level can help to extend battery life.

What's with all the abbreviations?

SOC: State of Charge, indicates the present battery capacity as a percentage of maximum capacity.

SOH: State of Health, indicates overall health and performance, reflecting the battery's ability to deliver its rated capacity.

DOD: Depth of Discharge, indicates how much charge has already been removed in relation to the initial maximum capacity.

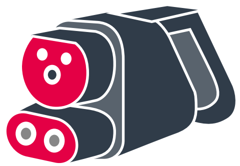
UNDERSTANDING CHARGING TECHNOLOGY

Common charging systems

Type 2 (only for AC charging)
Generally used for small vehicles such as cars and light vans. For protection and communication with the vehicle, an alternating current (AC) charging station is used. This ensures safe and convenient charging both at home and at public charging areas. The maximum power output of a standard system is limited to 22 kW.

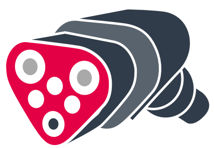
European Standard AC connector

Combined Charging System (CCS)
CCS delivers AC and DC current via a single cable and standardised connector system to the vehicle. The high-power charging (HPC) that provides the charging speed needed for commercial vehicles is only possible via DC. Maximum power output 500 kW



European Standard CCS connector

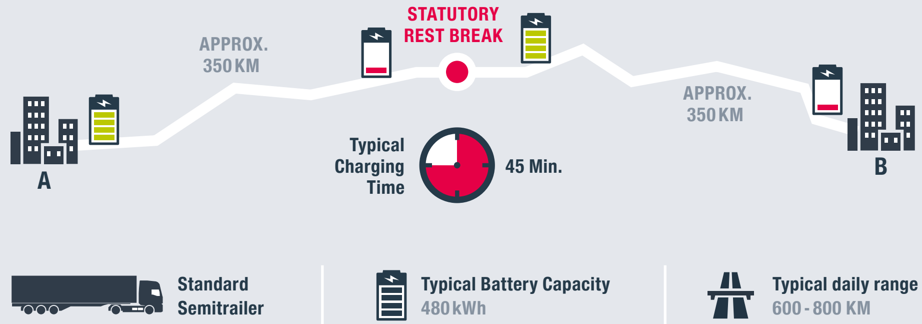
Megawatt Charging System (MCS)
Charging system suitable for large battery electric vehicles. Works with a voltage of up to 1,250 volts and uses its own plug. Designed to ultimately provide up to 3.75 megawatts, it ensures charging times for commercial vehicles are kept short enough for operational requirements.



MCS connector

CCS vs MCS: Charging currents compared

MCS – Enabling long-haul traffic



Megawatt charging is the enabler for long-haul traffic. With a charging capacity of up to 1,000 kW, a typical electric truck can be fully charged within 45 minutes. Given the legislative restraints on driver hours, 2 driving shifts of 400 km each can be achieved in a normal working day with a single rest break.

Charging system communications

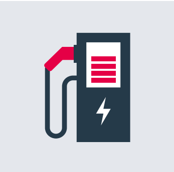
Communications between the charging system and vehicle ensure safe operation. Basic communication is hardware related while high-level communication is implemented via software and provides optional smart features.

Mode	Implementation method	Functions
Basic communication (BC)	Hardware	Connector detection Ready to charge handshake Vehicle immobilisation during charging Continuity check of earth conductor
Hi-level communication (HLC)	Software	Charging Process control (mandatory for DC) Load Management & Charge Scheduling Billing and Authorisation Remote control of charging process

3 CHARGING: THE INFRASTRUCTURE

THE ESSENTIALS:
FROM POWER TO CONTROL

Whatever the size of your fleet, be it a few delivery vans or a large-scale delivery operation, there are four core components that make up the charging infrastructure for a typical commercial vehicle depot

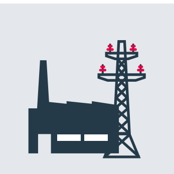


CHARGING STATION

This is the ‘interface’ for charging the vehicle. Different types are available to suit depot and vehicle charging requirements. You can find more information on pages 22 - 23.

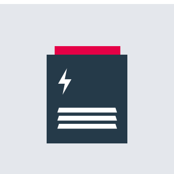
CHARGING MANAGEMENT SOFTWARE

Monitors charging status and manages the process and intelligent charging for optimised charging rates. See page 24 for more details.



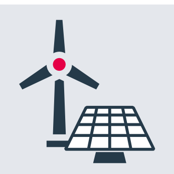
GRID CONNECTION / POWER SUPPLY

Ideally 400 V, needs to be sufficient to supply all the chargers you plan to have at the depot. More details about grid supply can be found on pages 28 - 29.



