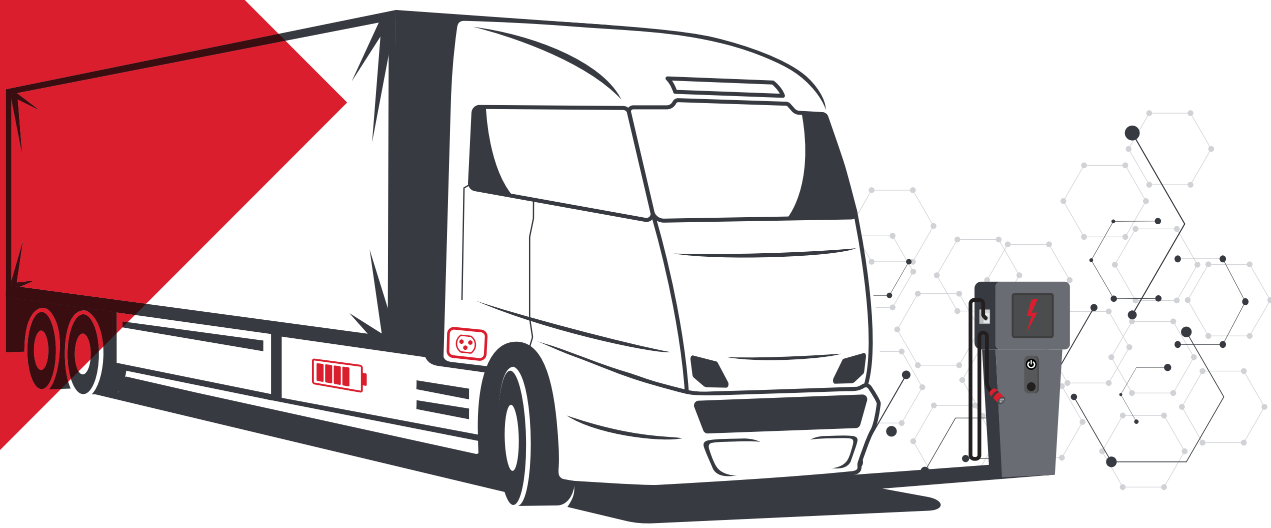
New Mobility



Electric Trucks Recharged

Understanding commercial vehicle charging requirements

Porsche Consulting

Strategic Vision. Smart Implementation.

Introduction

Commercial vehicle manufacturers are facing a shift from fossil energy toward alternative technologies. Restrictive regulations on CO_2 emissions, technology maturity, and a strong demand from customers for green supply chains will boost the electrification of a broad range of commercial applications in the upcoming years. The charging of battery powered commercial vehicles must therefore be seamlessly integrated into the operation cycles to ensure a profitable logistics business. Manufacturers must understand the charging requirements to adapt product specifications to customer needs.

01 Electrification of commercial vehicles

The commercial vehicle industry faces new challenges, such as CO_2 targets in Europe and a tightened regulatory program in the U.S. and China to reduce greenhouse gas emissions. Europe requires current CO_2 emissions from newly licensed commercial vehicles above 3.5 tons to be reduced by an average of 15 percent by 2025 and by 30 percent by 2030.[1] In the U.S., commercial vehicles above 15 tons (class 8 trucks) must reduce emissions by 15 percent between midyear 2017 and 2027.[2] To achieve these reduction targets, Battery Electric Vehicles (BEV) will play a leading role in the transportation sector, as significant reduction of CO_2 emissions are not expected for purely diesel-powered vehicles.

However, the switch from diesel vehicles to BEV poses new challenges. In comparison to the energy density of diesel, the lower energy density of Lithium-Ion Batteries (LIB) results in range limitations for BEVs if equal payloads are assumed for electric and diesel trucks. The battery capacity not only determines the vehicle range but also significantly affects the vehicle acquisition costs. Since the profitability of vehicle operators is greatly influenced by payload and vehicle operating time, the trade-off between battery capacity and payload needs to be resolved to maintain profits.

