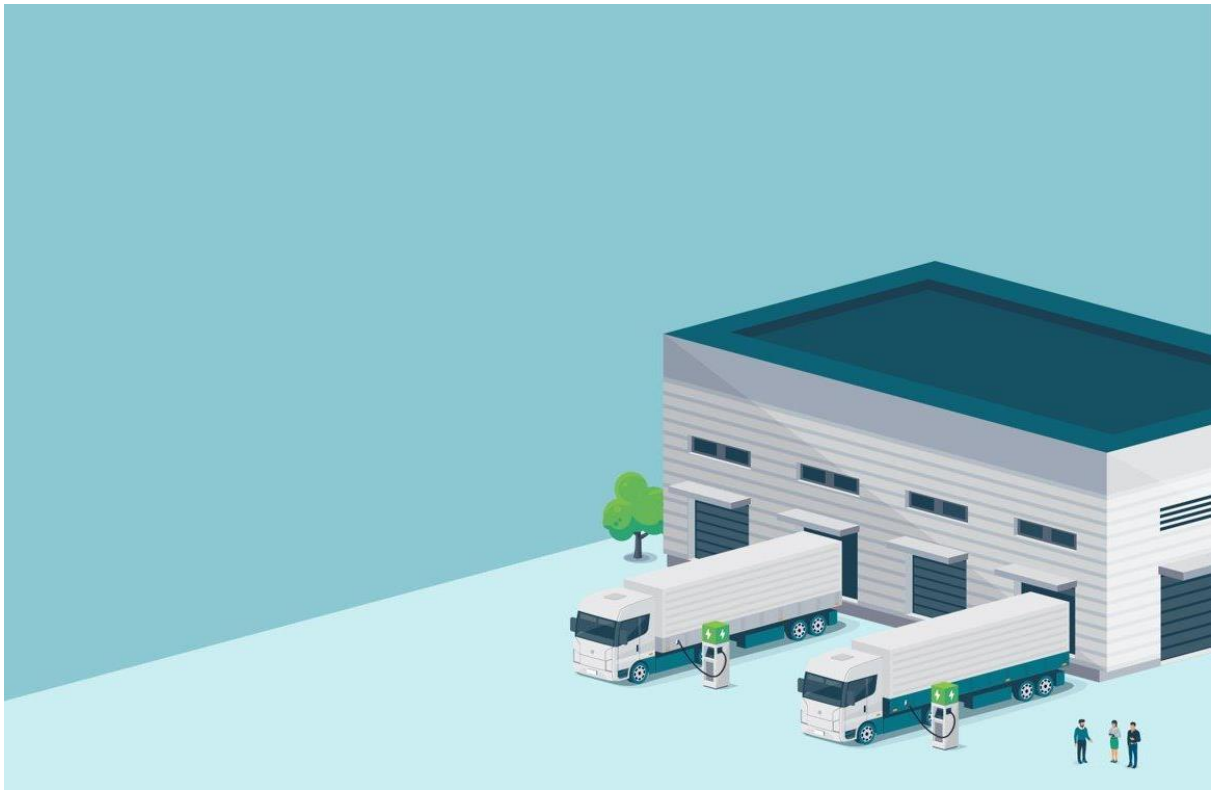

Truck depot charging

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Fraunhofer Institute for Systems and Innovation Research ISI

Breslauer Strasse 48, 76139 Karlsruhe, Germany
Dr. Till Gnann, till.gnann@isi.fraunhofer.de

Responsible for content

Florian Hacker, f.hacker@oeko.de; Dr. Till Gnann, till.gnann@isi.fraunhofer.de; Juliette Le Corguillé, j.lecorguille@oeko.de; Dr. Annegret Stephan, annegret.stephan@isi.fraunhofer.de; Lena Kappler, lena.kappler@isi.fraunhofer.de; Moritz Mottschall, m.mottschall@oeko.de; Prof. Dr. Patrick Plötz, patrick.ploetz@isi.fraunhofer.de

Contributing institutes

Oeko Institute e.V.

Borkumstr. 2, 13189 Berlin
Florian Hacker, f.hacker@oeko.de

Compiled on behalf of

Transport & Environment

Square de Meeûs 18, B-1050 Brussels, Belgium
Stresemannstr. 72, D-10963 Berlin, Germany

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[1] We clarified the taxation of energy stored across the document.

Key findings and recommendations

This report analyses truck depot charging from a logistics company's and energy perspective in four countries: Germany, France, Spain and the United Kingdom (UK). In this study, we focus on heavy-duty vehicles (HDVs) with a gross vehicle weight of 12 tons and above. In addition to an extensive literature research, four country workshops with different stakeholders related to depot charging with more than 80 participants in total, and five follow-up interviews were carried out. The following key findings are obtained.

Key findings

1 Depot charging is sufficient for most of the truck fleet.

Regarding the driving distances, France, Germany and the UK report a large share (40-50%) of trucks that drive less than 200-300 km/day with indication of somewhat higher average daily and annual driving distances for trucks in Spain. No public infrastructure would be required for these daily driving distances if infrastructure can be built at truck depots. This mostly regional traffic can easily be conducted by battery electric trucks with overnight charging at depots. Long-haul trips require additional on-route public charging.

2 There is still no clear picture of the optimal layout and role of shared charging infrastructure.

Three cases of depot charging can be differentiated: private depot charging is only accessible for the companies' own vehicles, semi-private depot charging is also made available for partners or customers but located on a companies' own premises, whereas semi-public depot charging means that the location is publicly accessible, but the infrastructure is only available to a distinct user group. For Spain, the workshop participants preferred semi-public depot charging, whereas stakeholders from Germany and the United Kingdom favoured the semi-private charging solution. In France, workshop participants were undecided between the three. The preference from Spanish experts could originate from the large industrial and logistics centres, in which semi-public charging might be easier to implement than in smaller depots.

3 Larger logistics companies play a major role in the initial phase of depot electrification.

Larger companies own a considerable share of registered trucks and provide a major part of transport performance - despite their comparatively small share of the total number of transport companies. These companies mostly own or rent their depots and often act as a freight forwarder, which means that they subcontract parts of the transport service. The subcontractors are usually smaller transport companies. Due to the larger fleets in large companies, the procurement of the first battery electric trucks only marginally restricts the flexibility of the truck fleet caused by range limitations. According to experts, larger companies have a higher proportion of direct customer contracts and longer contract terms, which reduces investment risks when procuring battery electric trucks. They can set up charging infrastructure at their depots more easily, which then can also be made available to contracted companies that do not have own depots. Although, in some cases, the installation of infrastructure is restricted by the property owner's specifications and consent or space limitations, larger companies will likely play a major role in the electrification of truck fleets

in the early market phase. Additionally, they also play an important role for the electrification of small company fleets, particularly through the provision of semi-private or semi-public charging infrastructure.

4 The transport market is characterized by a high proportion of small companies that need support in setting up infrastructure and purchasing battery electric trucks.

70-80% of logistics companies in the analysed countries are small or medium enterprises (SMEs) with five or less trucks. Their business is characterised by short-term contracts or participation in the freight spot market. This limits their planning certainty, and their risk aversion is correspondingly high. As their profit margins are also very low at 1-2% on average, they can hardly afford capital-intensive new vehicles and often already use leasing for trucks. It will be challenging for them to purchase battery trucks and the necessary charging infrastructure for their depots, as most of them do not own depots where they can park their vehicles and install charging infrastructure, they would frequently have to rely on third parties to provide the required infrastructure. In addition, their personnel capacities for developing knowledge are limited and they are therefore particularly dependent on the provision of practical information and advisory services. Against this background, experts share the expectation that small companies can electrify their fleets at an early stage only in cooperation with their clients and with targeted governmental support.

5 Grid availability varies locally, but some countries provide capacity data publicly.

The availability of medium voltage grid capacity required for depot charging strongly depends on local conditions in all four countries. The French medium voltage grid seems to be best prepared for a roll-out of depot charging, especially in industrial areas. In all countries, however, the current grid expansion plans seem to underestimate the future demand for battery truck depot charging. The authorities or grid operators in the United Kingdom, France and Spain provide public data on locally available grid capacities (typically stemming from grid extension plans for renewable energy sources). An EU obligation under the revised electricity market legislation to publish maps and capacities starting mid of 2025 will provide more planning security for France, Spain and Germany.

6 The grid connection for depot charging can take several years and coordination is needed.

Grid connection has long lead times in all four countries. While grid connection usually takes a few years in Germany, Spain and France, a duration of up to a decade was mentioned by one expert for the UK if the current substations cannot provide the power needed. The cost for grid connection also strongly depends on local conditions. As the first one to connect to the grid must usually bear the highest cost for a new grid connection, a coordinated approach for "burden sharing" would be favourable in all countries considered. Closer cooperation between logistics providers, grid operators, and public authorities is needed in all countries.

7 The preparations for smart charging have started in all four countries, but suitable vehicles are still missing.

Smart charging and vehicle-to-grid (V2G) are considered important by stakeholders in all countries. Both options would allow logistics companies to easier integrate vehicle charging in their businesses more easily in case of low grid availability. In addition, providing flexibility to energy markets, e.g., by delaying charging processes or even providing energy to the grid, could result in additional revenues and become a business model for some depot owners. One of the preconditions for rolling out smart and bidirectional charging is the presence of smart meters. In

this context, the technical conditions are most favourable in Spain and France with a smart meter rollout of 100% and 92%, respectively, as well as the UK with 60-70% - all far ahead of Germany with below 10% (mandatory rollout for specific customers and suppliers starts in 2025 in Germany). In many countries, taxation and levies still negatively affect the economic attractiveness of V2G — Spain being an exception here — but regulations are currently being adapted. France, Spain, and the UK also clarified large parts of the regulatory framework relevant for bidirectional charging regarding the participation in wholesale and/or ancillary markets, where Germany still lags behind. Local flexibility markets exist in the UK and France and the limited V2G participation is expected to increase in the future. Yet V2G capable vehicles are still scarce in Europe. Relevant standards still need common interpretations to ensure the interoperability between different vehicles, charging stations, and distribution grids.

8 France offers the most comprehensive funding programmes to logistics companies.

France and the UK offer funding programmes for the purchase of electric trucks. Germany has phased out a comprehensive vehicle subsidy program in January 2024. The Spanish program ended in April 2024. In France and Spain, funding rates and schemes are differentiated according to the size of the company, which is or was not the case in the UK and Germany. Spain, Germany and France also offer financial support for grid connection.

