

Charging Infrastructure Deployment Guidelines

Standardising Charging Infrastructure Deployment.

This document aims to enhance our organization-wide understanding of Heavy-Duty Truck Depot Charging Infrastructure deployment, equipping local teams with the necessary tools and processes for cost-effective and efficient needs assessment and implementation. Additionally, it delves into the intricacies of Electric Vehicle Supply Equipment (EVSE) by addressing commonly raised questions.

Address

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This Document was prepared by Energy Transition, Asset Strategy and Strategic Partnerships and the EVSE Workgroup. It uses the Smart Freight Centre's 'Guidelines-Charging-Infrastructure-Depot' as a basis, adapting to suit the first mile operations Maersk and its vendors operate within.

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Nomenclature

AC – Alternating Current

AFIR – Alternative fuels infrastructure regulation

CapEx – Capital Expenditure

CCS – Combined Charging System

CO₂ – Carbon Dioxide

CPO – Charge point operator

DC – Direct current

DNO – Distribution Network Operator

EU – European Union

EV – Electric Vehicle

GCWR – Gross combined vehicle weight rating

HDV – Heavy duty vehicle

KW – Kilowatt

kWh – Kilowatt hour

LCA – Life cycle assessment

MCS – Megawatt charging system.

SOC – State of Charge

TCO – Total Cost of Ownership

1. Introduction

The importance of road decarbonisation

Electrifying all commercial freight vehicles is imperative to achieve local, regional, and national CO₂ emissions targets. With transport emissions contributing 15% to global emissions and anticipated to increase, the focus on reducing the environmental impact of freight vehicles becomes paramount. Notably, 10 countries, including the US, China, Russia, India, Brazil, Japan, Canada, Germany, Mexico, and Iran, collectively contribute 53% of global transport emissions.

Highlighting the urgency, the World Resources Institute (WRI¹) reports that a significant 72% of global transport emissions stem from road vehicles, accounting for 80% of the emission rise between 1970 and 2010. Intriguingly, heavy-duty trucks (HDTs), constituting merely 2.5% of the road fleet, contribute over a quarter of transport emissions, producing 1.2 GtCO₂ annually according to the International Energy Agency (IEA).

Within the Maersk context, road freight represents 10% of overall emissions, with a substantial 82% contributing to total landside emissions (0.3 MtCO₂e Scope 1 and 7.8 MtCO₂e Scope 3). Responding to global concerns, key regions where Maersk operates have proposed stringent CO₂ emission standards for HDTs: the EU targets ²a 30% reduction by 2030 and 90% by 2040, the US envisions ³50% Zero Emission Vehicle (ZEV) sales by 2030 and 100% by 2040, and China aims ⁴for a 12% ZEV market share by 2025, increasing to 17% by 2030 and 20% by 2035.

Recognizing the inevitability of electric trucks in the market, the transition is not just a requirement but a prerequisite for participation and competitiveness. For Maersk, electrification is not viewed merely as a duty but as an opportunity to proactively prepare for the impending transition, yielding economic benefits and establishing a distinct competitive advantage.

Charging Infrastructure's role in the energy transition and Maersk's Strategy

A robust and efficient charging infrastructure is paramount to the success of Maersk's electrification efforts. This significance is underscored by the emphasis placed by both the EU and the US on charging infrastructure as a prerequisite to achieving ambitious electrification targets.

Key regulatory frameworks, such as the Alternative Fuels Infrastructure Regulation ⁵and the Trans-European Network⁶, have established targets for charging power availability and spatial distribution, particularly crucial for supporting long-haul operations. The Ten-T initiative specifies that charging options for Heavy-duty Vehicles (HDVs) should be no more than 60km apart by 2025, with power values reaching

¹ <https://www.wri.org/insights/everything-you-need-know-about-fastest-growing-source-global-emissions-transport#:~:text=In%20terms%20of%20transport%20modes,and%20international%20and%20coastal%20shipping.>

² https://ec.europa.eu/commission/presscorner/detail/en/ip_23_762

³ <https://www.energy.gov/sites/default/files/2023-01/the-us-national-blueprint-for-transportation-decarbonization.pdf>

⁴ <https://theicct.org/sites/default/files/publications/ze-hdvs-china-tco-EN-nov21.pdf>

⁵ [https://transport.ec.europa.eu/transport-themes/clean-transport/alternative-fuels-sustainable-mobility-europe/alternative-fuels-infrastructure_en#:~:text=The%20specific%20objectives%20of%20the,infrastructure%3B%20and%20\(iii\)%20to](https://transport.ec.europa.eu/transport-themes/clean-transport/alternative-fuels-sustainable-mobility-europe/alternative-fuels-infrastructure_en#:~:text=The%20specific%20objectives%20of%20the,infrastructure%3B%20and%20(iii)%20to)

⁶ https://transport.ec.europa.eu/transport-themes/infrastructure-and-investment/trans-european-transport-network-ten-t_en

1.4MW by the end of 2030 and further increasing to 3.5MW by 2035, mandating at least one 350kW station at each location.

Anticipating the critical role of depots, for first- and middle-mile operations, it is expected that 90%⁷ of HDT charging will occur at these locations, making depot charging infrastructure the single most crucial element. The ACEA⁸ and ICCT⁹ have modelled specific targets for the volume of depot charging infrastructure for Medium and Heavy-duty vehicles: By 2030, the EU envisions 235,000 chargers to reach a 30% emission reduction scenario, while the US plans for 125,000 chargers by 2025 and 520,000 chargers by 2030.

In terms of energy consumption, private fleet hubs are anticipated to cover 53% of the total energy demand for electric trucks, underlining the strategic role of these hubs in supporting the energy requirements of the burgeoning electric truck market.

Who is this guide for?

This guide serves as a comprehensive resource for local operations venturing into the deployment and ownership of electric vehicles (EVs), aiming to facilitate well-informed decisions when investing in charging solutions.

- Specifically tailored for **Product and operations stakeholders**, the guideline equips you with assessment tools to develop feasible recommendations and generate crucial data to support engagement in partnerships.
- Meanwhile, for **Procurement stakeholders**, the guide delivers an insightful overview of the infrastructure deployment process and operational procedures, enabling the optimization of procurement activities.
- Catering to **all stakeholders**, this guideline not only imparts educational content but also serves as a platform for sharing best practices and fostering a deeper understanding of the requisites for electrifying Maersk's transport operations.

Scope of the guideline

This guideline exclusively addresses the intricacies of charging infrastructure within transport depots and does not encompass fast EV charging in public settings.

It specifically relates to the charging infrastructure designed for EV trucks and does not extend its considerations to Hydrogen vehicles or any other forms of alternative energy or fuel vehicles.

It applies to facilities that service as a base to owned EV fleets operating during single or dual shifts.

The scope accommodates both owned and leased facilities.

How to read the guidelines

⁷ <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/why-most-etrucks-will-choose-overnight-charging>

⁸ https://www.acea.auto/files/Research-Whitepaper_A-European-EV-Charging-Infrastructure-Masterplan.pdf

⁹ <https://theicct.org/wp-content/uploads/2023/05/infrastructure-deployment-mhdv-may23.pdf>

The guidelines are organised as follows:

Firstly, we offer a concise overview of charging solutions for trucks, aiming to equip readers with essential knowledge and terminology pertinent to our operations.

Following this, we outline critical questions that local product, procurement and delivery teams should contemplate. These inquiries serve as determinants for the type of charging infrastructure required. This structured approach proves invaluable when engaging potential providers of charging infrastructure and related services.

Subsequently, we detail the high-level phases of procuring charging infrastructure, including timelines and capital expenditure (CapEx) considerations.

Moving forward, the guide discusses key considerations during the preparatory phase, facilitating the selection of optimal charging infrastructure solutions. Our objective is to ensure that the infrastructure aligns with demand while optimizing costs and adhering to spatial constraints and grid capacity.