Commercial vehicle manufacturers are investing heavily in navigating the challenges and opportunities posed by commercial vehicle electrification. Daimler Trucks & Buses, for example, has established the E-Mobility Group.[4] Navistar's NEXT team has presented the pure-electric eMV concept vehicle,[5] which is slated to go into production in 2021. TRATON (Volkswagen Group Truck & Bus stock corporation) is developing a new modular electric powertrain that can be used by all brands (Scania, MAN, and VW Carminho Omnibus).[6] Additionally, Volvo is pushing their project Volvo LIGHTS (Low Impact Green Heavy Transport Solutions) to establish electrified commercial vehicles,[7] while Tesla announced the market launch of its semitruck in 2020.[8]

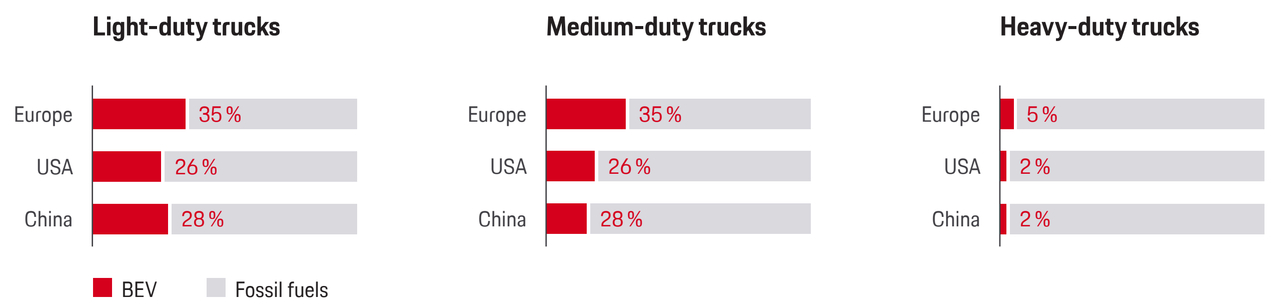


Figure 1. Battery electrification rate of commercial vehicles by 2030 in the segments light duty, medium duty, and heavy-duty. [3]

[1] Regulation 2019/1242 of the European parliament and the council-setting CO_2 emission performance standards for new heavy-duty vehicles.
[2] EPA Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2.
[3] EV Outlook 2019, International Energy Agency.
[4] https://www.daimler.com/produkte/lkw/freightliner/e-mobility-group.html.
[5] https://news.navistar.com/2019-10-28-Navistar-Launches-New-Business-Unit-NEXT-eMobility-Solutions.
[6] https://www.volkswagen-newsroom.com/en/press-releases/traton-ceo-renschler-in-the-next-ten-to-15-years-every-third-of-our-trucks-and-buses-can-have-an-alternative-drivetrain-most-of-them-fully-electric-5407
[7] https://www.volvotrucks.us/news-and-stories/press-releases/2018/september/volvo-trucks-to-introduce-all-electric-trucks-in-north-america/
[8] https://www.tesla.com/semi

02 Charging as a crucial challenge

Narrowing down the complexity of charging commercial vehicles the focus and scope of this paper is on charging trucks for goods transportation, in particular from the perspective of the logistics provider. Neither the charging of buses nor the construction and municipal application of trucks are considered in this paper.

A key factor for logistics providers of trucks is the seamless integration of charging events into the operation cycles of commercial vehicles. The identification of charging use cases along the operation cycles is the starting point to overcome the two main challenges in the commercial vehicle industry with regard to charging:

A.

At the moment, there is no specific charging infrastructure for commercial vehicles. An evaluation of logistics concepts is necessary to define suitable charging use cases and dedicated charging solutions for commercial vehicles.

B.