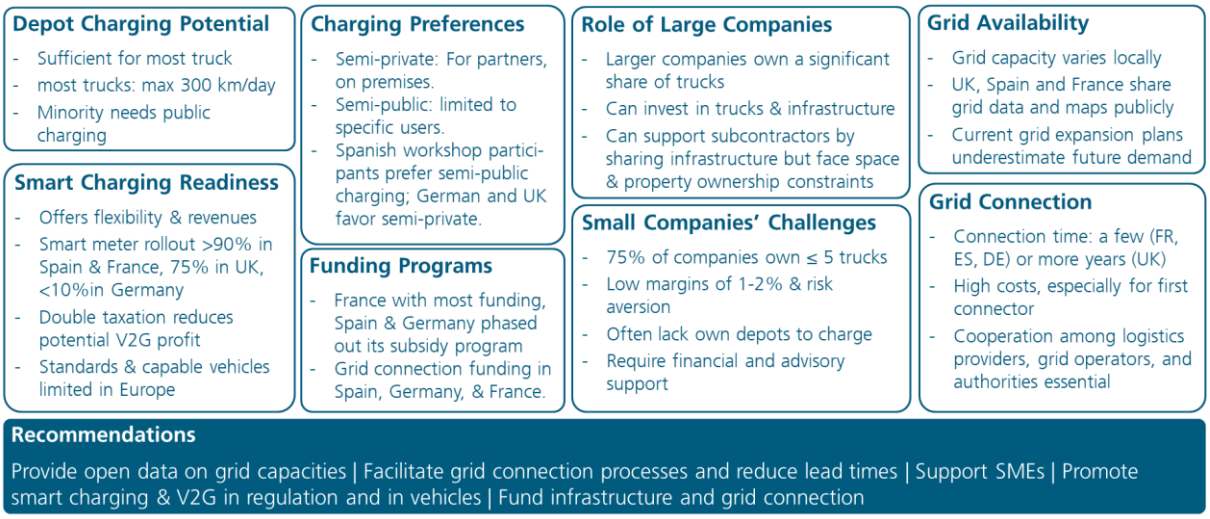


Figure 1: Executive Summary of key findings and recommendations.

Recommendations

Based on these key findings, we derive the following recommendations and measures for the development of depot charging infrastructure:

1. It is confirmed that a relevant proportion of the truck fleet can be electrified through depot charging in all countries considered. However, the data on availability of depots and preconditions at depot locations, such as grid connection, space restrictions etc. is very limited. **Systematic data collection on the practical conditions on site** should therefore be a high priority for the countries under consideration.

Proposed measure:

- Studies are needed to shed light on the distribution of depot ownership among logistics companies and the proportion of companies that have their own depot.

2. Depending on the framework conditions, different depot charging options are best-suited. These range from charging options exclusively for own trucks to semi-public charging parks in commercial areas. To exploit the full potential of depot charging, it is therefore necessary to ensure that the **technical, legal, and economic requirements for the implementation of all charging options are met**.

Proposed measures:

- A national or European guideline for safe truck charging would be useful to avoid excessive requirements in truck insurances.
- Obligations for landlords to allow the installation of charging infrastructure in the depot.
- Easier authorisation of changed land use in depots (sealed areas) for the installation of charging infrastructure.

3. In the early market phase, large and medium-sized transport companies with their own depots are likely to play a central role in the roll-out of infrastructure. Improving public **information on available grid connection capacity**, **accelerating grid connection**, and **fair cost allocation** are necessary for a successful roll-out. The **adaptation of legal requirements** is necessary to enable the installation of charging infrastructure on existing premises and to facilitate the shared use of infrastructure so that subcontractors can also benefit from depot charging infrastructure.

Proposed measures:

- Customers should offer longer contracts (battery truck life duration) to transport companies if they want them to operate BETs. Stricter sustainability reporting requirements can lead to an increasing willingness to use and value climate-neutral transportation services.
- Make grid capacity data and maps available to the public. Best practice: Spain, France and the United Kingdom. This is already addressed for EU member states through the update of the EU electricity market legislation.

4. Small companies make up a large proportion of the transport industry. Due to their entrepreneurial framework conditions, the electrification of their vehicle fleets represents a major challenge. **Targeted state support for small companies** for the installation and grid connection of charging infrastructure should therefore be pursued. In addition, the **expansion of low-threshold information and counselling services** for these companies is of great importance.

Proposed measures:

- Subsidies for grid expansion for SMEs. SMEs benefit strongly from simple application procedures. Complex and time-consuming tenders should be avoided. A mechanism to cover the upfront costs to spread the grid connection costs over a longer time (not a one-off payment) would be useful for SMEs. Best practice for targeted support for SMEs: Spain, France.

- Targeted information for SMEs is helpful, including best practice examples for SMEs, workshops (e.g. information transfer, training), a list of important materials (studies, websites, etc.), and a communication of the economic benefits of battery truck.
- Best practice example: In Spain, one possible option is for several SMEs to join forces and set up a "mutual guarantee company" in order to gain access to favourable credit conditions. The authorities can further support SMEs by offering information tailored to SMEs.
- Large transport companies should provide charging infrastructure to their subcontractors, and they could guarantee their subcontractors higher freight rates if they operate electric trucks.

5. The available grid connection capacity is a central limitation for the development of the charging infrastructure and the expansion of the grid connection capacity often takes long. **Information on the currently available local connection capacity** should therefore be made publicly available so that the planning of depot charging infrastructure can be based on this.

Proposed measures:

- Information dissemination: raise awareness among companies for the long duration of grid connection and expansion process.
- Countries should carry out official studies to anticipate infrastructure requirements and network planning. Best practice: Germany (Infrastructure Master Plan).

6. In view of the predicted rapid market ramp-up of e-trucks, the expansion of grid connection capacity represents the central limitation for the development of depot charging infrastructure. **Communication between transport companies and grid operators** should be standardized and accelerated in this context and coordinated regionally.

Proposed measures:

- Cooperation between logistics companies for grid connection expansion should be supported by the authorities. For example, establish the concept of "joint grid connection customers" who jointly organize the grid connection. It should be the task of the public authorities to create a coordination regulation that makes the grid expansion conditions transparent. Grid connection should be coordinated, especially for smaller companies.
- Simple online notification of requirements: grid operators should simplify their application procedures and reduce waiting times.
- At national, regional or city level: organize communication & workshops between transport associations, energy suppliers and local authorities.

7. Smart charging and V2G approaches can reduce the grid connection capacity required and provide flexibility for the energy market, thereby saving costs and possibly generating revenue. However, **regulatory barriers for V2G need to be removed** and **the technical foundations for V2G must** also **be developed on the vehicle and infrastructure side**. For the latter, Germany in particular is lagging behind in the rollout of smart meters.

Proposed measures:

- Raising user awareness of the benefits of load management and bidirectional charging.

- Dynamic pricing and specific tariff structures (e.g., capacity prices) can incentivise smart and bidirectional charging at depots and thus help to reduce grid congestion and lower electricity costs.
- Despite the availability of standards & protocols for bidirectional charging, a common interpretation is still required to ensure interoperability between vehicles, charging stations, and distribution networks. This interoperability means that different vehicles are compatible with different charging infrastructures, which can be particularly important for depot owners with heterogeneous fleets or semi-private and semi-public depot charging cases.

8. In the current market situation, the operation of electric trucks and the development of charging infrastructure is not yet economically competitive in many cases. Especially for the grid connection and the set-up of charging infrastructure, a **continuation of funding programs is advisable** as a supplement to ensure a steady market ramp-up.

Proposed measure:

- Continuation of existing funding programs for the grid connection and charging infrastructure for depot charging.

Contents

1 Introduction

1.1 Definition of depot charging

A nationwide and reliable charging infrastructure is the central prerequisite for being able to operate battery electric trucks (BET). In principle, two options are available for BET charging: (1) The trucks can either be charged at publicly accessible charging stations or (2) at depots, i.e. at non-public charging stations (BMDV 2023b).

Several studies show that the latter, depot charging, is expected to play a key role in future recharging strategies, as a significant share of trucks return to their depot after their trips. They can therefore fully recharge on private areas, rather than rely on public charging (see e.g. (Göckeler et al. 2023)). For instance, Speth and Plötz (2024) demonstrated that depot charging can be sufficient for most BET in Germany. Moreover, depot charging is essential in the current early development stages of the BET market, as only few public charging stations for heavy duty vehicles across Europe have been installed so far.

To address this matter, the Alternative Fuel Infrastructure Regulation (AFIR) sets minimum requirements for the set-up of public charging infrastructure points in the European Union by 2025 (EU 2023b). Once built, these points will be "the key to powering a heavy-duty battery-electric transportation system" (Göckeler et al. 2023), depot charging however is expected to be the core of BET charging.

Indeed charging at the depot is an efficient and reliable way to recharge a BET during its downtimes periods (NLL 2024). Hence, companies need to be able to install charging points on private grounds. A range of options are open to them: First, non-public charging includes charging facilities on the company's own premises (e.g. depot). Second, non-public charging also involves charging on third-party premises that also provide infrastructure for other users (e.g. at a customer's loading and unloading point). Finally, they can consider using temporary mobile charging points (e.g. for construction site vehicles). In the following, we distinguish between three cases of depot charging (see Figure 1):

- Case A 'Private Depot Charging' represents the classic case of a company setting up charging infrastructure on its own premises for the electric trucks in its own fleet. Depending on the circumstances, this is done either directly at the freight handling locations of the company itself (e.g. gate/ramp) or vehicles can be brought to a central charging point on the premises, before or after the lorry loading/unloading operations.
- Case B 'Semi-Private Depot Charging' enables the use of the charging infrastructure on the company's own premises by third parties who have a business relationship with the owner of the depot. These can be, for example, suppliers or contracted transport companies.
- Case C 'Semi-Public Depot Charging' describes an extended understanding of depot charging and is located on semi-public land - preferably in a commercial area - which is accessible to all vehicle owners but can be used as a charging location by neighbouring companies in particular. This option appears particularly attractive if the installation of charging infrastructure at the respective depots is technically, administratively and/or economically challenging. In principle, the operation of the charging infrastructure could be carried out by neighbouring companies as well as by a commercial charging infrastructure operator.

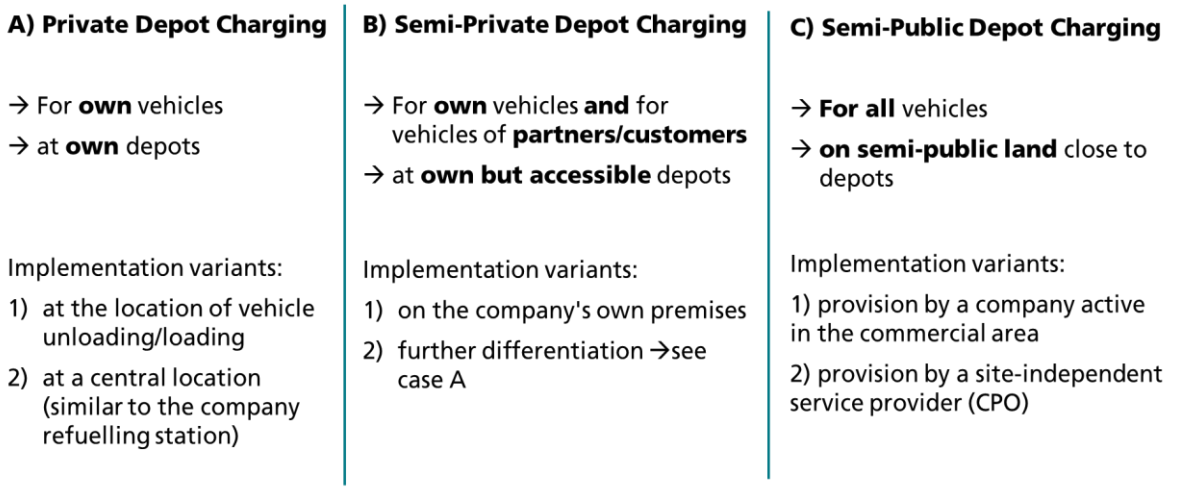


Figure 2: Depot charging cases

1.2 Total cost of ownership for depot charging

Although depot charging is considered important for a fast market uptake of electric vehicles, this solution also comes at a considerable cost along with the truck. As an example, we consider a large logistics provider who wants to electrify 40 trucks in 2025 in Germany that drive 280 km in two-shift operation per day, five days per week resulting in 70,000 km per year on their own private ground (case A). These trucks could be recharged overnight with 50 kW and a total power of 2 MW would be needed, or even between the shifts with 150 kW resulting in 6 MW total power. When considering one charging point per truck, we obtain the results for total annual cost as shown in Figure 2.