The most important steps in the preparational phase are to: (1) Establish your charging needs, (2) explore charging solutions, and (3) assess the depot. Throughout these stages, the guide offers tailored recommendations and insights aimed at enhancing efficiency and cost-effectiveness during infrastructure establishment.

Finally, we consolidate the most salient recommendations and lessons from the guide in section six, and Frequently Asked Questions that provide tangible guidance in starting your journey with implementing charging infrastructure in Section 7. We are confident that this information will prove instrumental for Maersk fleet and depot owners, potentially expediting the electrification of trucks across our global footprint.

Readiness Checklist

Recognising that each stakeholder may have different points of interest and understanding with respect to charging infrastructure, please use the checklist below to determine the information relevant to you:

Demand needs	I have determined the current and future number of trucks to be used at the facility	If not, see Section 3
	I have identified key truck specifications including battery capacity and charging power	If not, see Section 2
	I have calculated the energy needed by the trucks at the facility based on their operation	If not, see Section 5.1
	I have calculated the average power needed to meet the energy demand and understood the power levels for chargers	If not, see Section 5.1
	I am aware that heterogeneous fleets may require different chargers to fulfil individual needs.	If not, see Section 5.1
Charging solution	I have chosen a charger type with a power rating at least 2 times higher than the calculated average power demand	If not, see Section 5.2

	I understand the benefits of smart charging and energy management systems and factored this into charger selection	If not, see Section 5.3
	I am aware of the reasons why real charging power might be lower than nominal and factored that into the selection.	If not, see Section 5.3
Facility assessment and Grid connection	I have contacted the utility company to discuss potential grid connection limitations	If not, see Sections 5.3 and 7
	I have determined the current grid connection capacity is sufficient for the required charging infrastructure	If not, see Section 5.3
	I have investigated energy load management systems and their impact on reducing grid capacity costs.	If not, see Section 5.3
Location	I have assessed spatial and manoeuvrability constraints that may impose limitations on charger location.	If not, see Section 5.3
	I have consulted technical and safety regulations regarding charger installation and insurance implications	If not, see Section 5.3
	I have explored the addition of on-site BESS and RES.	If not, see Section 5.3
	I am aware that actions can be taken to future proof the installation and support expansion.	If not, see Section 5.3
Operation and Support	I have engaged with an approved CPO for equipment installation, operation and maintenance.	If not, see Section 5.3

2. Charging Solutions

The type of chargers chosen for a depot depends primarily on the charging power needed by the trucks to fulfil their daily energy requirements (driving, refrigeration etc...). The two main categories of charging are: alternating current (AC) and direct current (DC) charging. AC charging is used for lower charging powers up to 43 kilowatts (kW) – while DC can provide up to 350 kW with CCS and several megawatts (MW) with MCS. While DC charging is more widely used and supported by trucks, and adds several additional advantages (see Section ‘Charging levels supported by CCS and MCS’ below), the costs are also greater – keeping AC charging as a relevant option for lighter urban trucks. It is anticipated that due to the nature of Maersk’s operation being predominantly first mile, and the higher associated energy demands, DC charging is the most relevant charging category, and will be the core focus of the guideline.

This part of the guideline will present three important aspects to charging:

- The charging power that contemporary E-trucks typically support.
- Charging levels supported by CCS and MCS plugs,
- And finally, examples of real chargers and their physical characteristics.

We use the term charger to describe the entire physical asset/enclosure used to charge the vehicles. The term charge point is used to describe the individual outlets used to physically connect the trucks. Some chargers have two or more charge points allowing multiple trucks to share a single charger.

Supported charging powers in trucks today.

Different models of trucks will support different charging power levels for AC and DC charging. For some trucks there are different options for charging powers that can be specified at the time of order that can be added as a retrofit later. It is of course important to ensure that the trucks will match the charging equipment in terms of power.

Figure 1 illustrates a few examples of contemporary E-trucks and the charging power that they support:

OEM	Model	Charging power supported (DC)
Volvo	FH Electric	250 kWh
Scania	S400/R400	375 kWh
Tesla	Semi	750 kWh
BYD	8TT ER/SR	185/120 kWh
XCMG	XGA4254 BEV	320 kWh
Sinotruk	BEV35	240 kWh
IVECO/Nikola	Tre BEV	350 kWh
Renault	D ZE	150 kWh
Daimler	eActros 300/600	160/1000 kWh
Navistar	eRH	350 kWh

Figure 1: Example of charging power in trucks.

Be aware that charging above 22 kW AC or 150-200 kW DC is less common in contemporary trucks. Several Heavy-Duty trucks do not support AC – while DC charging support should be seen as mandatory.

Especially for high-power charging it is common that the experienced charging power will be lower than the nominal charging power specified by charging equipment and truck. This is determined by the so-called ‘charging curve’ of electric vehicles and is influenced by the temperature, the state of charge of the battery, and several other factors.

What is a charging curve? It is the change in speed that your EV asset will charge at as it gets fuller. When the asset is nearly empty, it charges faster, when it is nearly full, it charges slower. Imagine an empty football stadium, with no fixed seat allocation, the first person entering the stadium can choose any seat, seats closest to the gangways and entrances become full first, and as the stadium begins to fill seats become scarce and it becomes challenging to find a seat, when at 90% capacity, it can become extremely challenging and time consuming to find a seat.

EV batteries are made of many lithium-ion cells with positive cathodes, negative graphite-based anodes, and an electrolyte. Lithium ions and electrons move between these components during charging and discharging. When charging, an external current separates electrons from lithium atoms in the cathode. Electrons travel to the anode through a circuit, while lithium ions move to the anode through the electrolyte. The opposite happens during discharge. As the battery fills up, the movement of ions slows down, causing slower charging times.

Charging levels supported by CCS and MCS plugs.

The majority of charging at depots is facilitated using the Combined Charging System (CCS) type 2 inlet defined by the IEC 62196 standard. The inlet allows trucks to use both AC and DC chargers using the same physical plug opening.

The same association who has promoted CCS, CharIN, is also behind the development of a new charging standard to support higher charging powers, in the Megawatt range, especially designed for the heavy transport sector, including trucks. The Megawatt Charging System (MCS) standard will be more suitable to meet the demand from trucks in situation where short parking and layover periods will have to support the driving needs. This is especially relevant for long-haul transport where trucks charge along the route – or at destinations during loading/unloading.

Figure 2 shows some typical options for charging power, the corresponding charging speed, and associated cost range. The charging speed is based on the nominal charging power of the charge point and should be considered as the maximum charging speed obtained – the typical charging speed will be lower, especially for higher charging powers. Costs are based on ACEA estimates¹⁰.

AC charging vs. DC charging – what's the difference?

- Our common electricity system runs on alternating current (AC) which must be converted to direct current (DC) needed by the truck batteries. This means that a conversion from AC to DC needs to take place before electric energy can be delivered to the truck's battery.
- If that conversion happens in the truck, we call this AC charging – the charger simply delivers AC power to the vehicle which then takes care of the conversion. Conversely, if the charging station does the conversion, it is called DC charging.
- The power components taking care of the conversion will add cost and weight – this is why DC chargers are typically larger and cost more. Onboard chargers are typically small (with relatively limited power) to save costs and weight.
- The immediate benefit of DC charging is the increase in charging speed and the broader support among trucks. Moreover, the communication mode used in DC charging typically allows for more

¹⁰ <https://www.acea.auto/files/Research-Whitepaper-A-European-EV-Charging-Infrastructure-Masterplan.pdf>

advanced options including pre-heating, pre-conditioning, and information on the battery State of Charge (SoC).

Power (kW)	22/43	50	150	350	1000-3750
Nominal charging speed (Km pre hour charged)	14-43	33-50	100-150	233-350	1000+
Hardware Cost (Euro)	€ 1000-3000	€ 30,000	€ 70,000	€ 170,000	€ 200,000+
Current type	AC	DC - CCS			DC - MCS

Figure 2: AC and DC charging using CCS and MCS inlet. Charging speeds are based on an assumed consumption of 1-1.5kWh per km, the maximum/nominal charging power and cost is provided by 'European Charging Infrastructure Masterplan', ACEA, 2022.