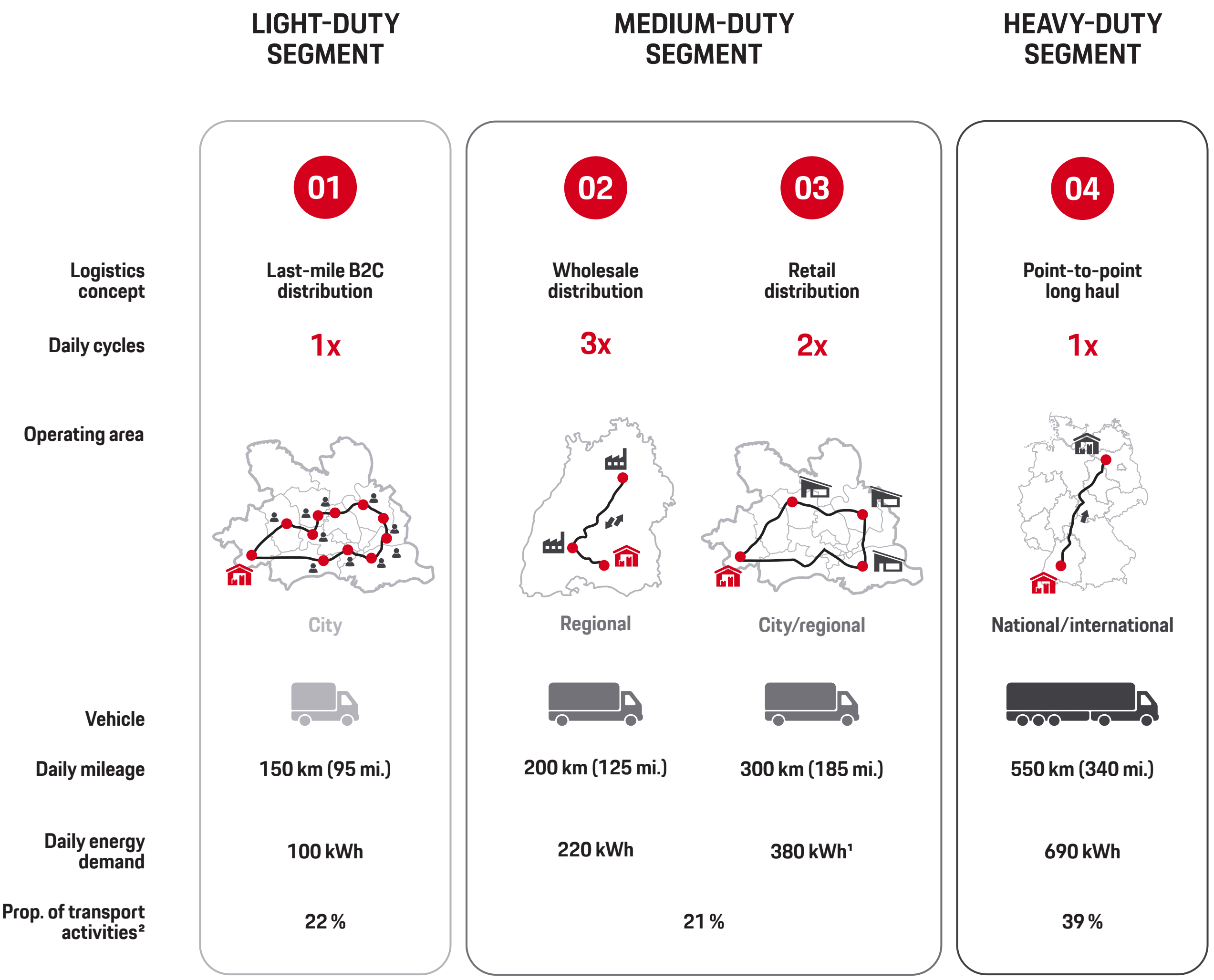
Electrification strategies must be highly customized to the diverse logistics concepts. The daily operation of BEVs and respective charging strategies can be assessed and optimized for each logistics concept based on charging use cases.

Charging is therefore the crucial issue in the electrification strategy of commercial vehicles. Optimized charging processes enable lower battery capacities but still allow the vehicles to meet the high operational requirements in terms of mileage, road time, and optimized timetables. Efficient deployment of vehicles is essential for a profitable business as fleet operator. Technical charging solutions to adequately service vehicle technology must be installed in wayside infrastructure at suitable locations.