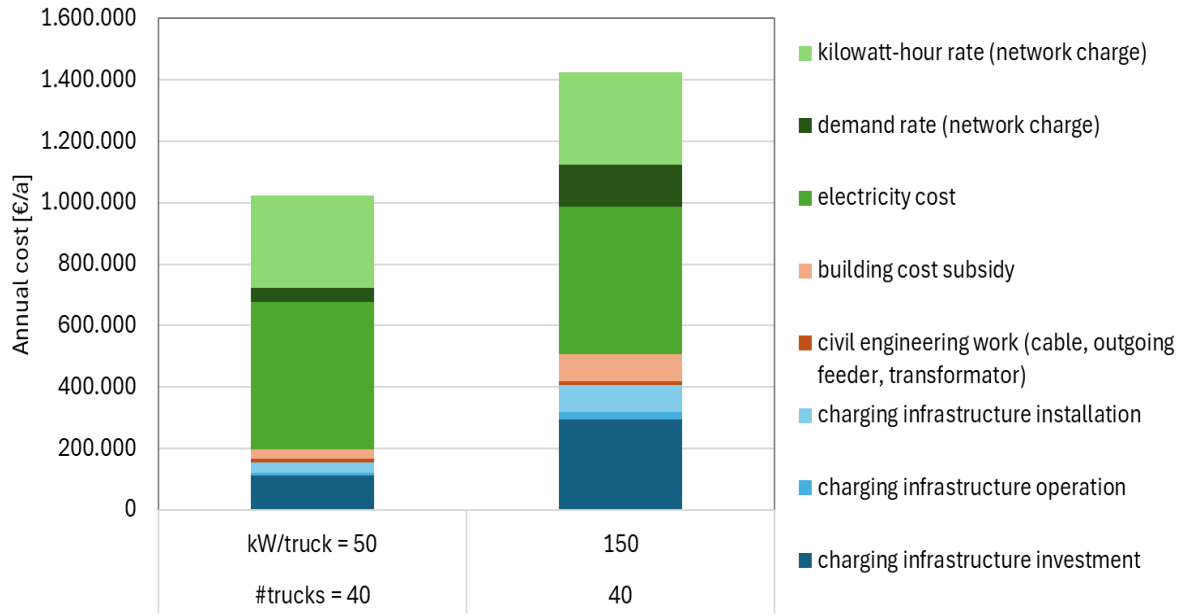


Figure 3: Exemplary annual cost for depot charging in Germany in 2025. Assumed are 40 trucks with 70,000 km annual driving distance and 50 or 150 kW charging power for each truck. Details to be found in (Frank et al. 2025 i.p.)

Here, the total annual cost for charging is shown differentiated by the cost for charging infrastructure (installation, operation and investment; in blue tones), grid connection (civil engineering work and building cost subsidy; in red tones), and electricity (electricity price including all taxes and surcharges except for network charge, demand rate and kilowatt-hour rate; in green tones).

We find that the electricity price and network charges will dominate the total cost for low power charging stations (50 kW). When considering higher power, the charging infrastructure and grid concession fee play an important role. The total annual costs sum up to 1 and 1.4 million Euro or, divided by the trucks and annual mileage, to 0.37 €/km (50 kW) or 0.50 €/km (150 kW) with all cost components. Thereof, the cost for charging infrastructure and grid concession sums up to 0.06 €/km (50 kW) or 0.15 €/km (150 kW), which could be lower if the charging infrastructure was share by multiple users or held for more than 10 years (Frank et al. 2025 i.p.). When compared to a Diesel truck with 40 l Diesel/100 km consumption and 1.30 €/l Diesel price resulting in 0.52 €/km, there is a cost advantage for electric trucks – which is even higher when considering the savings from reduced road toll – but the savings depend on several assumptions and the development of cost components. Just looking at the TCO in Figure 2, the pure cost for charging infrastructure and grid concession adds a noteworthy cost to vehicle operation when compared to the cost for electricity. However, when turning away from this purely private charging case to a semi-private or semi-public one, also billing and land purchase would have to be considered.

Thus, depot charging and its total cost of ownership (TCO) are dependent on factors from a logistics company's perspective:

- The electricity cost is directly dependent on vehicle usage and fleet size.
- The cost for charging infrastructure depends on depot ownership and potential other restrictions for charging infrastructure setup.
- Legal regulations, information on depot charging and funding schemes restrict or support the provision of depot charging infrastructure and can influence the cost indirectly.

Furthermore, depot charging also depends on factors related to the energy system:

- The total cost for electricity in the depot is dependent on the electricity price (including taxes) and network charges, but also on the current and future share of renewables in the system as well as the electricity tariff structure.
- The grid concession fee depends on the required total power and existing legal framework.
- The energy cost can be decreased when self-generated electricity is used.
- The provision of flexibility options can reduce cost further or even generate revenues (e.g., in the case providing energy back to the grid, i.e., vehicle-to-grid (V2G)).
- Certainly, the duration until grid connection can cause an additional cost for a logistics company when alternative solutions must be taken into account.

The analyses show that the total costs of depot charging infrastructure are highly dependent on the prerequisites and requirements of the transportation industry and the conditions of the energy system. In the following, these - in addition to other factors that influence the technical implementation of depot charging infrastructure - are therefore examined in more detail for several European countries in comparison.

1.3 Approach and definition of evaluation criteria

This report presents the findings of a study conducted for four European countries, which together represent a significant share of the European road freight transport: France, Germany, Spain, and the United Kingdom.

For the analysis of the four countries, we first conducted a systematic literature review, gathering information from publicly available sources, e.g. research reports and papers, information material from institutions dealing with depot charging. As a part of this process, information from ongoing research projects have also been taken into account. Second, to refine this base knowledge, experts were brought together in four country-workshops. The information gathered from over 80 participants in total allowed to evaluate and extend these first findings. Finally, five in-depth interviews completed the data collection. The in-depth expert interviews aimed to close remaining data gaps at country level and to discuss open questions and findings from the previous analysis steps. In this context, representatives of transport industry associations and a consulting institute from the countries under review were interviewed.

In order to assess the current situation and the challenges associated with the expansion of depot charging in the selected countries, we defined several evaluation criteria in consultation with T&E. These sets of criteria were also evaluated by the workshop participants and considered a useful and valid set of aspects for the assessment (a complete overview on all criteria and subcriteria can be found in the annex). The criteria are divided into two categories: "*logistics and vehicles*" and "*energy system*". So-called "*context factors*" (see following section) place the results in the context of relevant framework conditions for the market ramp-up of e-trucks and the expansion of infrastructure in the countries under consideration.

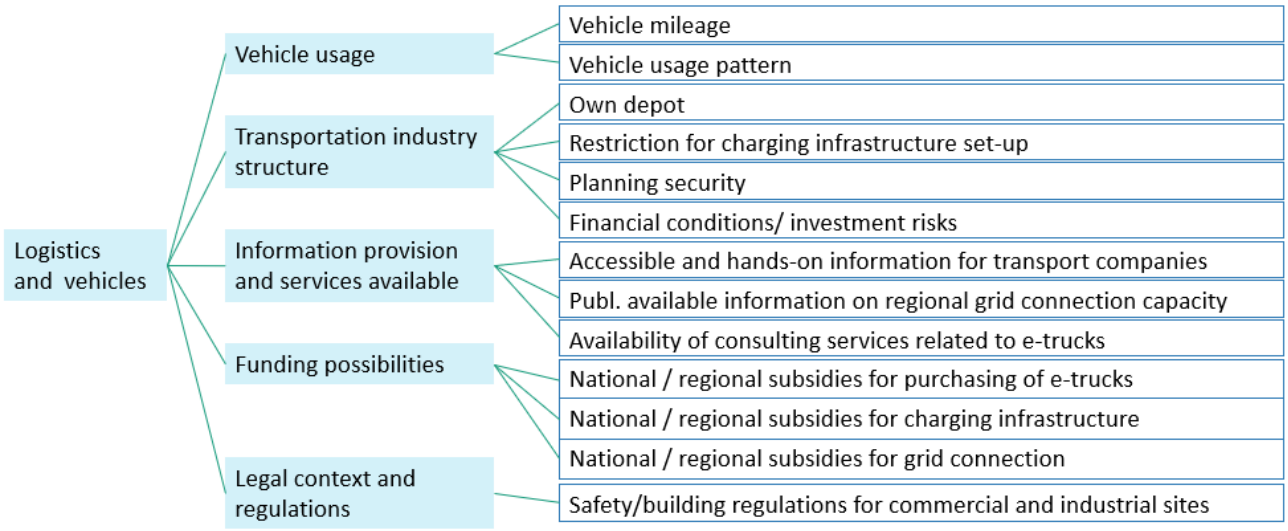


Figure 4: Factors on logistics and vehicles

The factors on logistics and vehicles (Figure 3) contain vehicle usage, transportation industry structure, information provision and services available, funding possibilities as well as legal context and regulations.

Vehicle usage is subdivided into:

- Vehicle mileage: The average daily mileage is necessary to understand the need for intraday charging. This directly affects infrastructure requirements and costs.

- *Vehicle usage patterns:* The description of potential common patterns helps to understand how depot charging infrastructure has to be designed. Infrastructure costs are affected as well.

Transportation industry structure contains the following four subcriteria:

- *Depot ownership* aims as determining whether logistics companies own depots by themselves and helps to understand the easiness of installing charging infrastructure. This factor permits the distinction of the depot charging cases and associated cost mentioned above.
- *Restrictions for charging infrastructure setup* contains technical and organisational restrictions for the installation that could imply additional planning costs.
- *Planning security* describes the limitations of transport companies to commit new investments (for e-trucks and charging infrastructure) due to short- or medium-term contracts.
- *Financing conditions / investment risks* relate to any other negative impacts on depot charging installation and BET procurement due to the given financing conditions for transport companies.

Information provision and services available marks whether there is:

- *Accessible and hands-on information for transport companies*, enabling low-threshold access to the necessary background information.
- *Publicly available information on regional grid connection capacity*, which serves as a basis for planning the connection of the charging infrastructure.
- Regional coordination of charging infrastructure requirements/expansion in order to bundle requirements and avoid conflicts of use.
- *Availability of consulting services related to e-trucks* to support companies in the concrete implementation on site.
- Further, the *funding possibilities* consist of:
- National/regional incentives for purchase and operation of e-trucks, compensating for the current cost disadvantages of BET.
- National/regional incentives for installation of charging infrastructure, reducing the high costs of the necessary infrastructure construction.
- *National/regional incentives for grid connection*, reducing the costs of the necessary grid connection of charging infrastructure.
- *Differences in granting of loans, level of interest rates* that affect the opportunities for transport companies to make additional investments.

The legal context and regulations contain:

- safety/building regulations for commercial and industrial sites.