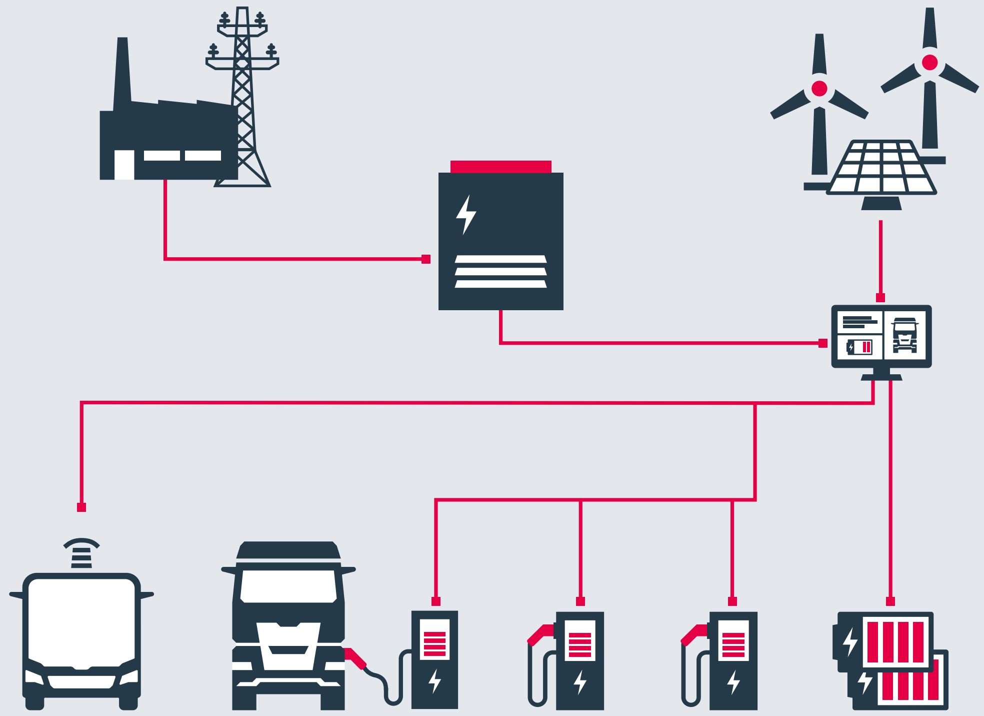
POWER TRANSFORMER

The size of a small container, the transformer converts the grid supply into the required site voltage. If not already available, it needs to be installed. More information on page 36.



OPTIONAL COMPONENTS

Can include own photo-voltaic plant, energy storage facility, etc.



Charging scenarios: Typical charging times and power requirements*

Depot Charging (overnight)	Public Charging (overnight)	Public Charging (opportunity charging)	Destination Charging
8-10 hours	12 hours	45 minutes, e. g. statutory rest break	30 - 60 minutes e. g. loading/unloading
Power needed: 100 - 150 kW per outlet	Power needed: 50 - 100 kW per outlet	Maximum power needed: 350 - 750 kW per outlet	Maximum power needed: 150 - 350 kW per outlet

*Reference values and actual times may differ in individual cases.

CHARGING STATION TECHNOLOGY

From small to large: Solutions for all needs

Whatever your charging needs, there are a range of solutions that can be configured to meet just about any space and operational requirement. Whether it's charging a small number of vehicles overnight at a depot or rapidly charging a large fleet while loading and unloading at a logistics center. Charging stations are available in four basic styles:

1. Mobile charger
Plugs in to standard 3-phase high-voltage outlet without the need for a transformer. Can be moved around as needed and is ideal for topping up as required, e. g. in a workshop. Supplies up to 80 kW.

2. Charging post
High power charging solution with control electronics and power dispenser in an integrated unit for simpler deployment. Available for charging single or multiple vehicles at 50 to 400 kW.

SPACE REQUIREMENTS: Typically, modern chargers are relatively compact. With the transformer located remotely, the charging station requires as little as around 1 m² of space in the parking area.

3. Charger with satellite
Power dispenser is separate from control electronics which can be installed remotely. Compact dispenser requires less space in parking/charging area. Typically 180 - 360 kW for one or multiple vehicles.

4. Overhead charger
Variant of satellite charger with dispenser positioned above vehicle and charging cable suspended from the gantry. Can also be used in buildings with cables suspended from the ceiling. Optimum solution where space is at a premium.

Battery charging times (approx.) from discharged to full

Charger output	Time to charge eTruck*	System
150 kW	180 - 210 min	High Power Charging (CCS)
375 kW	60 - 90 min	High Power Charging (CCS)
750 kW	30 - 45 min	Megawatt Charging System (MCS)

*Reference values and actual times may differ in individual cases.

CHARGING MANAGEMENT SYSTEMS

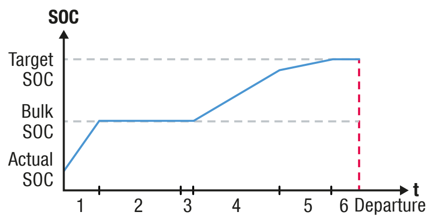
More to charging than meets the eye

The charging management system (CMS) is the intelligence behind the charging infrastructure. It performs a number of important functions. These include system monitoring, scheduling vehicle charging and optimisation.

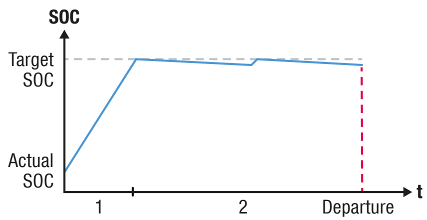
Monitoring and control

The CMS provides intelligent, automated control of vehicle charging, including voltage and current levels. Charging can be carried out using various profiles:

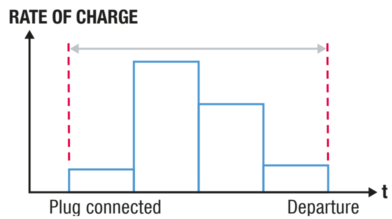
- **Timed charging:** charges battery to target SOC in two steps. Step 1, Bulk SOC, guarantees driving range while minimising battery aging. Step 2 conditions the vehicle until departure to prevent energy loss.



- **Immediate charging:** charges vehicle as quickly as possible within health limits of battery. Starts when plug is connected. Typically used in distribution and logistics centers, and public charging.



- **Profile charging:** charges battery to target SOC by departure time. Varying the rate of charge over time according to intraday energy pricing allows cost optimisation.



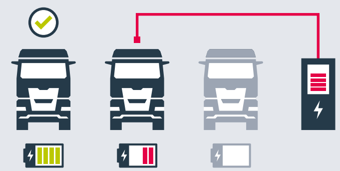
Multiple vehicle charging

With multiple vehicles connected to a single charger, the CMS charges each one, either sequentially, which is time consuming, or dynamically, apportioning the supply to all vehicles depending on their state of charge.