The classification of charging use cases is the basis for deriving vehicle requirements and thus the starting point of electrification roadmaps. Use cases also give rise to new business strategies along the entire transportation value chain. The most relevant charging use cases for electric commercial vehicles are defined based on the analysis of market-dominant logistics concepts. The main characteristics of a logistics concept help determine the specifications of a charging use case, including the charging location, charging power, and required charging duration. The evaluation of potentially rechargeable energy with the actual demand for energy in the daily operation of each logistics concept reveals the most critical charging use cases and highlights the challenges for commercial vehicle electrification.

03 The analysis of logistics concepts indicates the charging requirements

The operational environment of commercial vehicles comprises a wide range of different operational profiles, which are classified according to logistics concepts (see figure 2). These concepts are analyzed and charging opportunities identified with consideration for daily operational requirements. The main differentiating factors among such concepts are the vehicle tonnage, operation cycles, operating area, and daily mileage. The relevant concepts for truck logistics providers considered in this paper represent approximately 80 percent of the overall goods transportation in terms of transport performance (tonnage x distance).[9,10]



1 Including 40 kWh for refrigerator usage. | 2 Proportion of total transport activities in terms of ton-kilometers. The remaining percentage represents niche segments such as special-purpose transports or two-shift operations (based on EU transportation statistics).

Figure 2. Overview of identified logistics concepts.

[9] Truck2030 Status Report, Technische Universität München.
[10] Verkehrsverflechtungsprognose 2030, BMVI.

Commercial vehicles only generate revenue when transporting goods. Keeping the utilization high is therefore critical to business operation. In order to keep vehicles on the road, electrified vehicles must integrate robust charging processes into the dwell times. An analysis of logistics concepts has identified four main dwell times in daily operations:

A. depot holding time during reloading or overnight stays,
B. time spent during overnight stays on the road,
C. time spent during mandated driving breaks, and
D. time spent at the loading ramp.

Assuming that dwell times while loading or unloading can be used for charging, figure 3 indicates potential charging durations during daily operations for the logistics concepts. As shown in figure 3, various logistics concepts are characterized by different dwell times. With the proper investments in infrastructure, these dwell times can be leveraged as charging opportunities.

Logistics concept	01 Last-mile B2C distribution	02 Wholesale distribution	03 Retail distribution	04 Point-to-point long haul
DWELL TIMES[1]				
A. Depot	13 h	13 h	13 h	30 min.
B. Highway overnight	0 h	0 h	0 h	13 h overnight stay
C. Highway opportunity	0 h	0 h	0 h	45 min. break
D. Loading ramp	0 h	2.5 h	3.5 h	0 h[2]

○ 24 h

1 The dwell time of 0 h indicates that the charging use case is not applicable for the logistics concept. | 2 No potential charging duration at loading ramps is assumed due to decoupling the tractor unit from the semitrailer.

Figure 3. Overview of potential charging durations for each logistics concepts (varies by region, example represents EU).

04 Identification of charging use cases

The evaluation of dwell times is the basis for the identification of charging use cases. Because logistical supply chains are expected to be highly efficient, the charging infrastructure's technical characteristics must reflect operational efficiency. Hence, the charging process should be optimally integrated into vehicle dwell times.

The charging use cases are classified according to the location at which the charging process takes place; for example, the charging location at the depot is indicated by "at depot."