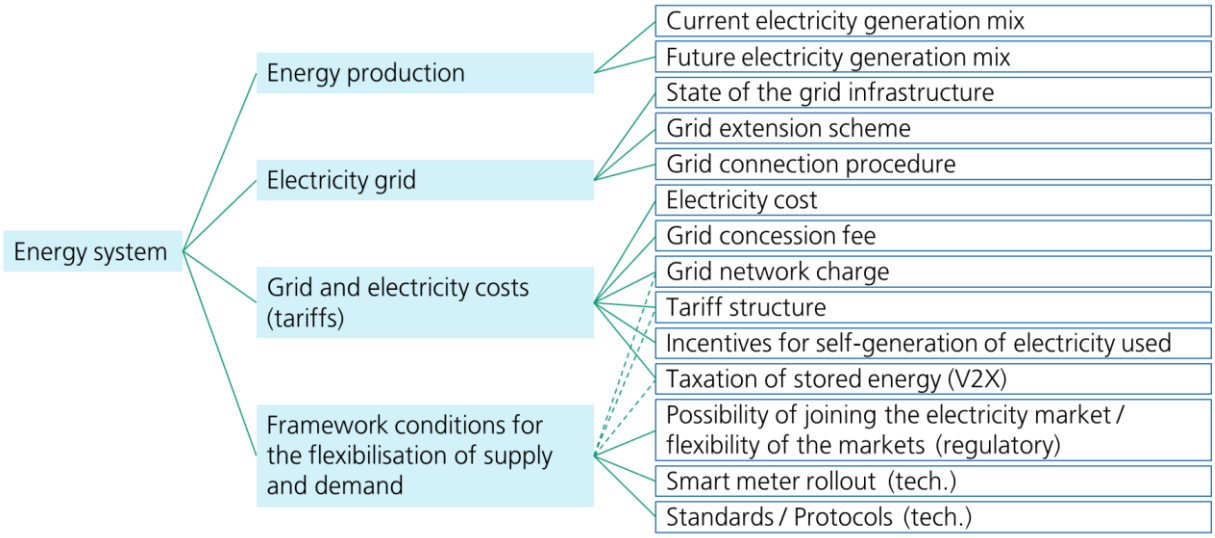


Figure 5: Factors on energy system

Within the energy system (Figure 4), we studied the energy production, the electricity grid, grid and electricity costs and framework conditions for the flexibilization. These are further subdivided into subcriteria.

For *energy production*, we analyse the

- *Current electricity generation mix* (share of renewable energy) which serves as an indicator for advancement in energy production conversion and impact on the grid. A higher share of renewable energy could imply a more mature grid for electricity generation that could serve the energy consumers. The need for flexible consumers is also higher in systems with high renewable energy shares.
- *Future electricity generation mix* (official goals for share of renewable energy in 2030 and 2045) contains the outlook.

The *electricity grid* contains three subcriteria:

- *State of the grid infrastructure* that describes the current capacity of substations or average distance to a substation. This has direct effects on depot charging cost since the civil engineering costs for the installation of charging infrastructure are highly dependent on this factor.
- *Existence of a grid extension scheme* contains information whether such a scheme is available at all. This would allow a smoother planning procedure for charging stations in a depot.
- *Grid connection procedure* in terms of organizational (duration, complexity) as well as technically available capacity affect the planning costs.

The *grid and electricity costs (tariffs)* consist of six subcriteria directly affecting depot charging cost:

- *Electricity cost* as a basis for usage, which have a high influence on the economic operation of electric trucks.
- *Grid concession fee (for network extension)* describes the cost that users have to pay for an increase in electric capacity
- *Grid network charge:* payment for grid usage as part of the electricity price
- *Electricity tariff structure* determines how the tariffs are determined in the different countries
- *Incentives for self-generation of electricity used* aims at identifying whether there are motivations to use self-generated electricity instead of transferring it into the grid

- *Taxation of stored energy (V2X)* describes whether there is a double taxation for electricity that is provided back to the grid. Double taxation and double payments of further fees and levies reduce the economic attractiveness of bidirectional charging services to the grid.

Finally, the *framework conditions for the flexibilization of supply and demand* contain the following subcriteria—in addition to aspects relating to the grid network charge, electricity tariff structure, and the taxation of stored energy (dashed lines in Figure 4):

- Possibility of joining the electricity market / flexibility of the markets
- *Smart meter rollout:* share of smart meters in the country of observation
- *Standards / Protocols:* existing formal procedures for the use of flexibility options

The analysis and assessment of the aforementioned factors at country level is only possible if the respective country-specific context is taken into account. In this regard, the expected market ramp-up and the development of public charging infrastructure - both supported by regulation and national targets - are particularly relevant. Their characteristics are therefore discussed for the countries under consideration in the following section.

1.4 Context factors in the observed countries

The CO_2 emission requirements for newly sold trucks and binding targets for the expansion of charging infrastructure are key influencing factors and drivers for the market development of BETs.

The binding CO_2 emission standards in the European Union (EU), which were revised and tightened in 2024, are putting pressure on manufacturers to introduce zero-emission vehicles to the market. While a reduction of 43% must be achieved in the EU by 2030 (compared to 2019/2020), the targets in the United Kingdom (UK), which are unchanged since it transposed earlier EU law, are currently less ambitious at 30%. Furthermore, the UK market has not yet made any further regulations, while the EU stipulates a 90% reduction by 2040 (see Table 1).

While for the EU, and therefore also for the member states Germany, Spain and France, the development of a public truck charging network every 60 to 100 km by 2030 is mandatory for all roads on the TEN-T network under the Alternative Fuel Infrastructure Regulation (AFIR), there are no binding targets for the United Kingdom to date.

Table 1: Relevant legislation and targets related to BET and charging infrastructure in the observed countries

	EU (incl. Germany, France, Spain)	**United Kingdom**
CO_2 standards for trucks [CO_2 emission reduction of new truck sales relative to 2019]	2025: 15% 2030: 43% 2035: 64% 2040: 90% (EU 2024b)	2025: 15% 2030: 30% (UK 2020)
Minimum charging infrastructure availability requirements	AFIR targets: One charging hub exclusively for HDVs every 60 km (TEN-T core) to 100 km (TEN-T network) in each direction of travel by 2030. (EU 2023a)	Currently no targets for a minimum number of charging point

These regulations are powerful drivers for increasing BET's penetration in the market. In response to the ambitious CO2 standards for heavy commercial vehicles, vehicle manufacturers have now adapted their strategy and are focussing primarily on BET. Manufacturers expect a gradual increase of the BETs share in sales until 2030, when they should account for more than 1/3 of sales in Europe (NOW 2024a).

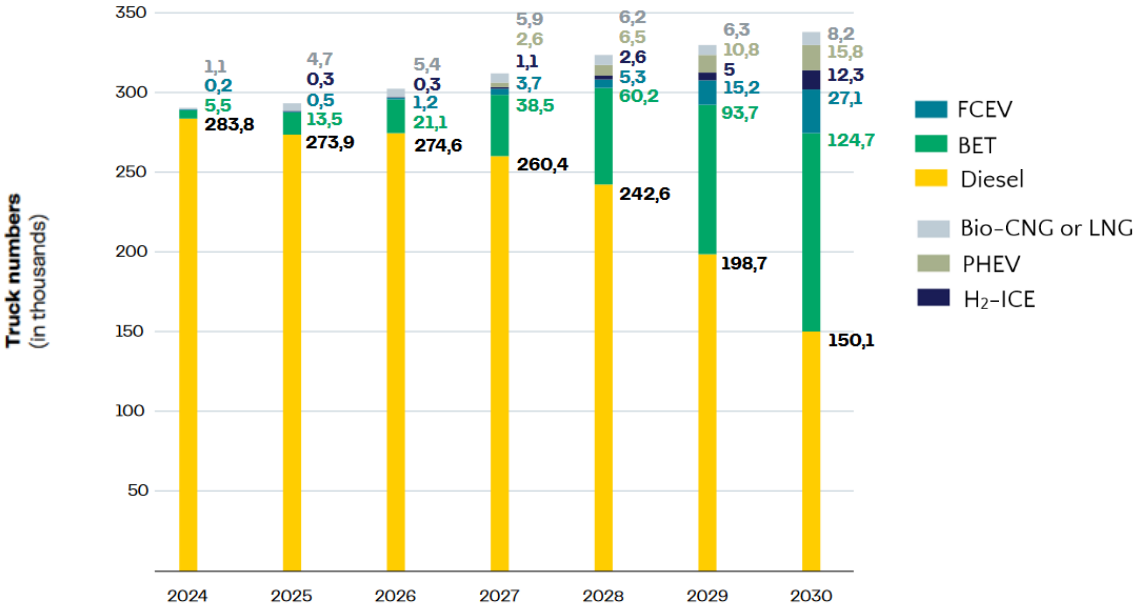


Figure 6: Forecast sales figures for heavy duty vehicles (>12t) in Europe according to manufacturer data (NOW 2024a)

Germany

Truck manufacturers see Germany as a decisive market for the ramp-up of BET as it is one of the strongest markets for HDVs in Europe and has ambitious sustainable transport policies (NOW 2023). Indeed, the German government has set (non-binding) objectives that are more ambitious than the European regulations.

According to the Climate Protection Programme 2030, one third of road freight transport mileage is to be covered by vehicles with electric powertrains or electricity-based fuels by 2030 (BMU 2019). To achieve these goals, a CO_2-based toll for lorries, a CO_2 price on fuels and an exemption from vehicle tax for emission-free lorries were introduced by the German authorities (Hacker et al. 2024)

In view of the expected more dynamic market for BET compared to the overall European market, numerous analyses conclude that the AFIR targets for infrastructure expansion are not sufficient to cover the charging needs in Germany (Hacker et al. 2024).

The federal government addresses the development of charging infrastructure in the Charging Infrastructure Master Plan II (BMDV 2022). In 2024, a tender was issued for the installation of charging stations at around 130 unserviced motorway service areas, in addition to the planned charging infrastructure at around 220 managed rest areas. The Federal Ministry for Digital and Transport estimates that this would cover two thirds of the demand for publicly accessible charging points on German highways (BMDV 2024). The one third left is expected to be covered by private investments.

France

The French national strategy to reduce CO_2 emissions sets targets for greenhouse gas emissions, known as 'carbon budgets', which must not be exceeded for each sector (Vie publique 2024a). For the transport sector, the carbon budget is 112 million tonnes of CO_2eq for the period between 2024 and 2028 and 94 million tonnes for the period between 2029 and 2033. 137 million tonnes of CO_2eq were emitted by the transport sector in 2015 (légifrance 2020). Experts have pointed out that a new revision of the national low-carbon strategy is currently in development and will be presented in 2025 (Vie publique 2024b). Measures such as low emission zones have been introduced in several major cities which, among other things, favour the use of zero-emission vehicles (e.g. Paris, Lyon, Grenoble, Marseille) (Ministère Territoires Écologie Logement 2023).

Explicit national targets for the electrification of road freight transport do not exist yet. However, Enedis, the main French DSO, has published an initial study on the need for public charging infrastructure for long-distance lorry transport. The results show that, in contrast to Germany, in 2030 the charging points foreseen in the AFIR are likely to cover the majority of the demand. Around 60 high- and medium-voltage charging stations will need to be installed or reinforced by 2035 (Enedis et al. 2024). Enedis is already working on the further development of its master plan for the development of the high-voltage grid to take the conclusions of this work into account. A further study estimating charging demand and the impact on the French electricity distribution network for both depot charging and public charging is in preparation. According to experts, the results will be available at a geographical resolution of high and medium voltage substations.