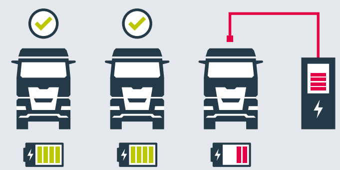
Charging schedule

Truck 1
23:00 - 1:20 Uhr

Truck 2
1:21 - 3:40 Uhr

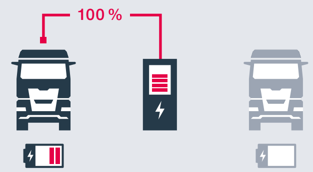


Truck 3
3:41 - 6:00 Uhr

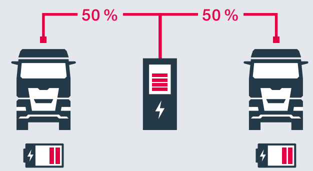


Charging order

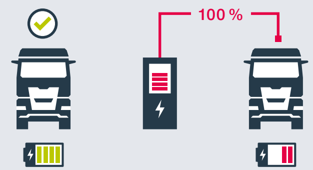
Truck 1 is the only one being charged – 100 % of the available power is used by Truck 1



Truck 1 and 2 are now plugged at the same time – The available power is shared equally: 50 % each



Truck 1 is fully charged, Truck 2 is the only one being charged – 100 % of the available power is used by Truck 2

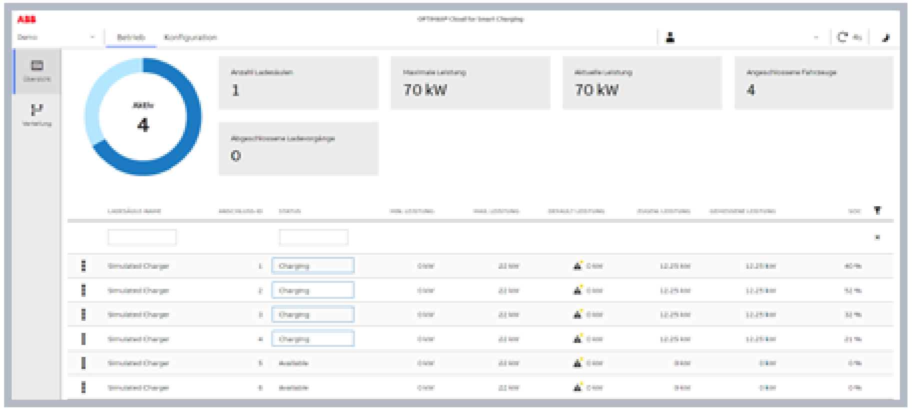


Intelligent energy and charging management

The CMS monitors the site's overall energy requirements and controls the output of all the chargers accordingly. This can include the integration of external sources such as solar power, providing greater control over consumption.

The CMS can also cap peak loads and thereby balance demand with the availability and cost of power. More information can be found in the Costs section on page 38.

Most CMS functions are fully automated and don't need monitoring by an operator. Critical alerts can be sent by email or SMS notification, if necessary. The costs for the CMS are quickly and easily offset by greater efficiency and cost savings.



SINGLE TRUCK SOLUTION: Every MAN eTruck includes eManager, an intelligent system within the vehicle that can control charging, including timed charging and the vehicle climate control.

SITE ENERGY SUPPLY

Calculating requirements

The size of your charging infrastructure will define the power supply needed for the site. It's important to match energy requirements to the available energy supply. Because no two charging infrastructure solutions are the same, we give here three example sites to show typical power requirements.

Scenario 1: Depot charging small fleet	
Size: Small operator, 2 eTrucks, 350 kWh each	**Available charging time:** Overnight (≈ 10 hours)
Solution 1 x 150 kW charger with two outlets and CMS for sequential charging (approx. 3 hour charging time)	**Peak power needed:** up to 150 kW max ■ often already available on site with existing transformer

Scenario 2: Depot charging medium fleet	
Size: Medium operator, 10 eTrucks, 350 kWh each	**Available charging time:** ■ 3 hours per vehicle. Daytime charging for 3 - 5 trucks possible.
Solution 5 x 350 kW CCS chargers with two outlets and CMS for sequential charging (approx. 3 hour night/1 hour daytime charging time)	**Peak power needed:** 5 x 350 kW = 1.750 kW ■ extra transformer often required, possible tariff change for flexible overnight charging

Scenario 3: Destination charging - logistics center	
Size: 6 x MCS stations for charging during loading/unloading, plus 4 x 350 kW chargers for overnight charging.	**Available charging time:** Mixed according to individual truck schedule.
Solution 6 x MCS chargers plus 4 x 350 MW chargers and CMS for sequential charging	**Peak power needed:** 6 x 1 MW plus 4 x 350 kW = 7.4 MW ■ extra transformer needed in most cases. Plus possible tariff change for flexible overnight charging

When demand exceeds energy supply

If the existing electricity supply isn't sufficient for your charging needs, there are several options depending on the total charging demand.

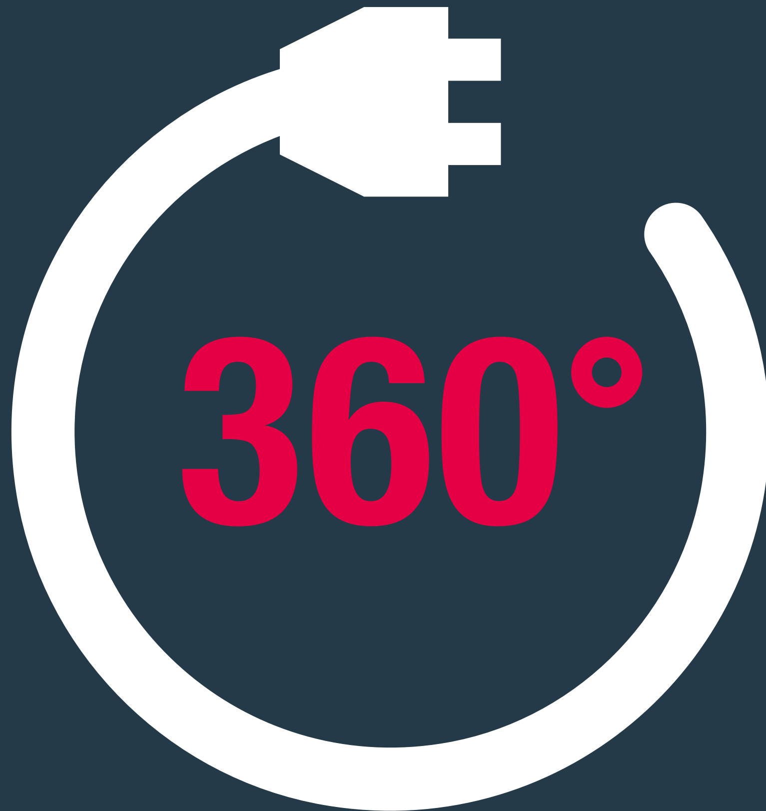
Intelligent charging: Peak demand can often be reduced by managing the charging schedule and limiting the number of vehicles charged simultaneously.