In this guideline, the emphasis is put on charging powers between 50-150kW DC charging, since this range represents best the needs encountered at depots within the scope of this guide. If the fleet has extraordinary charging demand and limited layover time available for charging at the depot – we recommend engaging directly with a charge point operator to discuss alternative options such as battery swapping or the possibility of 350 kW and MCS charging.

Charging solution examples – placement and physical footprint.

Depending on the chosen solution, the physical charging hardware will have different dimensions which influences the placement and protection needed in the environment in which they are installed. While equipment is continuously developed and specialised to fit into many types of environments – depending on specific user needs and special constraints – we here define two main types as illustrated in Figure 3, supporting CCS type plugs. The main difference between these categories is the space they will take up at the depot and the specific placement of the hardware relative to the trucks.

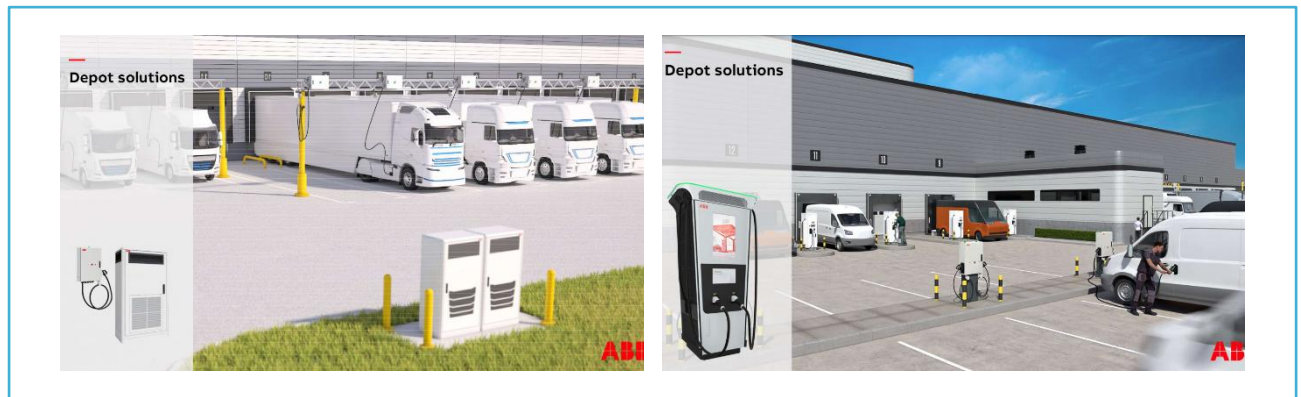


Figure 3: CCS charger types and dimensions. Free standing DC charger (DC CCS) source: ABB. Satellite chargers (DC CCS – Gantry configuration) Source ABB.

DC Charger – Free Standing.

The most common solution for DC chargers is the classical free-standing version. The chargers are placed on the terrain relatively close to where the trucks can park. The 'cube' size of such chargers increases the considerations which must be made for manoeuvrability of the trucks and takes up the most space compared to the other category. Standard solutions typically measure (H*W*D) 2250 x 420 x 854mm.

DC Charger – Mobile

Mobile charging solutions are a variant of 'Free standing' systems, whereby the charging unit is presented on a skid, or as part of a containerised system design. These solutions are used in applications where it is challenging to commit to a specific location, or where it is challenging to perform civil works. Standard containerised solutions typically measure (H*W*D) 2590 x 2440 x 3030mm.

DC Charger – Satellite

An alternative solution is the option of collecting power electronics in a separate enclosure which can be placed separately from the charging outlets themselves. This means that the charging solution will take up less space in the area where the trucks operate and can have advantages regarding safety and manoeuvrability. Standard solutions typically measure (H*W*D) 1500 x 300 x 300mm.

DC Charger – Gantry

Gantry systems are a type of 'Satellite' configuration, whereby the cables and charging outlets are suspended from a gantry that the trucks drive underneath. This type of installation is relatively new and used in environments where space is limited or for charging applications at load and unload at bay doors.

2.2 Diagram of typical Installation

When building charging infrastructure at a depot, the chargers will be integrated into the existing electricity installation. Figure 4 provides an overview of the components and key connection points. Commonly, depots are connected via underground cables to the public distribution grid. The connection point is equipped with an electricity meter measuring the consumption of the depot. The grid connection point is marked with number (1). The consumption of the already existing electric installation including all appliances is in the following referred to as the 'base load', indicated by (2). The chargers are integrated into the existing electric installation at point (3), which can be equipped with an electricity meter dedicated to measuring the aggregated consumption of the charging infrastructure.

One of the key questions when building charging infrastructure at a depot is if the existing electric installation of the building is sufficient for incorporating the additional load imposed by the chargers. The added consumption of the chargers at point (3) and the base load at point (2) must always be lower than the power rating of the grid connection point (1). This topic will be, among other items, discussed in the following section.

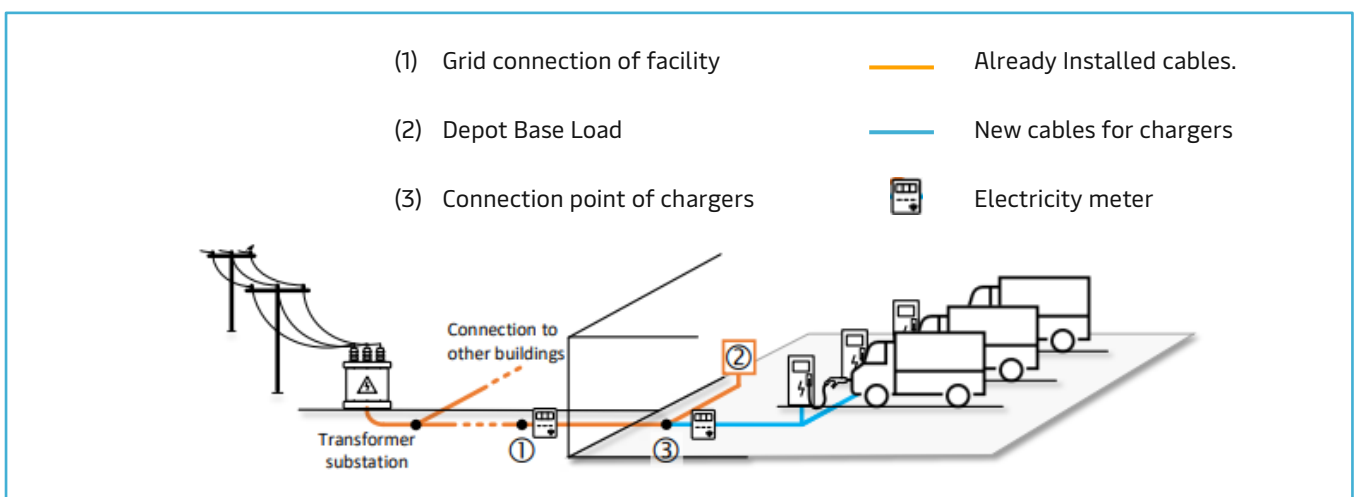


Figure 4: Overview of depot with charging infrastructure.

3. Key questions for your depot

Before choosing a charging solution for the depot there are a number of important questions that will determine the need in terms of chargers and grid connection. Having answers ready for most of these questions will help when going through the rest of the guideline, but also when talking to potential subcontractors or consultants.