Spain

In Spain the Comprehensive National Energy and Climate Plan (PNIEC) sets a 32% global emission reduction of greenhouse gas for 2030 relative to 1990 (Ministerio para la Transición Ecológica y el Reto Demográfico 2024b). In the PNIEC, the electrification is identified as a strategic point of the sustainable mobility strategy 2030: The authorities aim to support the development of charging infrastructure and the deployment of electric vehicles in private companies' fleet (Ministerio para la Transición Ecológica y el Reto Demográfico 2024a). However, there are no other road freight transport targets than these defined by the European Union in Spain. Measures were taken to support the deployment of BETs such as low emission zones creation, subventions for BET purchase or the harmonisation and update of standards for the installation of charging stations. Overall, these measures are however less ambitious than the one taken in Germany for instance, and some stakeholders are pushing for more government action to meet the EU's AFIR targets (AEDIVE 2024).

UK

In November 2021, the national government confirmed its intention to phase out the sale of new, non-zero emission trucks weighing up to 26 tonnes by 2035, with the intention that by 2040 all new trucks sold will be fully zero emission (GOV.UK 2023a). However, the binding CO_2 reduction requirements for newly registered trucks are currently – with a reduction of 30% by 2030 – less ambitious than in the EU, given that the EU's 2024 review was no longer transposed into UK law due to Brexit (see Table 1). A Vehicle Emissions Trading Scheme (VETS) exists for cars and vans and consists of a mandate for zero-emission vehicles ('ZEV') and a carbon dioxide standard, which aim is to limit the CO_2 emissions of new registered light-duty vehicles (LDV). According to experts, a comparable ZEV mandate for lorries has not yet been introduced and is not expected to be introduced in the next few years.

The Public Charge Point Regulations 2023 came into force on November 24th, 2023 (GOV.UK 2024a). The aim is to ensure that the experience of consumers using public charge points across the United Kingdom is consistent and positive. However very few public charging stations for lorries are available nationwide so far. A strategy for zero-emission truck and bus charging infrastructure was announced in 2023. The strategy is intended to set the strategic direction and define the respective roles and responsibilities of the government and industry for the development of the charging infrastructure (GOV.UK 2023a). Experts indicated that it was due for early 2025. Yet, they also indicated that the government did not confirm the inclusion of trucks in the rapid charging fund (RCF) (GOV.UK 2021).

In the following, we describe the status quo and future prospects of the aforementioned evaluation criteria for depot charging for the four countries of observation. For each country, we summarise the main findings. Finally, we compare the results of the four countries under consideration with regard to the prerequisites and challenges for the national implementation of depot charging.

2 Depot charging in Germany

2.1 Factors on logistics

2.1.1 Description of transport industry

Status quo

The structure of the German transport market is very heterogeneous. There are numerous small to medium-sized companies that operate in the market. Large road hauliers very commonly subcontract work to smaller transport companies. This market structure becomes evident when analysing the number of employees of the road freight transport companies of Germany: Less than a third of all employees work in companies with more than 50 trucks (22.7%), while small companies account for 31.1% of all employees (BALM 2020). Even companies with up to three trucks have a relevant share of employees (9%). However, even if the majority of companies in the logistics sector are SMEs, the majority of trucks are owned in large companies (see Figure 6).

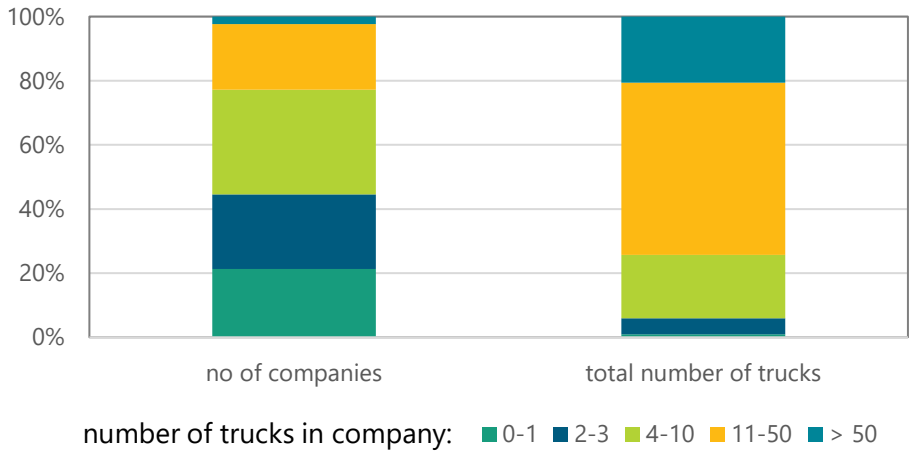


Figure 7: Number of companies and number of trucks in Germany (Source: (BALM 2020)). Right bar based on class centre multiplied by number of companies.

The market of transport companies further differs in road freight carriers and freight forwarders. Road freight carriers transport goods between the place of loading and unloading, with their own or chartered vehicles. A freight forwarder on the other hand organises the shipments of goods on behalf of its customer and does not necessarily own trucks. Although there are no official statistics available on this matter, workshops and in-depth interviews indicate that most large road freight businesses in Germany are freight forwarders, they often do not own trucks and focus on logistics while the road freight carriers are mainly small- to medium-sized companies.

Future prospects

With regard to possible electrification, small companies in the transport sector in particular face major challenges. These include reduced operational flexibility with a small fleet size and short contract terms of often only a few months, lower personnel capacities for knowledge development and difficult financing conditions for additional investments (see also the following influencing factors).

2.1.2 Vehicle Mileage

Status quo

Road transport of many groups of goods can be differentiated in typical ranges of distances, in which the majority of traffic occurs. The road transport of heavy goods, e.g. stones and soils, is typically characterised by short trips and usually occurs close to construction sites. On the contrary, light valuable goods are transported over long distances and distributed over a wider area. The main use-cases of heavy-road transport – many heavy goods transported over short distances and light-weight goods over long-distances – have direct implications on the distance statistics of the road freight transport industry. Short-distance trips with a length of less than 50 km account for two thirds of all trips operated by HDVs. When adding the regional delivery (< 150 km) to these, about 85% of all trips are covered. Yet, the share of vehicles in local and regional delivery only accounts for 45% of all vehicles. The average distance of a local transport trip is 18 km, and 92 km for regional delivery, which stands in contrast to the average length of a long-haul trip, 313 km ((KBA 2018); see Figure 8). Data analyses show a clear correlation between the annual mileage and the range category: while for moderate annual mileages of up to 40,000 km per year, single trips are usually only up to 200 km long, from 100,000 km annual mileage around half and from 140,000 km per year well over half of the trips have lengths of over 400 km (Göckeler et al. 2023).

Experts report that transport companies located in Germany usually carry out a large part of local and regional delivery transport while about 50% of long-distance transport on toll roads is operated by non-German companies. Indeed, Germany has one of the highest shares of road cabotage in Europe: The amount of goods transported on the national territory by foreign registered vehicles represents 9% of the overall transport activity in ton-kilometres in Europe (GOV.UK 2023b).

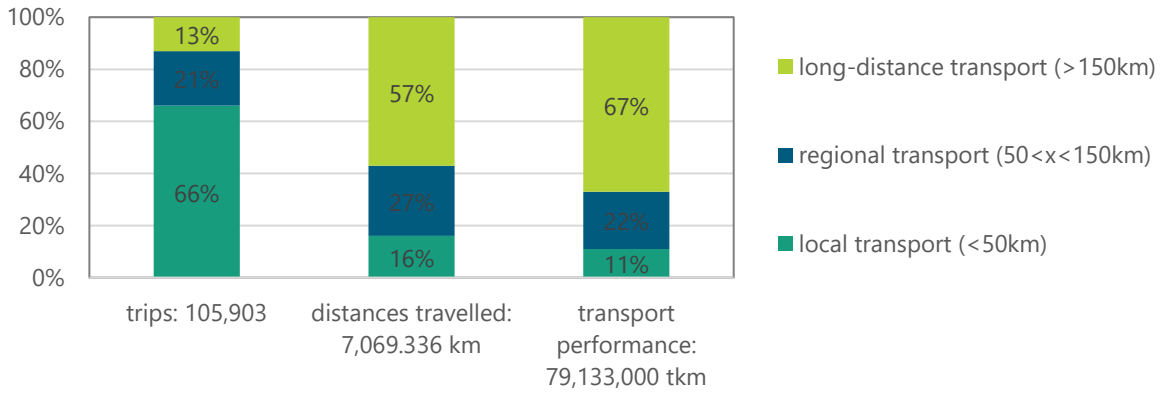


Figure 8: Transport structure of trucks in Germany (Q4/2018); Source: (KBA 2018)

Future prospects

When it comes to the deployment of BET, the daily vehicle mileage is of great importance. Participating companies in the workshops indicate that different use cases cause different potentials for electrification and dependencies on depot or public charging. Three use cases have been identified:

- Short distances in regional transport with less than 150 km per day could easily be managed with depot charging.
- Longer distances, up to 300 km per day (often operated with two shifts) would mostly be managed at the depot, with one of the three cases of depot charging described in the

introduction. Eventually they would also require intermediate charging at the destination site.

- Long-distance trips are expected to require public charging infrastructure to recharge the BET during the driver rest periods, topping up the energy recharged at the departure and destination depots.

2.1.3 Vehicle Usage Patterns

Status quo

In addition to the daily vehicle milage, the locations of downtimes of the vehicles also play a particular role in assessing the potential for battery recharging. In this context, a distinction must be made between vehicles operating regional delivery and long-haul transport services and between single-shift or multi-shift operated vehicles. While vehicles operating regional transport services often return to their starting point at the end of their tour, which is often the depot, this is only partially the case in long-haul transport. In addition, the downtimes in long-haul transport are shorter due to the higher number of kilometres travelled. In single-shift operation, there are usually long downtimes at night. In multi-shift operation, these are shorter. Additionally, the regularity and predictability of vehicle operations strongly vary depending on the use-case. Two surveys of transport companies in recent years have come to the conclusion that the majority of vehicles have at least 8 hours of downtime per day (Göckeler et al. 2022). In one study, however, a good third of the companies surveyed stated that their vehicles were parked for less than 8 hours per day (Kluschke et al. 2019).

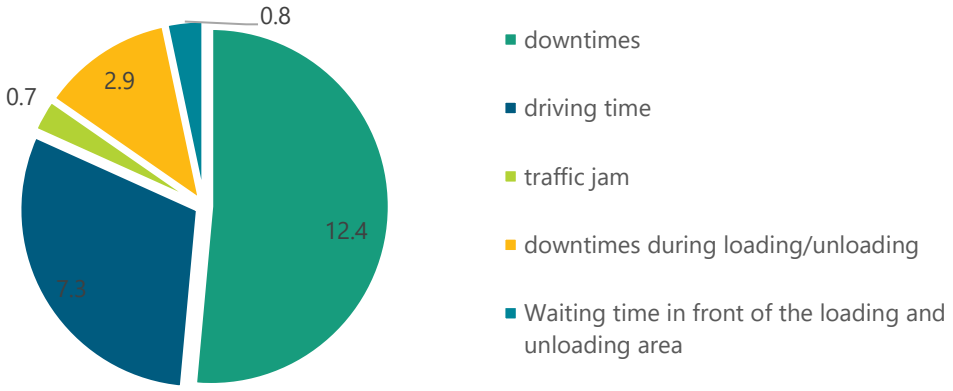


Figure 9: Average operating times of HDVs (survey of 46 transport companies in the StratES project; (Göckeler et al. 2022)).