On-site generation and storage: Solar panels and, where possible, wind turbines can be used to top up the incoming supply. Combined with on-site battery storage, they can also be used for overnight charging.

Opportunity charging: Charging eTrucks while they are away from the depot, using public charging during a rest break, for example, can reduce the energy requirements in your own charging infrastructure.

Revise energy contract: Discuss with your energy supplier about increasing supply. Would require additional transformer.

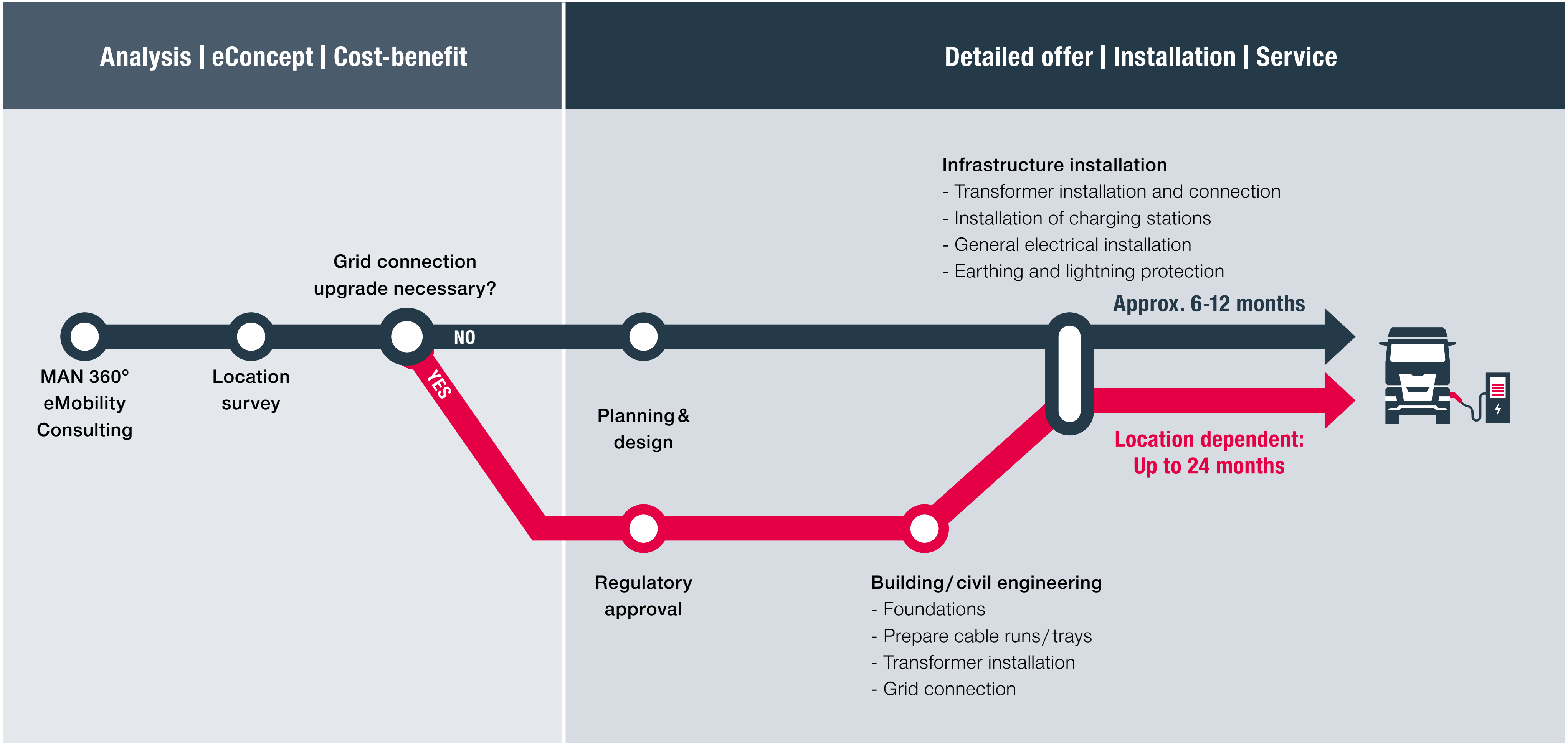
4 PROJECT IMPLEMENTATION



TIMELINE: FROM PLANNING TO IMPLEMENTATION

The length of time from initial planning to installation and commissioning depends on a number of factors. If a grid connection upgrade isn't necessary, installation can be as quick as six months.

Upgrading the grid typically means installation of a transformer together with construction work. Installation can then take up to 24 months, depending on complexity.

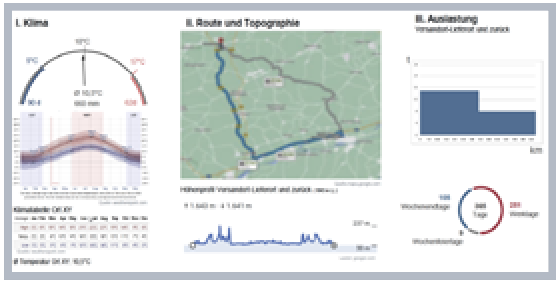


MAN 360° eMOBILITY CONSULTING

Doing the heavy lifting for you

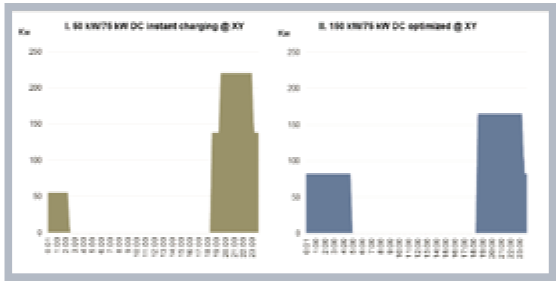
There's a lot to consider when implementing a charging infrastructure and that calls for specialist knowledge. The good news is that MAN 360° eMobility Consulting is here to help you. Together with our partner companies, we support you from the initial considerations through to implementation and commissioning.