	Question	Rationale
Establish your charging needs	How many electric trucks will use the depot now and in the future?	Make a forward-looking plan for how much of your EV fleet you will electrify and when.
	What are the usage patterns of the trucks using your facility?	Determine how long the trucks are parked at the facility and when.
	What distances do the trucks drive?	Both on average and worst case.
	How much energy are the trucks spending per km driven?	Provided by the truck OEM, but also take practical experience of other fleet operators into account.
Identify charging solutions	What charging power will the electric trucks be able to support for DC charging, respectively?	
	What are your long-term plans for charging opportunities at the depot?	How many charging options will you ultimately need at the depot.
Assess the depot	What is the grid connection capacity at your facility?	If in doubt, consult the facility manager or utility provider.
	Are there any size constraints at the depot which may limit the possibility of placing chargers or having the trucks access them?	Especially free-standing DC chargers take up space and custom solutions may be necessary.
	What regulations and safety considerations apply for the facility?	National/ regional/ local and technical regulations regarding the installation of charging infrastructure need to be consulted.
	Is the depot co-located with PV or battery storage, if not, are there any plans for this?	Both may decrease grid-associated costs and carbon footprint.

4. Establishing charging Infrastructure – phases and costs

This guideline is designed to support the first, preparatory phase of establishing charging infrastructure, as it is likely that an external partner will be engaged to support with the subsequent implementation and operation phases. As illustrated in Figure 5 this guideline focuses on the main steps that need to be taken to assess the best solutions for charging. We recommend contacting the local utility provider even before making this assessment as the possibilities, costs, and lead times that they can indicate will have a large bearing on the economy and time needed for the project.

Project Phase	Task	Sub-task	Responsibility
Preparation Phase	1.0 Contact utility provider		(Operations/Product)
	2.0 Feasibility Assessment	2.1 Establish charging needs. 2.2 Evaluate charging solution 2.3 Assess the facility.	(Operations/Product)
	3.0 Market tender	3.1 Site Design and Engineering plans developed 3.2 Procurement: Order placement/ contract awarded.	(Procurement) /CPO
Implementation	4.0 Extend grid capacity to site (as needed)		(Facility Management)
	5.0 Retrofit of facility electrical installation		(Construction Engineering)/ CPO/ Electrical Contractor
	6.0 Ground works: Cabling		(Construction Engineering)/ CPO/ Civils Engineering contractor
	7.0 Charger acquisition		CPO
	8.0 Ground works: Charger Installation		(Construction Engineering)/ CPO/ Civils Engineering contractor
	9.0 Commissioning		CPO
Operation	10.0 Charger maintenance and monitoring		CPO
	11.0 Billing and access		

Figure 5: main phases of establishing charging infrastructure.

In the following section 'Feasibility Assessment' you can read about the considerations which will go into dimensioning the infrastructure to the facility's particular needs – so you are better equipped when reaching out to potential partners, technicians, and your utility provider.

In this section we will provide time and CapEx estimates for establishing charging infrastructure.

4.1 Timeline for deploying charging infrastructure.

Establishing charging infrastructure can take from a few months up to several years (worst case) depending on the chosen charger solutions and the grid's ability to accommodate that demand.

A rise in demand for charging infrastructure means that bottlenecks may arise – and should be anticipated in the project plan. Establishing early contact and coordination with providers (charger providers, technicians, utility provider) will provide the delivery team with a better estimate of the time needed.

The time it will take to establish charging infrastructure depends on four main processes in the **implementation phase**, ¹¹delivery, permits, installation and potential grid extensions. The latter causing the most impact in terms of timeline volatility.

While the duration of each process varies significantly over time and for each country/region, we here provide examples from our own NAM and EU deployments with a rough estimate on the order of magnitude which may be expected.

Process stage	Considerations	DC 50 kW	DC 150 kW
Time for delivering chargers	Especially high-power chargers may have longer lead times	2-5 months	2-5 months
Construction permits	For high-power charging requiring larger re-constructions/facility retrofits, getting the appropriate permits may take time.	-	1-6 months
Installation	Electricians with experience in charging infrastructure are in high demand.	2-3 months	2-5 months
DNO approval and grid extension	Grid companies may have longer lead times for approving and delivering extra capacity due to high demand	1-3 months	3-36 months
Total time		4-8 months	6-24 months

The table illustrates the differences in time depending on the charging powers required – but also the uncertainties associated with the respective processes. It is assumed that some of the above processes can be carried out in parallel.

4.2 Infrastructure CapEx

The main determining factor to the CapEx is the size of the infrastructure in terms of numbers or charge points and the power rating of each. Faster chargers will in general cost more and result in larger costs for grid

¹¹ EU EV Charging Masterplan, expert interviews, Eurelectric, CLEPA: <https://www.acea.auto/files/Research-Whitepaper-A-European-EV-Charging-Infrastructure-Masterplan.pdf>

upgrades. The following table presents estimates for the main costs of establishing a single DC outlet based on numbers from ACEA supplemented by input from our existing deployments.

ACEA ¹² insight	Cost item	DC 50 kW	DC 150 kW
	Planning and Administration	€ 1,500	€ 2,000
	Charging Equipment	€ 10,000	€ 70,000
	Installation	€5,000	€60,000
	Cost per outlet	€16,500	€135,000
Real-world example	Grid upgrades – from best to worst case (based on connection fees of €130/Amp)	€0-10,500	€0-50,000
	Cost per outlet (with grid upgrades)	€16,500-30,000	€135,000-200,000

Facilities typically pay a fixed grid connection tariff per Ampere required at the facility – this will differ from country to country, and it is best to receive an early cost indication from the utility provider as soon as the power requirements have been estimated.

Key remarks on costs and installation times

- A 150 kW DC charger can cost €135-200k and take up to 36 months to install.
- As such it is important to establish an early understanding of the charging power requirement, as this will determine both CapEx and the time needed to complete the charging infrastructure.
- Regardless of the charging infrastructure, delivery teams should start the implementation process as early as possible to accommodate for possible delays and lead times in charger acquisition, installation and grid upgrades.
- Linked to the purchase of EV fleets, this process should be initiated at the earliest point of EV acquisition.

¹² <https://www.acea.auto/files/Research-Whitepaper-A-European-EV-Charging-Infrastructure-Masterplan.pdf>

5. Feasibility Assessment

When establishing charging infrastructure, three main steps are imperative:

Step 1	Establish your charging needs	First, it is essential to assess the charging demand of the trucks at the facility. This is done under consideration of truck properties and operating profile. This step estimates energy needs and power consumption of each truck.
Step 2	Identify charging solutions	This step aims at identifying charger types that are suitable for fulfilling the charging demand of the trucks, as well as determining the corresponding number of charge points needed at the depot.
Step 3	Assess the depot	To fulfil the energy needs of the trucks, the grid connection capacity and space requirements at the facility need to be assessed. This step analyses how the depot can be prepared to accomplish the shift to EV trucks.

The following sub-sections provide detailed information on each of the three steps. Although the steps build up on each other, the overall methodology is still considered part of the preparation phase. This means that decisions on the charging solution should only be made after the assessment of all three steps. For clarifying the theoretical aspects, an example fleet profile is used to demonstrate each step.

5.1 Establish your charging needs.

To determine the charging demand of a single truck, the daily driving distance (in km) and the consumption of the truck (in KWh/km) need to be considered. The energy demand 'E' of the truck is calculated as:

$$E = \text{distance} \times \text{Consumption} + \text{auxiliary}.$$

While the driving distance is usually well known by the operational teams, the consumption of the truck can be provided by the OEM. However, like for diesel trucks, the actual consumption can differ from the stated values. For this reason, practical experience and test drives can help identify the realistic truck consumption and provide important insights, since the consumption can largely vary with the driving styles. If present, auxiliary systems of the truck should also be taken into account, i.e., Reefer transport).

The energy charged at the facility cannot exceed the usable battery capacity of the truck. For instance, if the daily driving distance is larger than the maximum vehicle range, public chargers or charging opportunities at logistics centres need to be used in addition to depot charging. In these cases, the considerations for depot charging only take into account the truck's battery capacity as the energy demand, and not the overall consumption between depot charging.