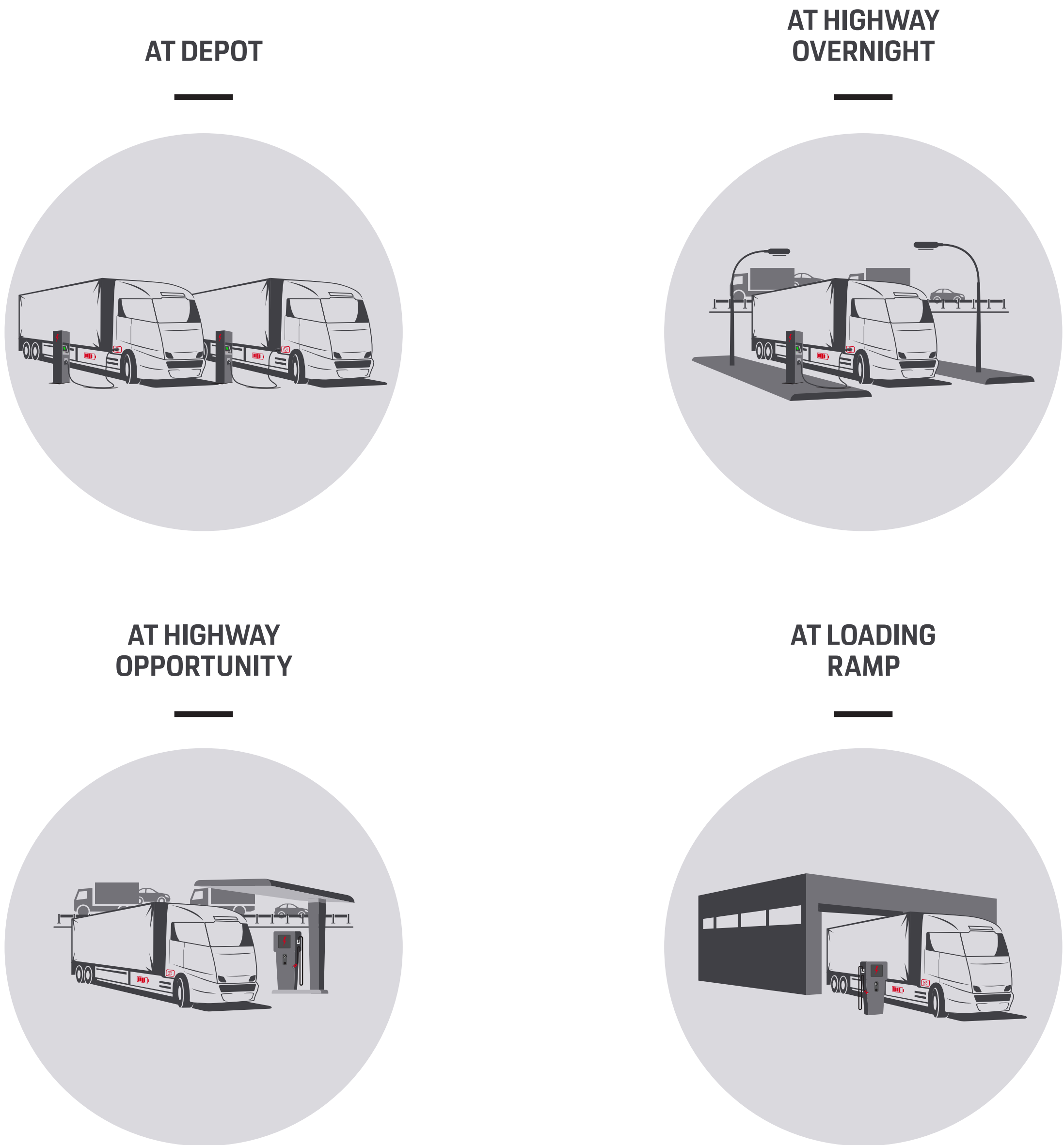


Figure 4. Charging use case for electric commercial vehicles.

The technical parameters of the charging hardware, or charging power, are then determined by taking into account the available time for charging in each use case. The number of charging events varies according to the logistics concept.

Furthermore, the total rechargeable energy per use case is estimated based on the energy demand and the potential charging duration per logistics concept.

AT DEPOT CHARGING

Charging takes place during the vehicle's dwell time between two shifts. The vehicle is located in a dedicated parking area on the fleet operator's property.