Our experts will clarify your exact charging requirements and make recommendations on the scope of the charging infrastructure based on the vehicle operating times, kilometers driven, and energy consumption.



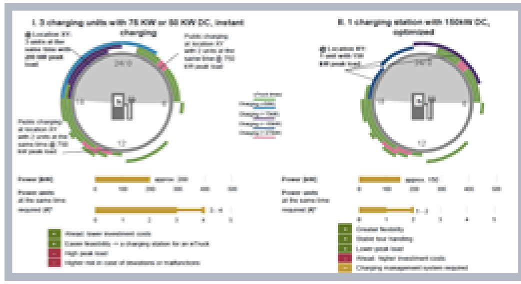
1. Analyse

Analyse your location, routes, calendar and climatic conditions



2. eConcept

Estimate required infrastructure



3. Cost-benefit

Develop cost-benefit scenario

From start to finish: A partner network for all your needs

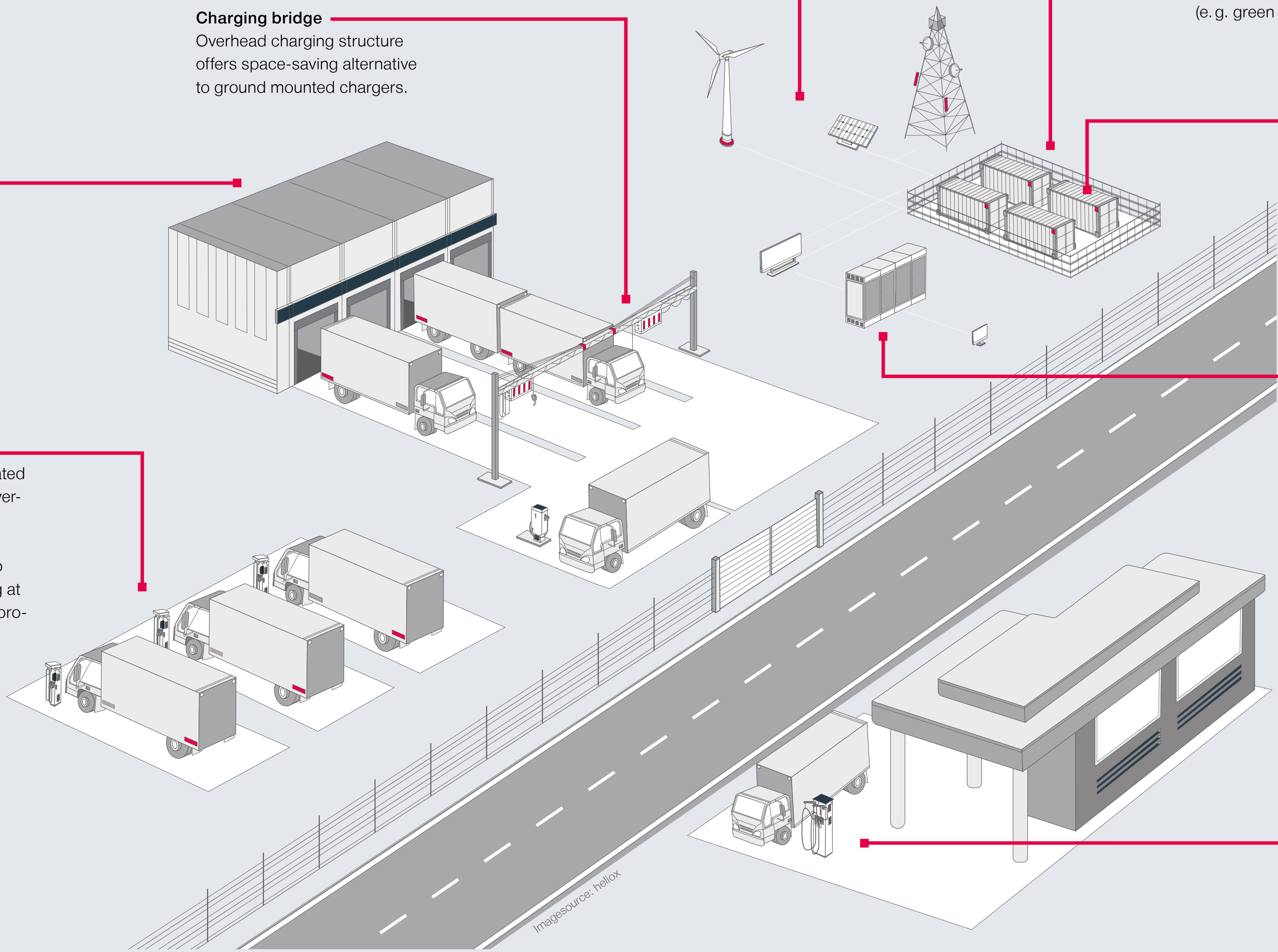
Depending on your location and requirements, we'll recommend and introduce you to one of our specialised infrastructure providers best suited to your needs. ABB, Heliox and SBRS are all renowned infrastructure partners, specialised in the field of charging infrastructure for commercial vehicles. At the end of the day, the choice is yours.

ABB heliox SBRS A Member of the Shell Group

Following the initial consultation, your selected partner will then develop a construction concept based on the current network connections and structural possibilities.

SITE PLANNING CONSIDERATIONS

Which scenario are you? We understand that there are diverse requirements and many options for building a charging infrastructure. Together with our partners, we'll help you find the right solution for your needs.