Once the energy demand of a truck is known, the minimum charging power that needs to be provided at the depot is calculated. The calculation is based on the truck's energy demand at the facility, E (in KWh), the time at the depot ' t ' (in hours), and the charging efficiency ' n ' (in percent):

$$P_{\min} = \frac{E}{t} \times \frac{1}{n}$$

The minimum power $P_{\min}$ indicates the power a truck would need to charge continuously during its time at the facility to fulfil the energy needs. The equation shows that for shorter layover times at the facility, the required power level increases. Furthermore, the efficiency ' n ' takes into account the power losses in charger and truck battery. With lower efficiency, more energy needs to be provided by the depot to compensate for the losses during the charging process. The charging efficiency depends on various factors such as the specific battery type, the charger type, and charging power. To provide a simple figure, we recommend calculating with an efficiency of 90%.

If the fleet comprises different types of trucks and/or different operating profiles the method should be applied to each truck group individually. This is necessary since the different trucks might require different chargers to fulfil their individual energy needs.

Example

The presented methodology is demonstrated with an example fleet profile, presented in the following table:

Truck Specification (Volvo FH Electric 2022)	
Category	Class 8/ N3
Weight (GCWR)	40,000 kgs
Usable Battery Capacity (80% of nominal capacity)	432kWh (540kWh total)
Consumption	1.1 kWh/km
DC Charging Power	250 KW
Range	340 km
Operation	
Type of operation	Containerised Drayage
Avg. Daily Driving Distance	250 km
Time at depot	18:00 – 7:00 (13 hours)
Number of assets	5

Firstly, the daily energy needs of a single truck are calculated based on the driving distance and the trucks energy consumption:

$$E = \text{distance} \times \text{consumption} = 250 \text{ km} \times 1.1 \text{ kWh/km} = 275 \text{ kWh}$$

The daily charging demand at the facility for 1 truck is 275 kWh. Therefore, the battery capacity of 432 kWh is sufficient to cover the daily energy needs.

The minimum charging power is estimated based on the energy demand, the time at the depot, and the charging efficiency. For the present case, a charging efficiency of $\eta = 90\%$ is assumed, considering power losses in charger and truck battery. The minimum power is calculated as:

$$P_{\min} = \frac{E}{t} \times \frac{1}{\eta} = \frac{275 \text{ kWh}}{13 \text{ hrs}} \times \frac{1}{90\%} = 23.5 \text{ kW}$$

The truck would need to charge continuously with an average power of 23.5 KW during the time at the facility to fulfil the energy needs. Building on this, the following section presents the selection process for the chargers.

5.2 Identify Charging solutions.

The decision on the charging infrastructure layout centres around two main questions, addressing the type and number of charge points.

A) What type of chargers are needed?

In the previous step the energy need 'E' per truck was estimated, as well as the minimum charging power $P_{\min}$. This power corresponds to continuous charging between arrival and departure. The power rating of the charger should clearly exceed this value to ensure that the truck reaches its energy needs with a sufficient time buffer before departure.

The time buffer should be considered for several reasons. First, if the truck arrives late at the facility, the charger has less time to provide the required energy. Second, in case of increased energy needs on single days, e.g., due to traffic or unanticipated detours, the charger must recharge more energy in the given layover time at the facility. Thirdly, a truck commonly reduces the charging power when the battery approaches its upper charge limit. Hence, the average charging power of a charging process is lower than the rated power of the charger.

When selecting a DC charger, the rated power should be at least double the minimum average power calculated in step 1:

$$P_{\text{DC Charger}} > 2 \times P_{\min}$$

The reason for this distinction lies in the overall higher power rating at DC chargers. Generally, trucks will reduce their charging power when their battery approaches 100% SoC. At high power levels, which are experienced at fast chargers, the truck will reduce the charging power from an earlier charge level, requiring a larger time buffer.

It should be noted that the values for $P_{\text{DC Charger}}$ are minimum requirements for the power rating of the charge points. The rating can also be chosen higher to achieve more flexibility for shifting the charging process to preferable time windows, for instance, to periods with lower electricity prices. Besides considerations on both investment and operating costs for the charging infrastructure, it is indispensable to assess the existing electric installation at the facility including the grid connection capacity, which is further addressed in Section 5.3.

Another crucial aspect in the selection of suitable chargers is the compatibility with the truck specification. For instance, assuming a truck can charge up to 150 Kw at a DC charger: if $P_{\min}$ was estimated at 25 kW, only DC charge points with 50 kW or more are suitable.

B) How many charge points are needed?

The number of charge points depends to a large extent on the fleet size, but is also influenced by their coincidence factor at the facility, i.e., if they are using the facility at the same time. For fleets with a homogenous schedule where all trucks arrive and leave at the same time, a truck/charge point ratio of 1:1 is needed, meaning that there is one functional charge point per truck. For fleets where the trucks have different operating schedules the number of charge points may be chosen to be less than the number of trucks, presuming that their schedules allow to use the same charge points consecutively.

Special considerations apply to DC chargers, which are often built with two charge points (connectors/plugs) per charger. In this case, one charger can be used by two trucks simultaneously. When selecting the charger rating, it is important to consider that each of the charge points can provide the power levels required for fulfilling the trucks' charging needs. Assuming a scenario where the minimum power rating for the charger was estimated as $P_{DC\ Charger} = 60\text{ kW}$. In this case, a DC charger with two connections at 75 kW can charge two trucks simultaneously. Hence, the total power rating of the DC charger is 150 kW.

Example

In the previous step the minimum average charging power of the truck at the facility was estimated at 23.5 kW. This value corresponds to continuous charging between arrival and departure.

The power rating of the charge point should clearly exceed this value to ensure that the truck reaches the required energy with a sufficient time buffer. The minimum power rating of the charge point is estimated as:

$$P_{DC\ Charger} > 2 \times 23.5\text{ kW} = 47\text{ kW}.$$

In the present example, a DC charge point with a rated power of 50 kW is suitable for fulfilling the charging needs. A charge point with a rated power of <50kW should not be considered, as it does not provide a sufficient time buffer in case of delayed arrivals at the facility or an increased energy demand due to unanticipated detours. The following figure shows the truck charging profile at a 50 kW DC Charge point. The truck arrives at the depot at 18:00 and leaves at 07:00 the next morning. The charging process is completed around 01:00.

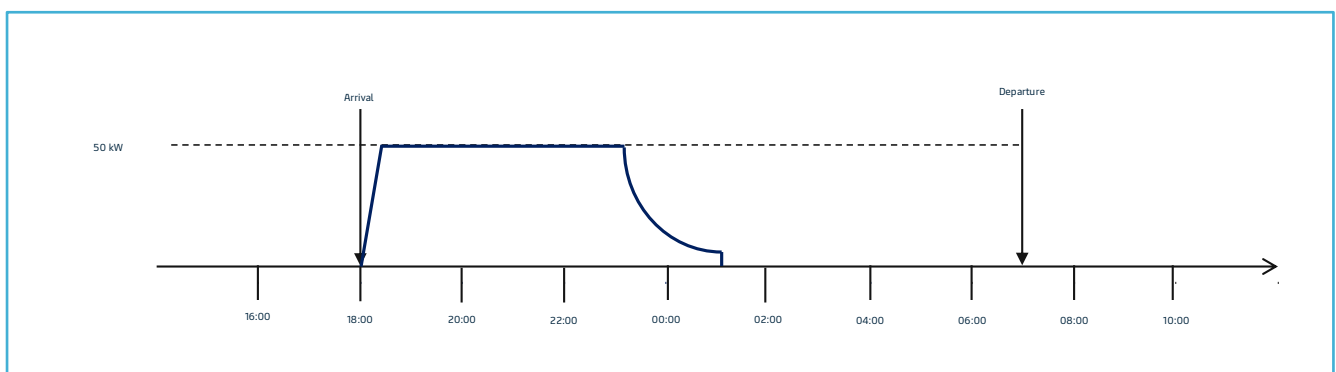


Figure 7: Charging profile of a single truck at a 50 kW DC charge point.