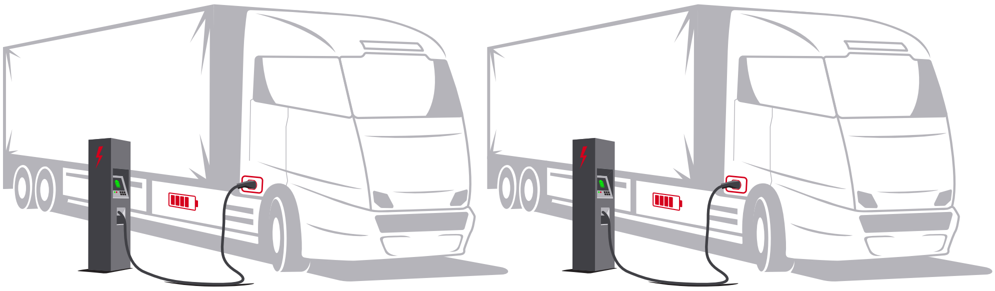
Challenges: several vehicles are likely to charge at the same time. In order to limit the peak demand on the grid, an intelligent charging management system is required to facilitate robust charging functionality. Furthermore, charging plugs for each vehicle would be preferable so that no vehicle rotation is necessary.

Charging duration: very long (more than 10 hours, mainly during overnight stay)

Frequency of charging event per shift: very few (one or two events)

Charging power: slow (less than 50 kW sufficient—AC/DC)

Potential energy to fulfill daily operations in EU: 50 percent



AT HIGHWAY OVERNIGHT CHARGING

A significant amount of commercial vehicle charging will take place during overnight stops at highway service areas. These longer rest periods are dictated by region-specific regulations requiring drivers to take breaks (for example, at least 11 hours in the EU and 10 hours in the U.S.).

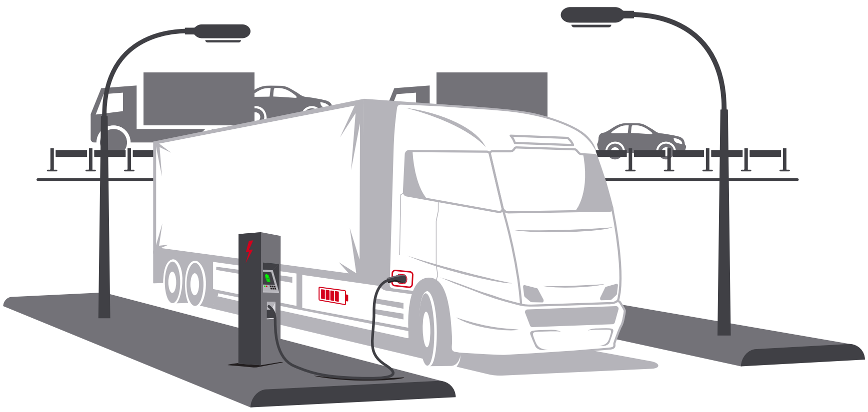
Challenges: several vehicles are parked and must charge at the same time. This necessitates a charging management system enabling intelligent charging functions to limit the electrical grid's peak demand (peak shaving) and load shifting. Furthermore, several charging plugs for each single charging station are preferred so that multiple commercial vehicles can be charged simultaneously without any rotation among the charging stations.

Charging duration: very long (more than 10 hours, during overnight stay)

Frequency of charging event per shift: very few (one event)

Charging power: slow (less than 50 kW sufficient—AC/DC)

Potential energy to fulfill daily operations in EU: 40 percent



AT HIGHWAY OPPORTUNITY CHARGING

This category encompasses charging that takes place during short breaks at highway service areas. These breaks are dictated by region-specific regulations requiring frequent driver pauses during daily vehicle operation (for example, 45 minutes in Europa and 30 minutes in the U.S.).[11]