On-site energy generation
Via photo-voltaic system or wind turbine. Can supplement incoming supply to reduce peak demand and energy costs.

Incoming energy supply
Energy optimisation (e. g. green electricity).

Charging bridge
Overhead charging structure offers space-saving alternative to ground mounted chargers.

Transformer
Required to bring grid voltage to level required on site. Concrete foundations and civil engineering requirements must be taken into account.

Destination charging
Recharging between shifts or at customer destination to extend the range requires high-power chargers, typically MCS.

Charging unit
Converts AC to DC power which is then fed to satellite unit.

Depot charging
Chargers (180 - 350 kW) located in existing vehicle park for overnight charging.

Individual setup according to number of vehicles; charging at flexible overnight tariffs can provide significant cost savings.

Public charging
For greenfield sites, road access must be taken into consideration. Local authority and regulatory requirements must be observed.

MCS charging for long-haul traffic and CCS chargers for overnight charging.

FINANCIAL CONSIDERATIONS

The ups and downs of charging costs

Setting up a charging infrastructure clearly represents a significant initial investment, the overall cost of which is defined by the charging needs - “cost up” factors.

Cost up factors

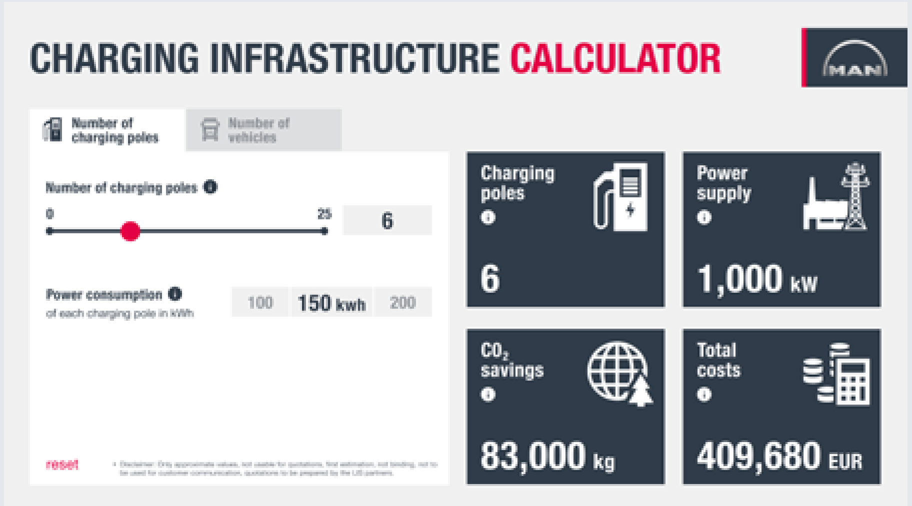
Cost up factors include charging hardware and software together with any civil engineering work that might be required, for example foundations for a transformer or changes to a depot layout to accommodate the chargers.

The major cost drivers in charging infrastructures

Technical design & civil engineering	Charging infrastructure	Operating costs
Project planning & implementation	Hardware costs (charging stations etc)	Electricity costs
Detailed design	Software installation (Charging Management System)	Operational support incl. monitoring
Civil engineering works	Installation costs	Service & maintenance
Electrical engineering & distribution system	Commissioning	
Transformer: purchase and installation, plus civil engineering costs	Calibration conformity	

How long is a piece of string?

The potential scenarios for charging infrastructures are so varied, it’s impossible to give a rule of thumb calculation for costing. Nevertheless, the use case example given here shows approximate costs for a depot charging infrastructure at a site with a 1,000 kW grid connection charging via six charging poles.



The MAN Charging Infrastructure Calculator gives you an approximate guide to costs. Just enter a few basic data points about vehicles, routes, etc. for a quick and simple cost overview.

Our charging infrastructure experts can provide a cost indication for different size and charging concepts. For a detailed offer that covers all local aspects, a detailed on-site analysis is required.

COST OPTIMISATION

Cost down factors

From smart charging to on-site power generation, there are a number of opportunities to reduce or offset both the initial investment of the charging infrastructure and the running costs - the so-called "cost down" factors.

Subsidies
Government and regional green subsidies or tax breaks are often available to help offset the investment costs and can make a significant contribution to cost savings.

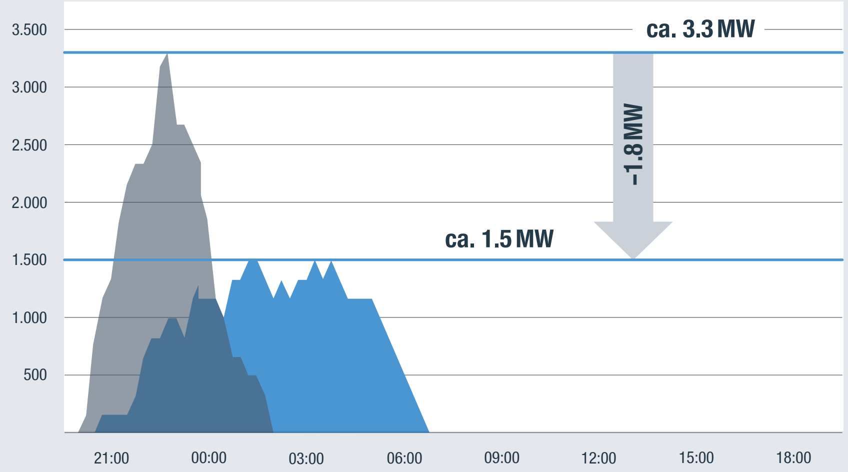
On-site generation
Solar panels or wind turbines for own power generation can not only reduce your own power costs but also open up the possibility of generating revenue through selling electricity back to the grid. Plus, good charging management planning can reduce the number of charging posts required, thereby minimising the initial investment.

Tariff optimisation
As a general rule, commercial energy prices fluctuate during the course of the day according to demand. Significant cost savings can be made by coordinating charging operations with these off-peak tariffs.

Photo-voltaic systems can often be installed at depots or distribution centers as a supplement to the existing grid supply, thereby reducing costs and minimising peak demand.