Future prospects

In particular for trucks operating in regional transport and on a single shift, electrification with depot charging can often already be realised today, even with low charging power. The situation is more challenging with multi-shift operations. This often requires intermediate charging at the depot between shifts, higher charging capacities and a planning of the charging cycles. Ideally, battery charging should take place at the loading ramp, but this is not always technically possible (e.g., because the distances between the loading ramps/gates are not large enough to set a charging station).

For vehicles that are used both for regional transport during the day and long-distance transport at night, the situation is even more challenging due to shorter downtimes. Thus, high charging capacities are required between tours in the depot / at the freight transfer point. Here too, charging stations directly at the loading ramp are an advantage.

Long-haul vehicles that are on the road all week, on the other hand, are largely dependent on public charging infrastructure. Depot charging infrastructure is not sufficient to power them for 100% of the journey.

2.1.4 Depot Ownership

Status quo

Statistically sound information about depot ownership is not available for Germany and opinions about the share of companies with their own depot vary largely. While some workshop participants indicate that all larger companies have their own depots, a study states that more than 70% of small companies (19% of them being single member companies) don't have any depot, yet the freight forwarder that is sub-contracting them may have a depot (BALM 2020). The in-depth interviews indicate that this may be a definition problem as also sub-contracting companies offer parking lots to their subcontractors on their premises. Practitioners report that even small companies usually have a depot that includes parking spaces for vehicles in addition to their administrative offices. This means that only a few vehicles are actually parked at the curb side, as local authorities also want to avoid truck parking in public spaces wherever possible.

Future prospects

The depot ownership of logistics companies remains unclear and so do the shares of different use cases for depot charging (private, semi-private, semi-public). Reliable data on the availability of depots of transport companies would be desirable. However, one additional challenge is the ownership of the depot ground, which is often rented or provided while contracts with the landlords normally span for more than three years. Thus, the landlords have to give approval to set up charging infrastructure at the depot (i.e. incentives/obligations for landlords are required). Potential dismantling costs need to be considered as well.

To deal with the lack of information on this topic, studies are needed to shed light on the distribution of depot ownership among logistics companies and the share of companies owning their own depot.

2.1.5 Planning security

Status quo

The investment required for fleet electrification is considerably high. Given the significant sums involved, investment decisions depend on the duration of contracts with customers and subcontractors so that companies can plan with a reasonable degree of certainty. Yet, the German logistics market is overall very volatile because customer-supplier relationships are not particularly stable. Additionally, contract duration usually varies according to the size of the logistics company. Large companies bid for major tenders and therefore generally have contract durations of between two and three years. Smaller companies tend to have shorter contract durations. For instance, subcontractors' contract duration ranges from six months to one year and the spot market is even characterised by ultra-short contracts, which have a duration of less than six months. The share of

the spot market is substantial, in fact 60% of the long-haul transport operations fall within the spot market, and thus have agreement periods of less than 6 months.

Future prospects

These conditions constitute a challenge for small businesses that have no certainty about their future activities and will be reluctant to commit to any major investments. For larger companies, while they benefit from longer contracts, their duration (approx. three years) is often not long enough to justify making the investment. Ideally, contracts covering the entire period of use of a BET could enable companies to undertake the electrification of their fleets. Or the clients or customers of the vehicle owner would have to provide other guarantees or incentives (e.g. higher freight rates) for the operation of BETs during the contract period.

2.1.6 Restrictions for charging infrastructure

Status quo

The first companies using BET identified the following practical difficulties in setting up charging infrastructure on their depots:

- The grid availability is insufficient and grid extension costs are high. In most cases the current grid capacity available is not sufficient to electrify the whole fleet, so companies need to extend their connection capacity. Extending the grid connection involves significant costs and efforts for logistics companies, along with considerable delays. (see sections grid connection procedure and grid concession fee).
- There is a lack of space available on existing sites for the installation of charging points. Depending on the vehicle usage pattern, two types of charging configurations can be considered. On one hand the charging infrastructure can be set up directly at the terminal, thus combining charging and goods loading/unloading but this requires very plannable processes. More importantly**,** this is in most cases not yet feasible because the space between the ramps/gates is not large enough to allow the installation of a charging point. On the other hand, charging infrastructure can be installed on an open area, enabling a more flexible use, but requiring a lot of space. In some cases, there is no capacity to install such a large-scale charging infrastructure on the existing depot sites.
- If the depot is rented, landlords must give their agreement for the installation of charging infrastructure at the site. In this case potential additional dismantling costs are also to be considered.
- Finally, there are restrictive (warehouse) insurance conditions. Whether the charging infrastructure can be open to third parties often depends on insurance terms and conditions. Among others, this can be explained by security concerns regarding external visitors at the depot.

Future prospects

On almost every depot there are restrictions mentioned by workshop participants and interviewees. The solutions proposed by stakeholders include:

- A cooperation between companies, e.g. when one is facing a large number of restrictions. In this way they are no longer solely dependent on their own home depot to charge. This means moving away from exclusively one's own grounds to large areas such as industrial

and harbour areas, which can then guarantee a 24-hour green electricity supply for all parties through a smart energy and electricity concept, including storage etc.
- An expansion of logistics areas (which are sealed areas), to gain space for the charging infrastructure. However, this is strongly dependent on communal policy.
- Incentives/obligations for landlords required to allow charging infrastructure set-up, if the depot is leased.

2.1.7 Safety / building regulations for commercial and industrial sites

Status quo

The following challenges due to regulations were mentioned in the workshop and interviews:

- For fire prevention the Ordinance on the Construction of Operating Rooms for Electrical Systems (EltBauVO) is of relevance. For instance, in the case of the set-up of a transformer, spaces separated from other activities may be required.
- Local state building codes require standards for bearing capacities of roofs which represents a challenge for the installation of solar panels.
- The positioning of the charging station at the ramp and required structural protective measures to prevent damage or demolition are required.
- The existing conditions at the time of the construction of depots or the creation of standards did not take the future electrification of fleets into account. This leads to a number of challenges that can be addressed by adapting the above-mentioned regulations for example.

2.1.8 Financial conditions/Investment risks

Status quo

The transport sector in Germany typically operates with very low margins. However, there are differences between large and small transport companies in terms of available cash flow. Small companies operating as subcontractors generally have fewer financial resources and are in a difficult position as far as the banks are concerned. Small companies reported that the loan costs are high, and the bank refused to grant a loan because of their credit ratings. Considering the current prices of BET there are technically only a handful of companies that could afford them. The same holds for investments for charging infrastructure in the megawatt range which is hardly affordable by a single company regardless of the company size. Furthermore, it is essential not to underestimate the effect of interest rates on the final infrastructure and BET purchase costs.

Future prospects

Currently, the investment risk for the procurement of BET increases with decreasing company size. As long as BET prices do not fall and the residual value risk remains high, companies will increasingly opt for leasing instead of purchasing vehicles when financing vehicles. As far as the charging infrastructure is concerned, the utilisation of the charging infrastructure will in most cases not initially reach the optimum, while at the same time the investments remain considerable. Cooperation between companies and semi-public charging stations will therefore be necessary. Subsidies staggered according to company size could help to manage the initial investment, taking into account the different pre-conditions depending on the size of the company.

2.1.9 Regional coordination of charging infrastructure requirements / expansion

Status quo

Coordination for requesting the grid capacity extension is needed. Coordination can be useful if several users require charging infrastructure locally in a small radius so the number of requests to the network operator is reduced. Currently, there is a “first come, first served” approach when it comes to grid connection requests, meaning that cooperation could be beneficial to involved parties. Furthermore, in the case of private depot charging the occupancy rate of charging infrastructure often does not reach the optimum, and the investments are considerable, so cooperation can be even more advantageous. For instance, semi-public depot charging can contribute to increasing the cost-effectiveness of investments.

Future prospects

Currently, there is no or very few coordination between actors. Areas are also partly leased for a specific purpose and thus network capacity is already used up without considering other stakeholders. Therefore not only the exchange between companies is important but also the communication with the logistics centres or public authorities. In general, local authorities underestimate the issue and the demand and could impulse the coordination/break the logic of first come/first serve using regional planning and the appropriate regulatory instruments. (e.g., CO_2 reduction targets, corporate tax revenues, etc.)

The Federal Association of the Energy and Water Industry (BDEW) discusses the role of the "joint grid connection clients" who organise the grid connection together. In industrial areas, there is also already the possibility of making coordinated arrangements to use renewable energies appropriately on site or to use storage and thus take the pressure off the grid.

2.1.10 Accessible and hands-on information for transport companies

Status quo

In recent years, various stakeholders have developed information services on depot charging for users. These range from application-related results from research projects, tools and guidelines from the responsible public administration and ministries or specialist committees to commercial offers and advice from vehicle manufacturers. For example, the "Depot Laden" task force, which was initiated by the German Ministry of Transport in 2022 and involved around 60 stakeholders, laid important foundations in a 6-month process.

Several documents and websites are accessible online:

- Guide for users, which was created by the responsible federal organisation (NOW) and is based on the above-mentioned stakeholder participation: "Einfach laden am Depot" (BMDV 2023b)
- Free counselling tool that was developed as part of a research project and is publicly available on the NOW website: www.my-e-roads.de
- VDE Guide: Technischer Leitfaden Ladeinfrastruktur Elektromobilität (not truck-specific)
- OEM's eConsulting service (helpful according to logistics companies).

Future prospects

So far, there are only a few experts on the market, but the amount of information available has increased and is expected to continue to grow due to the dynamic nature of the topic. Some processes are not fundamentally different from those of high-power charging (HPC) installation for cars. Synergies exist in particular through the knowledge of installation and project planning companies. From the transport companies' point of view, however, there is a lack of information on the consequences of energy regulations in the context of setting up charging infrastructure. The companies themselves often lack expertise in this area.

2.1.11 Availability of consulting services related to charging e-trucks at the depot

Status quo

According to workshop participants, the expertise in this field predominantly lies with the charging point operators, and here, in turn, public charging infrastructure is pushed. Other than that, technical planning / hardware planning and project management tools are available in good quality and quantity. The lack of an information platform for reliable journey and charging planning (public) is an operational challenge.

Future prospects

Technology providers still have relatively little focus on truck/depot use cases. It is therefore challenging for logistics companies to differentiate between car and truck use cases (both backend and hardware).

2.1.12 Publicly available information on regional grid connection capacity

Status quo

Information on regional grid connection capacities is currently not publicly available. Some grid operator can carry out a quick grid connection capacity check (SNAP) based on an address and the desired connection capacity (Mitnetz Strom 2024). A Germany-wide map-based overview is largely rejected by the distribution grid operators due to security concerns (as they report that the information could be used for attacks). This information is therefore usually obtained in practice through personal consultations or specific enquiries with the responsible grid operator, which takes some time. The mandatory publication of grid capacities starting mid of 2025 will at least reduce the planning insecurity (Rosslowe et al. 2024).