For the fleet of 5 trucks, a total of 5 DC Charge points with a rated power of 50 kW each are needed. This corresponds to a truck/charge point ratio of 1:1. The aggregated consumption of all charging processes is

crucial to assess in relation to the available grid connection capacity, which is addressed in the following section.

5.3 Assess the depot.

To facilitate the successful implementation of charging infrastructure at a facility, both electrical and spatial requirements need to be considered. This step addresses related questions and further provides recommendations for the management and operation of the facility.

A) Is the grid connection sufficient?

When installing charging infrastructure at a facility, it is crucial to assess if the existing grid capacity is sufficient to incorporate the demand added by the chargers, under consideration of the already existing consumption at the facility. Assuming the "worst case" of simultaneous charging at the rated power of all chargers, the maximum total added load is calculated as:

$$P_{\text{Charging}} = \text{number of chargers} \times \text{power per charger}$$

The grid connection capacity must be able to satisfy both the charging needs and the base load consisting of the other appliances of the depot (e.g., lights, air conditioning units etc...), as introduced in Section 2.2. If the additional load imposed by the added charging infrastructure cannot be incorporated in the existing electric installation of the facility, the grid connection needs to be upgraded. It is noteworthy that grid connection upgrades commonly entail significant investment costs for equipment and installation, as well as higher grid connection fees to the distribution grid operator (Section 4). Due to the high costs, it is essential to consider solutions for minimizing grid connection upgrades. This includes load management systems, which ensure that the collective power consumption of all chargers always stays below a certain limit – and that the available power is shared among the trucks.

On-site Battery Energy Storage Systems (BESS) and Photovoltaic systems (PV) can reduce both the grid impact and the operating costs. The BESS can be charged during hours with low electricity prices and with locally produced energy, and later discharged to cover parts of the truck demand.

Example

In the present example we assume a grid capacity of the facility of 43 kW. This corresponds to a standard 3 phase grid connection of 230V and 63A.

The following figure illustrates the base load by other appliances, aggregated with the charging processes of the 5 trucks, assuming immediate charging after arrival at the depot. The trucks add an additional load of $5 \times 50\text{kW} = 250\text{ kW}$ to the base load. As visible in the figure, the existing grid capacity of 43kW is not sufficient to incorporate the additional load imposed by truck charging. Assuming a maximum base load of 15 KW during the time of truck charging, the grid connection must be increased to at least 265 kW, which is approximately six times the current grid connection.

The need for large grid connection upgrades can be reduced by using load management solutions for the charger. This allows to actively control and coordinate the charging processes of all trucks, utilizing the

temporal flexibility of the charging processes. The effect is also demonstrated in the following figure. By shifting the energy consumption of the chargers, the overall power consumption at the facility can be kept below a given threshold, in the given example, below 135kW. Despite the imposed power limit, the charging processes are finished around 2hrs before departure.

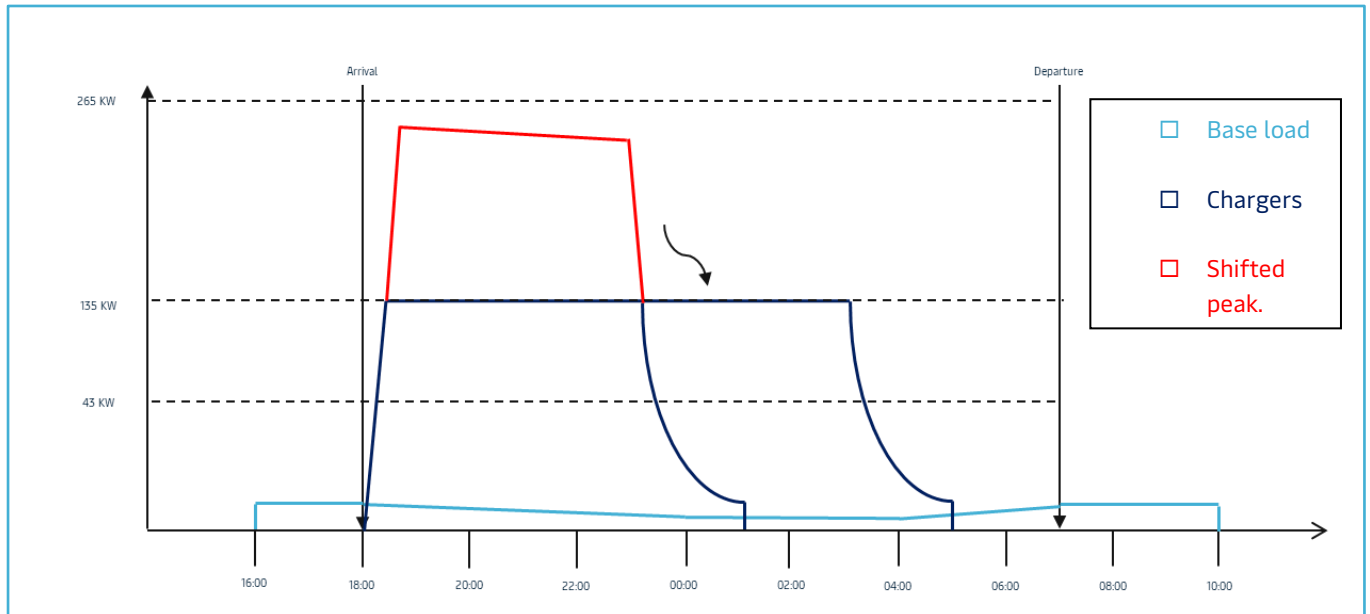


Figure 8: Truck charging with load management. The peak consumption can be effectively mitigated by shifting the load to later times, reducing the need for extensive grid upgrades.

To facilitate load management, it is important to select chargers that comply with application protocols, such as OCPP (Open Charge Point Protocol). The protocol allows chargers and central management systems to communicate with each other. This is particularly important if the chargers are from different manufacturers.

Besides limiting the overall power consumption to a desired threshold, load management solutions offer additional advantages. The controllability of the individual charging processes allows to shift the charging to preferable time windows, for instance to hours with low electricity price, or to hours of own solar production. This can reduce operating costs, especially with fluctuating electricity prices. As previously highlighted in Section 5.2, the temporal flexibility can be increased by selecting chargers with connector power levels above the minimum values for $P_{DC \text{ charger}}$ derived in Step 2. The considerations on the optimal power level for the chargers centre around the following points.

The higher the power level of the chargers, the higher the flexibility to shift the charging processes to low-price time windows, which reduces operating costs. However, the investment costs for the chargers are higher, as illustrated in Section 4. Furthermore, the grid connection capacity must be suitable for utilizing this flexibility. Potential upgrades of the grid connection increase investment costs and may entail a significant implementation period. Moreover, preventing high power consumption at the grid connection point effectively reduces operating costs in case network charges to utilities consider the peak power during a given billing period. All in all, the optimal power rating of the chargers depends on various factors, which are location-specific and might change over time (e.g., electricity prices, tariffs). In this context, the minimum required power rating derived in step 2 (Section 5.2) provides a lower bound to identify technically feasible solutions.

B) What are the space and safety requirements at the facility?

When planning the installation of charging infrastructure at a facility, space and safety requirements must be taken into account. The consideration centre around the following aspects:

The installation of chargers requires sufficient space for both the actual hardware and the accessibility of the trucks to the chargers. Considerations regarding the trucks' manoeuvrability at the facility are imperative, so parking and swing-out collisions are avoided.

The exact charger position next to the truck's parking spot must be chosen carefully. The position of the plug inlet must be considered at the correct side (left/right), and with the correct distance from the front of the truck.

Technical standards regarding the installation of charging infrastructure must be consulted. This concerns aspects such as maximum and minimum distances between technical components, or compliance with EMC (Electro-magnetic compatibility) requirements.