Intelligent charging: Peak shaving
The price a company pays for electricity is determined by its peak demand. With a smart power meter, the Charging Management System can automatically schedule charging and limit output levels where necessary to ensure that demand remains at a lower tariff level.

Avoiding peak demand



Intelligent charging can significantly reduce energy costs by avoiding peaks. The gray curve shows peak demand when all vehicles are charged simultaneously. The blue curve shows reduced peak demand when charging power is adjusted or vehicles sequentially charged over time.

SAVING ALONG THE CHARGING JOURNEY: To maximise cost benefits, accurate tour planning and charging strategy is necessary. Start with 360° eMobility Consulting to be sure you take an optimal path through the process.

PUBLIC CHARGING

The power for long-distance haulage

Opportunity charging for long-distance traffic or local overnight public charging? Either way, public charging calls for a reliable, widely available infrastructure. The good news is that public charging facilities needed for commercial vehicles are being driven rapidly forward across Europe.

EU legislation
The European Commission's Alternative Fuels Infrastructure Regulation (AFIR) calls for a minimum of charging locations for trucks along the most important European highways (TEN-T network). The current directive stipulates that charging stations with at least one charging station of at least 350 kW should be available every 60 km on core routes and 120 km on extended networks by 2030.

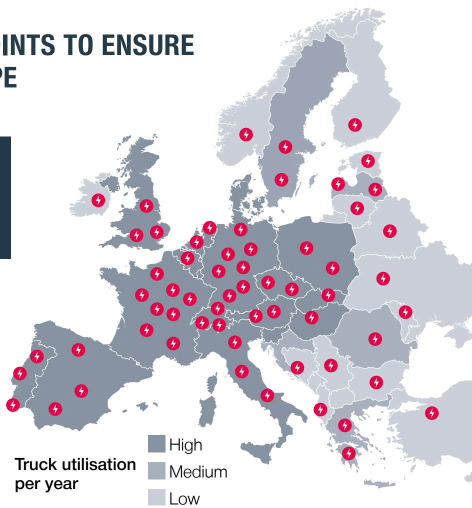
Private initiatives
Various consortiums such as Milence as well as individual companies are actively working on building and managing networks of high-performance charging infrastructures across major transit routes in Europe. Milence, for example, plans to build 1,700 public charging points across Europe by 2027.

MINIMUM NUMBER OF CHARGING POINTS TO ENSURE A BASIC INFRASTRUCTURE IN EUROPE

4,067	1,715
Charging points	Locations

5 to 10 MW
Connection capacity per long-distance charging hub

20-30 km
Maximum distance between charging points on TEN-T corridors

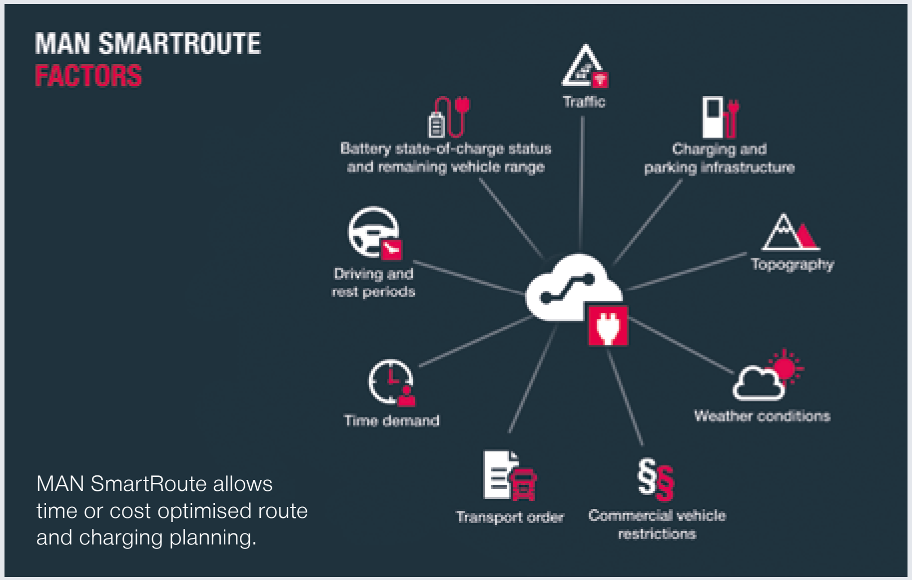


Cost control

Just as with filling up with conventional diesel on motorway routes, cost savings through public charging can be made. Use of fuel cards can help reduce costs by up to 20 % when using public charging stations where the card issuer operates the charging station.

Intelligent route planning

Route planning software can incorporate charging costs from price comparison portals and tailor routes to provide the optimum combination between the most energy- and cost-effective route according to up-to-date information.



5 USEFUL INFORMATION

ELECTRIFICATION CHECKLIST

As can be seen from this brochure, many aspects need to be considered when preparing a charging infrastructure for eTrucks. Here, we've brought together the most important in a single checklist.

1. **Check charging needs**
   - ☐ In what situation do you want to charge (overnight vs opportunity)
   - ☐ How many vehicles needs to be charged and what are typical drive in/out times?
   - ☐ Is it possible to reallocate the vehicles after full charge or do they stay still for the whole night?
   - ☐ Can peak power demand be avoided by intelligent load strategy?
   - ☐ Do you plan for future viability by planning ground work for the next 2-3 installation waves?

2. **Selecting right partner?**
   - ☐ Do you prefer a local partner and a full service provider?
   - ☐ Is public charging as a solution an option to avoid investments?
   - ☐ Are you looking for a one-time or strategic long term partner?

3. **Site Assessment**
   - ☐ Determine the optimal location for charging stations.
   - ☐ Ensure proximity to power sources and parking spaces.
   - ☐ Evaluate local regulations and zoning requirements.

4. **Power Supply**
   - ☐ Calculate power requirements based on charging station types (Level 1, Level 2, DC fast).
   - ☐ Ensure adequate electrical capacity and infrastructure upgrades.
   - ☐ Plan for future scalability.