Future prospects

It is considered important to have this information publicly available, as it provides an indication of how costly and time-consuming it would be to set up the charging infrastructure/grid connection. The current state of information provision is seen as an obstacle to an efficient and rapid expansion of the charging infrastructure.

2.1.13 National / regional incentives for purchase and operation of e-trucks

Status quo

The national funding programme for climate-friendly heavy-duty trucks and their charging infrastructure was stopped in early 2024 and no further national funding programme is in discussion

right now. On a national level, there is an exemption from the truck toll until the end of 2025 and a significantly reduced truck toll for BET as of 2026.The German investment and development bank (KfW) also offers loans for companies, up to 25 million € with an interest of 2.24% p.a. for e-trucks.

On a regional level, several funding schemes at federal states level exist, i.e.:

- Berlin: Classes N1, N2, BEV 25% of eligible costs, max. 15,000 €
- Baden-Württemberg: Class N1: € 4,000; N2: € 30,000; N3: 60,000 €
- North Rhine Westphalia: Classes N2 & N3; 50% of additional investment costs up to 200,000 €.

Future prospects

Currently, only regional subsidies are available for the next few years while the price of BET is still high. If reintroduced, the subsidies should be differentiated based on company size according to workshop participants due to differences in profit margins and resulting investment abilities.

2.1.14 National / regional incentives for installation of charging infrastructure

Status quo

The national funding programme for climate-friendly heavy-duty trucks and their charging infrastructure, (KsNI-funding programme) was stopped in early 2024 (BALM 2024). The German Federal Ministry for Digital and Transport (BMDV) offers a subsidy for the purchase and installation of private charging infrastructure (DC >50 kW) for small, medium-sized and large companies of up to 40% and up to 30,000 € per charging point (depending on company size and charging power) (BMDV 2023a). Regional subsidies also exist, e.g. in Berlin (50% of costs, AC up to 2,500 €, DC >22kW up to 30,000 €). Loans from the KfW (German state-owned investment and development bank) for companies could also be used for charging infrastructure up to 25 million € for an interest of 2.24% p.a. for charging infrastructure.

Future prospects

The workshop participants and interviewees demand for a targeted funding to develop non-public charging infrastructure. They state that there is no adequate funding that would actually close the economic gap. This is urgently needed to achieve the market ramp-up by 2030. Funding independent of the vehicle with higher power for future needs is also required as it was the case in Baden-Württemberg, yet not in the KsNI-programme.

2.1.15 National / regional incentives for grid connection

Status quo

The grid connection is included in the subsidy for charging infrastructure from the German Federal Ministry for Digital and Transport (BMDV). This programme subsidies up to 40% of the cost of the sum of grid connection and charging points costs, and this up to 30,000 € per charging point, depending on the company size. On a regional level, Berlin also offers grid connection subsidies at the low voltage grid of max. 5,500 € and at the medium voltage of max. 55,000 € for instance.

Future prospects

As grid connection cost varies largely according to the location of the logistic depot, a differentiated support scheme is of great interest to the workshop participants and interviewees.

2.2 Factors on energy

2.2.1 Current electricity generation mix

Status quo

In 2023, around 515 billion kilowatt hours of electricity were generated in Germany. The share of electricity generated from renewable energies increased from 44% in 2022 to 52% in 2023. Green electricity is in 2023 mainly generated by wind power (26.8%), biomass (8.5%) and photovoltaics (11.9%). (Destatis 2024).

2.2.2 Future electricity generation mix

Status quo

The Renewable Energy Sources Act (EEG) aims to transform Germany's electricity supply to be sustainable and greenhouse gas-neutral, relying entirely on renewable energies. To achieve this, the share of electricity from renewables must reach at least 80% of gross consumption by 2030 (BMJ 2023).

The German government has formulated fixed expansion targets for the coming years in the Renewable Energy Sources Act (EEG) and the Offshore Wind Energy Act (WindSeeG)). According to these acts the output of wind turbines should reach 145 gigawatts by 2030 and 230 gigawatts by 2045. For solar energy, the target is 215 gigawatts by 2030 and 400 gigawatts by 2045 (BMJ 2024b). In its Federal Climate Protection Act (Bundes-Klimaschutzgesetz), Germany has set itself the goal of becoming net greenhouse gas neutral by 2045 (BMJ 2019). Assuming a total installed capacity of 723 GW power production in 2045 (Fraunhofer ISI et al. 2024), this would mean a share of 55% of photovoltaic power and 32% of wind power (onshore and offshore).

2.2.3 State of grid infrastructure

Status quo

The connection of large logistics depots typically requires a medium-voltage grid connection. Experts mentioned that the availability of medium-voltage substation capacity varies greatly between locations. According to them this depends strongly on the distribution grid operator and the extent to which specialized companies are available.

Future prospects

The availability of medium-voltage grid connection it is often very limited or reserved for the growth of other loads such as heat pumps. Capacity availability is estimated be of 10-20%, which can limit the connectivity of depots because current grid infrastructure is often sufficient for two to three trucks, but not for more vehicles. This is a major obstacle to a stronger ramp-up of electromobility.

Planning security helps logistics companies to expand their charging networks and also helps grid operators to plan their networks. Moreover, the possibility to identify available grid capacities via non-binding preliminary grid connection enquiries is important for logistics companies.

2.2.4 Grid extension scheme

Status quo

The Federal Network Agency's (Bundesnetzagentur) report on the condition and expansion of distribution networks summarizes information reported by distribution network operators. The data is based on the 2022 survey, in accordance with the applicable § 14 Abs. 2 in conjunction with § 14d of the old Energy Industry Act (EnWG) version. The survey targeted all distribution network operators with more than 100,000 directly or indirectly connected customers. According to the report the expected distribution grid expansion requirements for the next 10 years (as of 2022) amount to 92,642 kilometres of lines that need to be reinforced, optimized, newly built, or replaced (BNetzA 2023).

Section 14d EnWG provides for a rolling process of scenario development and subsequent grid expansion planning for all distribution network operators with more than 100,000 electricity customers. Individual experts highlight that early communication of own plans to the responsible grid operator is important for the planning and prospective creation of additional capacities. If it is known that a certain amount of charging capacity is to be installed in the next few years, the distribution network operator can also expand grid capacities with foresight, according to a workshop participant (BMJ 2024a; Fraunhofer ISI and Oeko Institute 2024a).

Table 2: Distribution grid expansion with increase in transmission capacity in kilometres

New construction, replacement with increased transmission capacity, reinforcement and optimization

	Planned measure	Concrete planning	In construction	Total
HV	11,296	5,588	1,618	18,501
HV/MV incl. MV	1,736	807	64,396	66,939
MV/LV incl. LV	314	73	6,815	7,202
Total	13,346	6,467	72,829	92,642

Future prospects

Stakeholders fear that current network capacity planning does not adequately consider the electrification of heavy-duty transport due to a lack of reliable forecasts for the specific ramp-up and required planning and execution certainty for network expansion measures. Further grid expansion planning should therefore take into account the increasing power requirements resulting from the electrification of heavy-duty vehicles.

2.2.5 Grid connection procedure

Status quo

The time required for the grid connection differs between three months and several years. The duration depends on several factors, like the number of current orders from the grid operator, capacities, distance to the nearest substation, availability of specialized personnel, delivery times of

hardware or whether grid upgrading measures are necessary. If grid upgrading measures are necessary on the part of the grid operator, grid connection can take years according to experts.

Future prospects

Today, grid operators don't have standardized specifications, and each construction of a transformer station is a separate and individual project. In addition, transformer delivery times with up to twelve months represent big challenges for depot charging. One solution to the long transformer delivery times may be to build up stocks or to check whether it is possible and economically sensible to rent a transformer. Another difficulty is the need to make a specific request to a network operator to identify the capacity available. Yet, grid operators are already overwhelmed by the large number of requests.

2.2.6 Electricity cost

Status quo

Electricity prices have a significant impact on the economics of electric truck operation. Table 3 shows electricity prices of household, non-household and industrial consumers.

Table 3: Electricity prices with and without taxes

Category	Annual Consumption according to source	Average price second half 2023 with taxes (€/kWh)	Average price second half 2023 w/o taxes (€/kWh)
Household	2,500 kWh – 5,000 kWh	0.40	0.30
Non-household	500 MWh – 2,000 MWh	0.22	0.19
Industry	> 2,000 MWh	0.15 – 0.20	0.13 – 0.18

Source: (EU 2024a)

Future prospects

As transport companies are energy-intensive businesses a government measure to cap electricity prices ("Strompreisbremse") could be helpful. Note that such a measure would decrease an electricity price spread (assuming dynamic prices) and hence lower revenues that potential flexibility services could yield in.

2.2.7 Grid concession fee (for capacity extension)

Status quo

Depots that electrify their fleets and expand their charging infrastructure might require extensions of existing grid capacities. The overall cost for capacity extension depends on the potential grid connection configuration, coming with different connection capacities (Greve et al. 2022) (Table 4) and directly influencing TCO. Yet, the connectors, i.e., the companies don't have to pay the full costs of the grid connection but only a share, the so-called building costs subsidy ("Baukostenzuschuss").

The building cost subsidy represents a financial contribution to the total cost for capacity extension by the connectors, and is a one-time payment to the grid operator that is intended to encourage connectors to base the amount of connection capacity on their actual needs (BNetzA 2024). For the company, the cost for capacity extension consists of this building costs subsidy, in addition to the civil engineering work, and the control panels (Fraunhofer ISI and Oeko Institute 2024a). Yet, there are very different conditions at different locations, and hence also costs for grid connection, in Germany (Fraunhofer ISI and Oeko Institute 2024a).

Table 4: Grid connection configuration, capacity and investment cost

Grid connection configuration	Grid connection capacity	Investment cost
Integration into existing medium-voltage ring	<= 8 MVA	70-350 k €
Connection to existing medium voltage busbar in the substation via new medium-voltage cable	8 MVA – 20 MVA	0.4-2 million €
Extension of the substation and connection via new medium-voltage cable	20 MVA – 30 MVA	2-5 million €
New dedicated connection to high-voltage network with specially built high-medium-voltage substation	> 30 MVA	6-20 million €

Source: (Greve et al. 2022)

Future prospects

Grid concession fees are perceived as deterrently high by stakeholders in Germany. Hence, some stakeholders request public funding to render the installation of charging stations economically viable. They argue that these costs can typically not be forwarded to the clients, who usually do not pay extra for CO_2-free transport. Furthermore, companies must request grid extension today for a complete changeover, which means high costs, even if they only need it later.

2.2.8 Grid network charge

Status quo

While the level of grid network charges generally affects the TCO for depot charging, the structure of grid network charges, in particular the existence of a capacity-based component of grid network charges can represent an incentive for reducing peaks using smart charging or even V2X and thereby provide a lever to further reduce the depot's cost. In Germany, grid network charges consist of a volume-based (€ct/kWh) and a capacity-based component (€ct/kW) for large customers, i.e., customers with an electricity demand >100 MWh/a and hence registering power metering (RLM, registrierende Leistungsmessung). The average grid network charges differed between commercial and industrial customers in 2023 (BNetzA and BKartA 2023): Commercial customers (typically customers with demand of 10 MWh/a – 2 GWh/a) paid 7.42 ct/kWh including metering point operation (+8% compared to 2022) plus a capacity price if applicable. Industrial customers (typically

customers with demand > 2 GWh/a) paid 3.3 ct/kWh including metering point operation (+12% compared to 2022) plus the capacity price. Grid network tariffs are expected to increase further in 2024 (BNetzA and BKartA 2023). Note that there is substantial variation of grid network charges between different locations in Germany (BNetzA and BKartA 2023).