That facility must comply with national, regional, and local regulation related to charging infrastructure and parking of electric vehicles. It is recommended to get in dialogue with local entities such as fire brigades.

Insurance policies should be checked for specific requirements concerning charging infrastructure.

When electrifying only parts of the fleet, it is worth considering to already prepare the underground infrastructure (Cable conduit) for additional chargers.

C) Management and Operation

After assessing the facility with respect to electrical, spatial, and environmental requirements, a decision is to be made whether the installation of charging infrastructure is feasible at the given location. If not, it should be considered to move the fleet to a different facility that can meet the requirements.

To ensure smooth fleet management, information on the charging processes of the individual trucks can be linked to the fleet management software used for planning and monitoring the fleet operation. In this way, the fleet operator receives updated information on the status of each truck, e.g., the connection status (not connected/plugged-in/charging), the charge level, and the estimated time when charging will be completed.

Closely tied to the selection of charging infrastructure and software solution is whether to contract with a Charge Point Operator (CPO). This is mandated in all cases of deploying infrastructure at a Maersk facility. CPOs are companies which are specialised in providing, installing, and operating charging equipment. The equipment can either be owned by the CPO or they can operate the equipment on behalf of a 3rd party (i.e. Maersk). While it is generally recommended that the facility operating the EV fleet owns the equipment, it is likely that the vast majority of facilities will remain asset light with respect to owning infrastructure. In both cases it makes sense to let the technical operation and maintenance to an external partner. A CPO can provide a package which simplifies the infrastructure acquisition and operation – but that adds operational costs long term work factoring into your Investment Proposal (IP).

With the current electricity mix, the LCA emissions of electric trucks are already better than Diesel ICE, in a lot of western countries, and continue to improve with increasing shares of renewables and improved production practices for battery cells. To provide a solution aligned with the requirements of the ECO inland E-Truck product (60% emission reduction), the electricity retailer MUST offer green electricity options and the ability to procure Renewable Electricity Certificates or Guarantees of Origin.

A centrally developed charging infrastructure strategy is looking to explore the feasibility of offering semi-public access to our infrastructure network during times when Maersk's own fleet are on duty. If Maersk's fleet are driving during the day and returning to the depot in the evening, the idle infrastructure could be operated by our trucking vendors or customers as semi-public chargers offering a lever to increase operational efficiency of our 3rd party operated fleet and increased adoption of trucks within our vendor network.

5.4 Selected Cases

The methodology presented in Section 5 was applied to various fleet profiles, shown in table 2. The blue section of the table summarises the inputs and assumptions for each fleet. In addition to the operating schedule, example truck specifications such as battery capacity and maximum charging powers were made. The green section of the table presents the results obtained by applying the three-step methodology from section 5. If the driving demand exceeds the battery capacity of the truck, additional charging along the way is necessary, as previously highlighted in Section 5.1. For the calculation of the results, it was assumed that the fleet has a homogenous schedule, i.e., all trucks have similar arrival and departure times. The selected DC chargers power levels were assumed with incremental steps of 25kW. It is noteworthy that different manufacturers offer different product lines that may provide finer steps for the power rating. For the calculation of the total charging cluster load two values are given. The first ("max") indicates the maximum power consumption of the charging infrastructure assuming all trucks are charging simultaneously. The second value ("min") provides a lower bound of the possible power consumption, under the ideal assumption that a load management system is used to control the charging processes of the different trucks.

Profile no.		1.	2.	3.	4.	5.
Operation	Use Case	Drayage	Drayage	Middle Mile	Middle Mile	Long Haul
	Fleet Size	2	10	25	10	1
	Daily Distance	240km	240km	450km	360km	1000km
	Time at depot	12h	16h	8h	10h	12h
Truck Specification	Consumption	0.95 kWh/km	1.35 kWh/km	1.00 kWh/km	1.35 kWh/km	1.24 kWh/km
	Battery capacity	316 kWh	468 kWh	316 kWh	468 kWh	432 kWh
	Max DC charging power	150 kW	375 kW	150 kW	375 kW	250 kW
1. Charging demand	Truck energy demand	228 kWh	324 kWh	316 kWh	468 kWh	432 kWh
	Min truck charging power	21 kW	23 kW	44 kW	52 kW	40 kW
2. Charging Infrastructure	Charger type	DC 50 kW	DC 50 kW	DC 100 kW	DC 125 kW	DC 100 kW
	Number of charge points	2	10	25	10	1
3. Grid Infrastructure	Max. charging cluster load	100 kW	500 kW	2500 kW	1250 kW	100 kW
	Min. Charging cluster load.	42 kW	230 kW	1100 kW	520 kW	40 kW

Table 2: Overview of charging infrastructure example of 5 different fleet profiles common in Maersk's operations.

6. Summary – Main Recommendations (Linked to the Readiness checklist)

1. Establish your charging needs.

- ✓ Determine how many trucks will use the facility now and in the future. Identify key truck specifications, such as battery capacity and possible charging power levels.
- ✓ Find the energy needed by the trucks at your depot, based on how much they drive and consume during operation.
- ✓ You can calculate the average power needed to meet the energy demand, in order to understand which power levels, the chargers should support.
- ☞ In case the fleet comprises different types of trucks and/or different operating profiles, the trucks might require different chargers to fulfil their individual needs.

2. Identify charging solutions.

- ✓ Choose a charger type with a power rating at least 2 times higher than your average power demand estimated in the previous step.
- ✓ As a simple rule, we recommend one charge point per truck. However, if parts of the fleet have opposing schedules, the number of charge points may be chosen lower than the number of trucks.
- ✓ Select chargers with smart charging capability. This allows to control the charging infrastructure through a load management system.
- ☞ Especially for high power charging it is common that the experienced charging power will be lower than the nominal charging power specified by the charging equipment and truck.
- ☞ For higher charging demand we recommend DC charging due to additional advantages in terms of charging powers and communication capabilities.
- ☞ Heterogeneous fleets with diverse truck types and/or operating profiles might require a mix charger type.

3. Assess the facility.

- ✓ The utility company should be contacted immediately to discuss potential grid connection limitations. Upgrading the grid may take a significant amount of time to complete and has a considerable cost associated with it.
- ✓ Determine if the grid connection capacity is sufficient to support the charging infrastructure.
- ✓ A load management system may reduce the grid capacity costs significantly. On the other hand, underinvesting in grid capacity while relying on load management too heavily might constrain future extensions of the facility, and further reduces the flexibility for smart charging.
- ✓ It is important to identify potential size constraints at the facility which may impact the placement of chargers. Similarly, the access to the charger needs to be assessed, taking into account the manoeuvrability of the trucks.
- ✓ Consult technical and safety regulations regarding the installation of charging infrastructure, as well as implications on insurance policies.
- ✓ Engage with approved CPOs to delegate the operation and maintenance of the equipment.
- ☞ On-site BESS and RES are highly complementary. Investigate potential of adding these to the facility.
- ☞ Be aware of national requirements regarding the installation of chargers and make a proactive plan for having enough to fulfil both legislation and your own fleets needs.
- ☞ When installing the first chargers, prepare underground channels, conduits, and cables so that you may continuously add chargers over time.