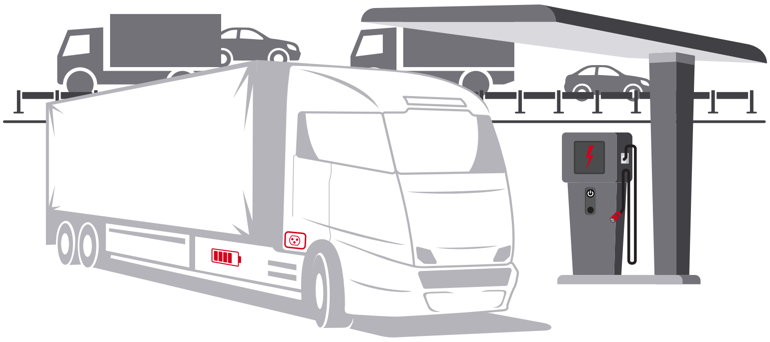
Challenges: simultaneous, ultrafast charging of up to 10 commercial vehicles will require a power grid capable of handling peak power demand spikes in the magnitude of several megawatts. Technological challenges are placed not only on the the charging hardware but also to the vehicle itself and the power supplies.

Charging duration: short (less than 45 minutes, during the driver's break)

Frequency of charging event per shift: few (one or two events)

Charging power: ultrafast (up to 500 kW required—DC)

Potential energy to fulfill daily operations in EU: 5 percent



AT LOADING RAMP CHARGING

The loading ramp at the customer or fleet operator facilities will be used to charge the vehicle during the loading and unloading process.

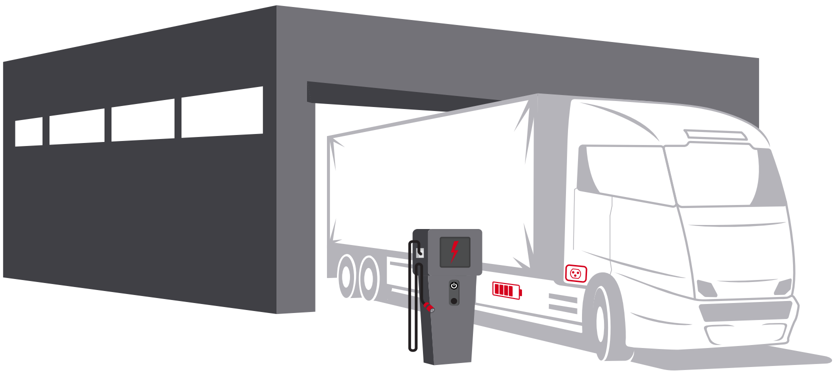
Challenges: complex installation due to limited space in loading zones. Furthermore, the investment in charging hardware greatly depends on the facility's ownership structure; the fleet operator is seldom the facility owner.

Charging duration: short (less than 45 minutes while un-/loading)

Frequency of charging event per shift: various times (two to eight events)

Charging power: fast (more than 100 kW required—DC)

Potential energy to fulfill daily operations in EU: 5 percent



[11] Assuming a single vehicle driver.