5. **Charging Station Selection**
   - ☐ Choose appropriate charging station models.
   - ☐ Consider compatibility with vehicle types (also car charging planned?).
   - ☐ Assess features like charging speed and user interface.

6. **(Semi-) Public use**
   - ☐ Do you plan to offer the charging facility to third parties?
   - ☐ When and to whom should access be granted?
   - ☐ Who should organise publication and billing for you?
   - ☐ Define market conformant pricing!

7. **Permits and Compliance**
   - ☐ Obtain necessary permits and approvals from local authorities.
   - ☐ Comply with electrical and building codes.
   - ☐ Ensure ADA compliance for accessibility.

8. **Infrastructure Installation**
   - ☐ Hire licensed electricians for safe and proper installation.
   - ☐ Install charging stations securely and at the correct height.
   - ☐ Implement proper signage and markings.

9. **Networking and Software**
   - ☐ Set up network connectivity for remote monitoring and management.
   - ☐ Configure charging station software for user access and payments.
   - ☐ Ensure cybersecurity measures are in place.

10. **Maintenance Plan**
    - ☐ Establish a regular maintenance schedule for charging stations.
    - ☐ Train staff or hire service providers for maintenance tasks.
    - ☐ Monitor and address any reported issues promptly.

11. **User Education and Outreach**
    - ☐ Create informational materials for users on how to use the charging stations.
    - ☐ Promote the new infrastructure to potential users.
    - ☐ Gather feedback and make improvements based on user experiences.

GLOSSARY

Alternative Fuels Infrastructure Regulation (AFIR) – EU directive aimed at creating a robust charging network across Europe. Requires all EU countries, Charge Point Operators and e-mobility service providers to follow specific rules when implementing public EV charging stations for passenger and heavy-duty vehicles.

Amp – Abbreviated form of ampere. Unit of electrical current used as a measure of the rate at which electric charge flows through a circuit.

BEV – Battery Electric Vehicle

Bi-Directional Charging – Charging infrastructure that allows electric trucks to not only charge from the grid but also discharge electricity back into the grid, enabling grid support and vehicle-to-grid (V2G) capabilities.

Charging Management System (CMS) – IT software system that manages and optimises the electric vehicle charging process. Often (but not exclusively) cloud-based.

Charge point operator (CPO) – The CPO acts as the economic provider of the charging system. The CPO is responsible for construction and operation of the infrastructure and agrees with an MSP on rules for using the CPO's infrastructure.

Charging point (CP) – Component of the user unit, consisting of a charging cable and connector. Exactly one vehicle can be connected to a charging point.

Combined Charging System (CCS) – The most common charging standard for electric vehicles, including trucks in Europe. Most CCS chargers have a maximum power output of between 50 and 400 kW.

DC charging system – An external charger that provides voltage from the AC grid to the vehicle as controlled DC voltage. The charge control is here taken over by the vehicle. The central components of a DC charging system are the charging point, user unit and power unit.

Demand response – A strategy where charging infrastructure can be controlled remotely to reduce or shift electricity consumption during peak demand periods.

DOD (Depth of Discharge) – indicates how much charge has already been removed in relation to the initial maximum capacity.

EV – Electric Vehicle

ISO 15118 – international standard that defines the digital communication protocol between an EV and charging station to be used when recharging the EV's high-voltage battery.

Kilowatt (kW) – A kW equals 1,000 watts. For electric vehicles, kW can refer to the charging power, which determines how quickly a vehicle is charged, or to the vehicle's own power output while driving. Today's electric trucks normally have maximum power outputs of between 300 and 500 kW, equal to approximately 400 to 675 hp.

Kilowatt-hour (kWh) – Refers to an amount of energy used or stored. Is it equal to one kW of power output for one hour. Most passenger cars have 50 to 100 kWh batteries. Today's heavy-duty electric trucks have between 250 and 600 kWh of battery capacity.

Megawatt (MW) – Equals 1,000 kW and is normally discussed in the context of the Megawatt Charging System.

Megawatt Charging System (MCS) – A new charging standard for heavy-duty electric applications, such as heavy trucks, boats, and industrial applications. The MCS standard will have a maximum power output of up to 3.75 MW, equal to 3,750 kW, and will be commercially available by 2024.

GLOSSARY

Mobility service provider (MSP) – A user agrees with the Mobility Service Provider to use the charging system. The MSP offers various media to a user to access the charging system such as RFID-card, mobile applications, Plug & Charge.

Open charge point protocol (OCPP) – The OCPP is a standard that defines the communication between the IT back end and the DC charging system.

Overhead Charging – Charging infrastructure that delivers electricity from an overhead source to the electric truck.

Power unit (PU) – The power electronics of a DC charging system, with modular construction. The power unit is separate from the user unit.

State of Charge (SOC) – Indicator of the present battery capacity as a percentage of maximum capacity.

State of Health (SOH) – Indicator of overall health and performance, reflecting the battery's ability to deliver its rated capacity.

User unit (UU) – The operating and display unit of a DC charging system with charging cable, connector and a charging connector mount to store the charging connector when idle.

Volt – Unit of measurement for electric potential difference, also known as voltage. Describes the "force" that drives electric charges (electrons) to move through a conductor, such as a wire.

Watt – A unit of power similar to horsepower (1 kW equals 1.341 hp). A watt is calculated by multiplying amps by volts.

FURTHER READING AND USEFUL LINKS

Alternative Fuels Infrastructure Regulation (AFIR). European Union (2021):
https://transport.ec.europa.eu/transport-themes/clean-transport/alternative-fuels-sustainable-mobility-europe/alternative-fuels-infrastructure_en

Questions and Answers: Sustainable and Smart Mobility Strategy. European Commission (2020).
https://ec.europa.eu/commission/presscorner/detail/en/QANDA_20_2330

Truck Stop Locations in Europe: Fraunhofer ISI / European Automobile Manufacturers Association
https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2021/ACEA_truckstop_report_update.pdf

Charging Solutions for Battery-Electric Trucks: The International Council on Clean Transport
www.theicct.org

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