7. FAQs

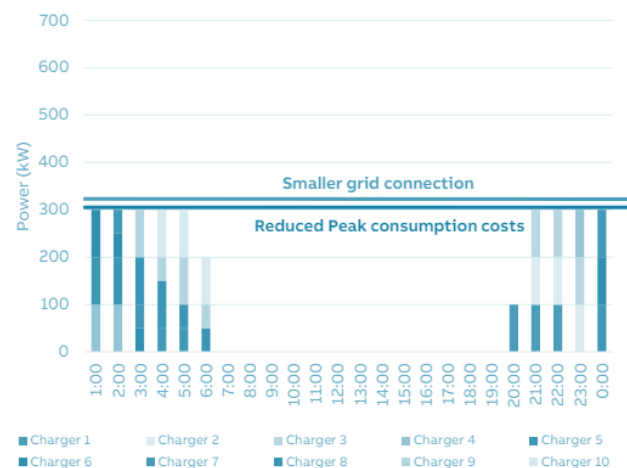
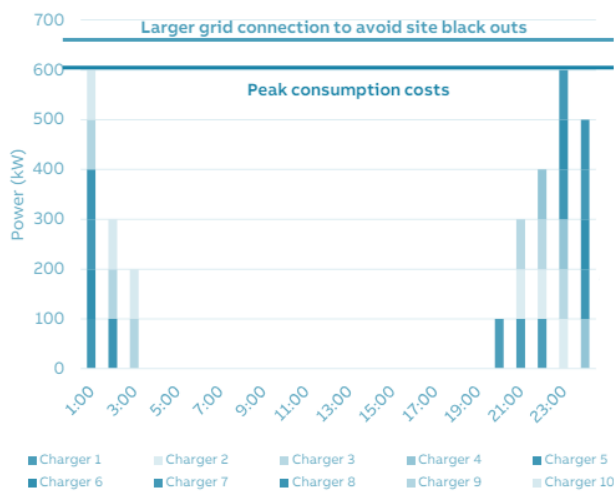
Why is Energy Management important?

Whilst this is explained in detail in section 5.3-A another real-world example can be provided to illustrate the value of having an energy management system in place to reduce both CapEX and OpEX costs:

Fleet profile: 10 Trucks, 300 kWh battery capacity, P DC Charger 100kW, 10 Chargers.

Without Load Management:
€30k Annual energy costs.

With Load Management:
€10-120k savings in avoided grid connection costs.
€19k Annual energy costs. (44% OpEX saving)



How do I find out what kind of grid connection I have?

Finding out contracted capacity, i.e., the maximum power currently supplied to the facility, can often be found on the invoice of either your energy supplier or DNO.

Determining current power consumption can often be examined by a technical service provider.

If you do not have sufficient power remaining to support charging, the next step is to find out what the maximum connection capacity is without upgrading the physical grid connection. Consumption under your current contract may have not yet reached this maximum connection capacity. Information regarding this capacity can be requested from the DNO.

How do I upgrade my grid connection?

If the maximum connection capacity is not sufficient for the expected electricity consumption, the next step is to explore the options for upgrading the electricity grid connection. If you wish to increase the maximum connection capacity, the DNO 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 infrastructure changes.

To upgrade the grid connection, undertake the following steps with a CPO:

1. Submit a request for an upgrade of the grid connection to the DNO. If you already have an account manager with the DNO, you can contact this person. Otherwise, there are often online request forms on the website of your DNO.
2. The DNO 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 costs, the DNO will likely ask about the location where you wish the grid connection to be installed. Usually, a site map is requested. In addition, the DNO will inquire about your expected energy consumption.
3. The DNO will assess whether the grid connection can be upgraded, estimate the cost and lead time of this upgrade and prepare a quotation.

What are the associated Costs with the grid connection?

One-time costs:

- ✓ Grid connection costs: Comprising one-time costs for the construction and installation of the grid connection (work that the DNO must perform), these amounts depend on the size and location of this connection. The DNO will provide a quotation for the required work.
- ✓ Energy Systems (hardware): These costs are associated with 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 RES.
- ✓ Electricity grid management costs: The recurring costs for the grid connection can consist of fixed and/or variable costs. Both 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 provided by a CPO.
- ✓ Additional cost considerations: It is possible that other costs may exist in your region in addition to the ones indicated above. An electrical grid connection can require that you have metering equipment installed, 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 DNO may impose a higher fee. Since this differs between countries and DNO's, please make sure your DNO and energy supplier inform you about all relevant and potentially relevant costs.

What do I need to consider if the facility is leased?

If the Maersk facility is leased, you need to develop your plans jointly with the landlord. You must, of course, consult with an obtain permission for any charging infrastructure that you wish to construct. It is furthermore very important that you take a long-term view of any such investment.

Engaging with the Landlord: The landlord will primarily be interested in the safety of the technical installations. Many landlords have a contracted technical service provider responsible for all technical systems. Since the installation of charging stations is something that 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 be prudent to coordinate with the contracted technical service provider.

Charging equipment is normally constructed for a longer period use (5 to 10 years). You should discuss options with the landlord and draw up an agreement (usually with the CPO) 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 agreement.

How should I prepare or plan for the civil 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. It is also envisaged that Maersk will only play a facilitating role when it comes to the implementation phases of the project, and much of the Civils and Construction work will be coordinated and planned through a CPO. Nevertheless, the most important planning steps are indicated below:

- ✓ **Request an upgraded grid connection (optional).** You request this from the DNO. It is important to start early because lead times to implementation can run into months. Consult with the DNO and then complete the application.
- ✓ **Instruct a 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 that is often forgotten.
- ✓ **Order a transformer substation (optional).** This order placement can be done directly or (in most cases) through a third party (often the CPO or technical service provider).
- ✓ **Order the charging stations.** This can also be done directly or through a third party (such as the truck OEM or CPO). Make clear agreements about delivery times and terms of delivery.
- ✓ **Place the order for installation work.** The site can be prepared prior to delivery of the charging infrastructure and grid connection upgrade. Such pre-delivery installation work will shorten the lead time.
- ✓ **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 physical charging bays. Preparatory work can also be carried out in this regard in order to shorten the lead time.
- ✓ **Commission the grid connection.** Once the grid connection has been upgraded it must be commissioned by the energy supplier in collaboration with the DNO. During commissioning, final tests are carried out in the presence of the CPO.
- ✓ **Commission the charging stations.** This activity includes delivery, installation, 'commissioning' and explanation of the charging stations. After installing a charge station, the technical service provider/CPO will commission it. The charge station supplier will also have someone present for the final checks. You should be provided with a clear explanation during this step, making it possible to test if the charging station works properly and if any unclarity exists.
- ✓ **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. This is the responsibility of the CPO you appoint and should be considered in the framework agreement you have with them. It should concern all electrical hardware, not only the charging stations but also the transformer.

What are the risks involved in the civils/construction phase, and how could I mitigate them?

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

Risk	Severity	Mitigation
Contaminated Soil	Low	It may be important to have a clean soil certificate, as work in contaminated soil may require a different approach at a different cost. If in doubt, 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	High	Another risk is subsidence of installations and charging stations. A cone penetration test (CPT) should be carried out as a preventative measure. On the basis of this test, the CPO and/or civil contractor can implement other measures to prevent subsidence.
Cables and pipes	Medium	There is a risk of damage to existing cables and pipes during civil work. For this reason, it is necessary to contact the technical services provider appointed to the site. They will be able to give you information about where there are cables and pipelines. If in doubt test trenches are required.
Dimensions that are too small or inefficient design.	High	Such constraints may disrupt logistics flows at the facility and possibly result in damage. If a great deal of movement occurs at the facility or if space is very tight, it is always prudent to have the plan checked by a transport/dispatch expert.
Transport Hinderance	Medium	Of course, the transport operation often continues while the charging infrastructure is being installed, the installation and construction work potentially causing disruption at the facility. Ensure therefore that site managers are involved in the planning so that any operational hindrance is minimised.
Future Developments	Medium	To avoid duplication of work during future expansion, possible future developments should be taken into account at the time of initial installation. How is your EV fleet going to develop? What other facilities will you possibly add to the location in the future? The costs of an extra casing are relatively low and can save you greater costs in the future.
Malfunctions	High	It is important that you have a well-functioning system, in which trucks can be charged without any problems. It is advisable to place the responsibility of the entire system (or parts of it) with one organisation (CPO). Such delegation of responsibility will enable you to avoid finger-pointing in the event of failures. It is important to take into account any such allocation of responsibility during the procurement phase.