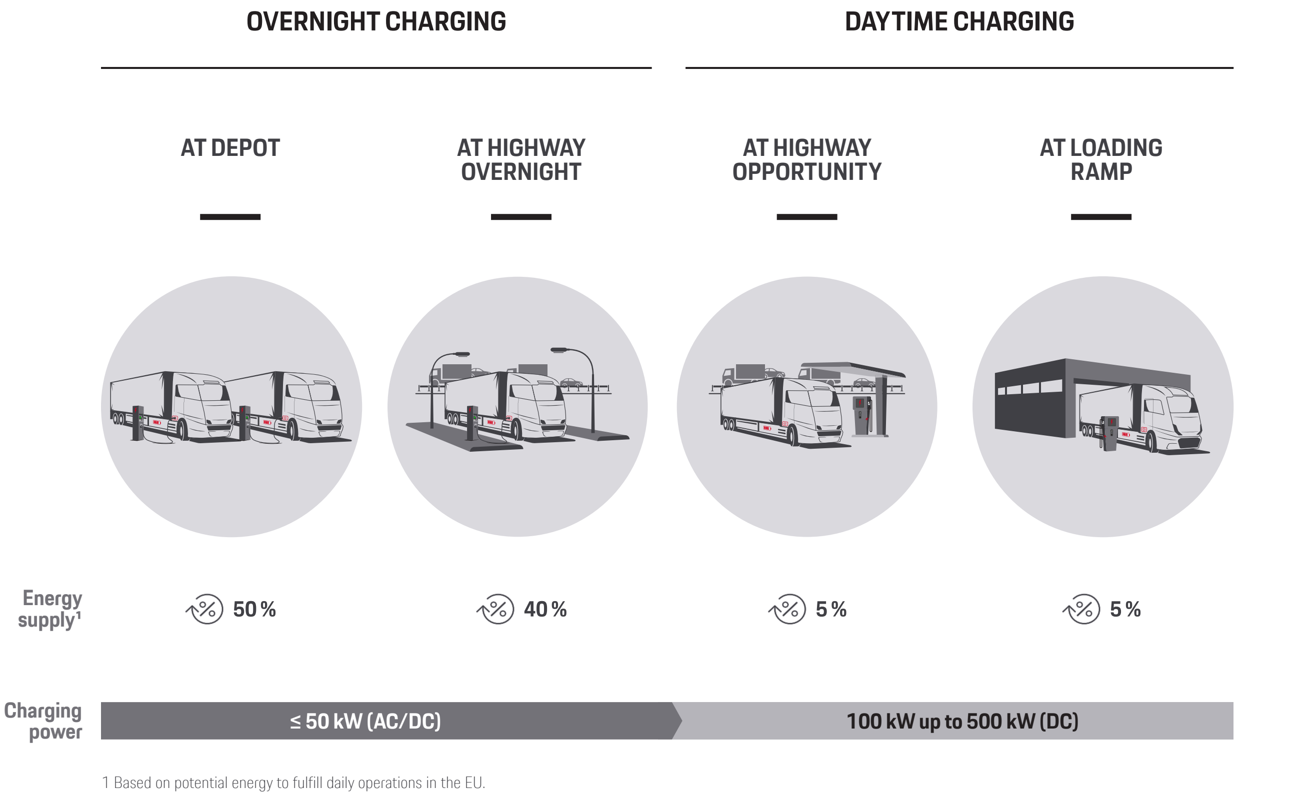


Figure 5. Energy distribution along the identified charging use case for electric commercial vehicles, with proportion based on energy consumption.

05 Conclusion and outlook

Stringent CO_2 targets for commercial vehicles in regions such as Europe and the U.S. will lead to a fundamental change in power train technology as manufacturers seek to avoid regulatory penalties. The importance of in power train electrification and battery systems will massively increase in the coming years, broadening the portfolio of electric commercial vehicles available to fulfill a wide range of applications. The electrification strategies of manufactures need to take into account the ways charging processes are integrated into the existing supply chain and its impact on daily operation.

The logistics concepts considered are based on todays supply chain requirements and demonstrate four charging use cases for commercial vehicle electrification. The charging use cases can be subdivided into overnight and daytime charging. While 90 percent of the energy will be charged overnight, the remaining 10 percent of the daily energy demand is fulfilled during the day. Overnight charging use cases such as at depot and at highway overnight are typically longer in duration and require lower charging power. By contrast, the charging use cases at loading ramp and at highway opportunity are short in duration and require much higher charging power.

Regarding the impact of Original Equipment Manufacturers (OEM) electrification strategies for trucks, several implications become apparent: B2C, wholesale, and retail distribution are the most suitable and realizable logistics concepts for electrification in terms of daily mileage and their charging use case (charging location and dwell time). Either a high battery capacity (more than 500 kWh) or high charging power for daily operations (up to 500 kW) is required to fulfill the daily energy demand for long-haul logistics concepts. High battery capacity and charging power are challenging due to their cost, reduction of payload, and demand on grid power. Battery powered commercial vehicles in the long-haul segment will be suitable for a few logistics concepts with fixed routes, restricted daily mileage (up to 400 kilometers), and limited payload. Alternative technologies, such as fuel cell, are likely to be more advantageous in the long-haul segment, with technology maturity and competitive cost attained within the next decade.

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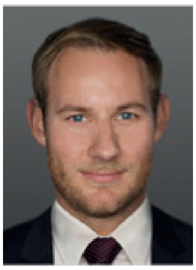

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