Future prospects for the deployment of smart (and bidirectional) depot charging

Today, while for most non-residential customers grid network charges include a capacity-based component, they are dominated by the volume-based component. This means that depots with high load peaks e.g., due to fast and/or simultaneous charging typically have to pay high cost due to their (maximum) capacities but are also incentivised to implement smart (bidirectional) charging, potentially reducing TCO and supporting a more efficient network use.

2.2.9 Electricity tariff structure

Status quo

Dynamic prices can incentivize smart depot charging and hence, help to reduce grid congestions and reduce electricity cost and, in doing so, the TCO for depots. Yet, most customers in Germany still have static tariffs and offering dynamic prices is only a requirement for larger customers (> 100 MWh/a). In 2023, the German government adopted the new digitalization law ("Gesetz zum Neustart der Digitalisierung der Energiewende"), requiring all electricity suppliers to offer dynamic electricity tariffs to their customers from 2025 on (BMWK 2023b). In combination with smart (overnight) charging, dynamic tariffs are seen as essential for the business case of depot charging and stakeholders expect this solution to become standard for depot charging within the next 3-5 years (Fraunhofer ISI and Oeko Institute 2024a).

Future prospects

While legislation has changed recently supporting the implementation of dynamic tariffs, they are still new for many logistics companies in Germany and are expected to represent a complicated issue for them: today, already receiving an offer from the respective electricity supplier can represent a challenge, which might even be complicated once dynamic tariffs (have to) come into play. Hence, stakeholders including electricity suppliers and customers such as depot owners have to familiarise with both new price levels and processes which can delay the potential benefits of dynamic tariffs.

2.2.10 Incentives for self-generation of electricity used

Status quo

For depots, it can be interesting to self-generate electricity, e.g., via photovoltaic power plants, in particular to improve the financial attractiveness of the depot. An economic incentive generally exists if self-generated electricity is cheaper than the electricity purchased from the grid. However, whether the usage of self-generated electricity is profitable or not depends on the specific situation, which includes the load profiles of the location, the overall demand and the driving profiles of the fleet. In addition, the greenhouse gas (GHG) quota has become relevant for the owners of electric vehicles and the operators of charging stations (Umweltbundesamt 2024) in Germany with the entry into force of a new regulation (38th Bundes-Immissionsschutzverordnung BImSchV (BMJ 2017)) in January 2022. The GHG quota requires oil companies to reduce their GHG emissions by a specific and continuously increasing quota (2024: 9.35% in relation to the reference value, i.e., the fossil

comparative value (Zoll 2024)). Electric vehicle owners and the operators of (semi-)public charging points can apply to the Federal Environment Agency for the GHG emissions calculated on a flat-rate basis and then offer them for sale to the oil companies obliged to reduce them. Hence, depot owners operating electric vehicles and potentially also charging stations can substantially benefit from this THG quota and generate additional income.

Future prospects

While companies have started to combine depot charging with the installation of a photovoltaic power plant in Germany, there are still challenges around the investments in photovoltaic power such as high initial investment cost and the potentially low grid connection capacity, requiring a gradual build-out of the photovoltaic system. Moreover, the high upfront investments might prevent depot owners, in particular small and medium-sized enterprises (SME), from installing a photovoltaic power plant. Unprofitable investments might endanger the existence of these companies more quickly than of bigger ones.

Moreover, the currently low prices for the reduced GHG emissions in the context of the GHG quota as well as the uncertainty on future price developments prevent an economically attractive business case. In addition, opening the depot charging point to the public might also limit its availability for the original use case, i.e., the depot charging. Moreover, the GHG quota also incentivizes public charging points, which might represent the more attractive charging solution for the customer because of a better availability for the customer than that of semi-public charging points.

2.2.11 Taxation of stored energy

Status quo

Whether depot owners can financially benefit from offering the energy stored in their fleet also as flexibility source to the grid depends on the economics of bidirectional charging. Yet, taxation and payments of further fees and levies reduce the economic attractiveness of vehicle-to-grid (V2G). In Germany, current regulation (i.e., the Energy Industry Act and the Electricity Tax Act) do not exempt mobile storage from grid charges and taxation, respectively. While the Energy Industry Act, mentions that levies for electricity storage and energy loss shall be reduced to zero for stored electricity that is charged from and supplied to the grid within the same year, the definition of storage in the Energy Industry Act focuses on “Anlagen” (plants) and, hence, does not (yet) include mobile storage. Therefore, for mobile batteries, taxation and further grid fees still occur for the electricity when charged, and again for the energy discharged to the grid once consumed by the end-user (smartEn and DNV 2023). Yet, the German government has started to amend the Electricity Tax Law with paragraph 5a (electrive.net 2024; Deutscher Bundestag 2024) to avoid the double taxation of electricity. This would improve the profitability of V2G and further decrease the TCO for depot charging. Grid fees are not affected by the amendment.

2.2.12 Possibility of joining the electricity market/flexibility markets

Status quo

Electricity and flexibility markets can provide options to generate additional revenues for depot owners, e.g., by delaying or postponing charging processes or by providing electricity to the grid (vehicle-to-grid, V2G). In Germany, there is no legal framework for vehicles to join wholesale markets and local markets regulating market-based procurement of local flexibility do not (yet)

exist (smartEn and DNV 2023). Currently, the most attractive business area in this context is seen in the area of busses.

Future prospects

Potential conflicts between the capacity requirements for mobility and flexibility solutions can hinder logistics companies from the provision of flexibility services as business opportunity. Moreover, the regulatory and technical framework conditions currently hinder V2G implementation.

In addition, vehicles capable of V2X are still scarce in Europe but many OEMs have started to implement V2G or announced V2G-capability in the European market (Kühnbach et al. 2024) with a focus on electric cars. European truck manufacturers have also started to look into V2G and plan to adapt their vehicles.

2.2.13 Smart meter rollout

Status quo

Smart meter rollout in Germany is very low compared to other countries (<1% in 2022) (smartEn and DNV 2023) but there are plans for increasing the deployment of smart meters (BMWK 2023a): Mandatory rollout starts from 2025 for customers with an electricity demand of 6.000-100.000 kWh/a and for suppliers with installed capacities of 7-100 kW (in 2023 and on average, a 4-people-household living in a single-family house consumed 5,100 kWh (Statista 2024)). At least 95% of these customers have to be equipped with a smart meter until the end of 2030. For customers with an electricity demand >100.000 kWh/a and suppliers with installed supply capacities >100 kW, mandatory rollout starts in 2028 and at least 95% of these customers have to be equipped with a smart meter until the end of 2032. Customers with annual electricity demands smaller than 6.000 kW and suppliers with 1-7 kW installed capacities are considered optional. Note that large customers (electricity demand >100.000 kWh/a) are required to have RLM with a 15-min measurement and transfer of the average load already today. But also, these customers have to start using intelligent metering systems (intelligente Messsysteme, iMSys) including Smart Meter Gateways.

2.2.14 Standards/protocols for flexibility provision

Status quo

For bidirectional charging, ISO 15118-20 regulates the standardized communication between the vehicle and the charging infrastructure. According to the Cleanroom-Talks of the NLL (Nationale Leitstelle Ladeinfrastruktur), all participating OEMs, which have primarily been German and European OEMs with a market share in passenger cars of nearly 80%, will implement ISO 15118-20 from 2025 (NOW 2024b).

In addition, the protocol OCPP regulates the communication between the charging infrastructure and the backend. OCPP versions 2.0 and more advanced increasingly focus on bidirectional charging (NOW 2024b). OCPP 2.1 is expected to be released in Q1 2025 and includes a new functional block on smart charging (Open Charge Alliance 2024). In the future, IEC 63110 is expected to replace OCPP (NOW 2024b).

Future prospects

Despite the availability of these standards/protocols, a common interpretation is still needed of ISO 15118-2X to ensure the interoperability between the vehicles, charging stations, and distribution grids—a target that is also being pursued by the International Energy Agency's Task – 3 - Interoperability of Bidirectional Charging (INBID) (Task 53 2024). This interoperability means that different vehicles are compatible with different charging infrastructures, which can be of importance for the implementation of bidirectional charging in particular for depot owners with heterogenous fleets and/or semi-private or semi-public depot charging cases.

2.3 Summary for Germany

Local and regional transport will require depot charging

The German logistics sector is characterised by many small companies with few vehicles each. These companies usually act financially risk averse as they cannot bear large investments. Local and regional transport will be the first to require depot charging as long downtimes of vehicles and often single-shift operation allow low-voltage grid connection with low power. In two-shift operation, a higher power solution to recharge en route can fulfil the charging needs. For long-haul transport, depot charging overnight is the lowest cost option and should be accompanied by public charging facilities to cover long distances away from the depot.

Small companies need to be supported in cooperation or with subsidies

While large companies often have their own or rented vehicle depots, smaller companies often leave their trucks at the depots of clients and are dependent on the (non-)existing charging infrastructure. A second obstacle for smaller companies lies in the common contract structure in the transport industry. There are hardly any contracts that run for longer than three years, they are often shorter than one year on average, or the companies even (only) operate on the spot market, where they bid for individual trips or tours. This makes it difficult for small companies in particular to invest in battery electric trucks and charging infrastructure at the depot, as there is insufficient planning security. One possible way to overcome this hurdle is for subcontractors and clients to work together. This can be achieved, for example, through the joint use of charging infrastructure and longer contract periods or higher freight rates when using e-trucks. As small companies in particular suffer from this situation, as they often do not have their own depots, are price-sensitive and have less favourable financial conditions, staggered subsidies for vehicles and infrastructure could also be a solution.

Coordination of grid access and information on grid capacity are lacking

Currently there are no coordination activities at national level in Germany, nor any best practice for a joint and coordinated charging infrastructure setup, but regional activities are ongoing. A coordination could show the need for strengthening the electricity grid and for additional grid connection points as well as avoid conflicts among companies regarding grid connection demand at an early stage. Further, there is general information about BET and depot charging available at this point, but a lack of information on grid connection capacity or consulting services, a lack of information on the consequences of energy regulations and missing expertise by transport companies. At the moment, only some state level subsidies for charging infrastructure and grid connection are available and none for the funding of e-trucks.

Grid availability and connection procedure vary

The availability of free medium-voltage substation capacity varies greatly between locations and can hardly be generalized. Since there are no publicly available overview plans for current state and expansion, this lack of planning security is a major problem for logistics companies and grid operators. For the next 10 years (as of 2022), the expected distribution grid expansion requirements amount to 92,642 kilometres of lines that need to be reinforced, optimized, newly built, or replaced. However, industry doubts that these plans adequately consider the electrification of heavy-duty transport due to a lack of reliable forecasts for the specific ramp-up and demands for planning and execution certainty for network expansion measures. Further, grid connection can take from three months to several years, influenced by a high number of factors (technical, location specific, workforce availability) plus the project specificity caused by a lack of standardization.

Grid connection cost is a big obstacle and barrier for logistics companies

Investment costs for grid connections differ for different connection configurations and can reach from several hundred thousand to 20 million €. EURs, but companies don't have to pay the entire cost of grid connection. The costs for a connection consist of a building costs subsidy, the civil engineering work, and control panels. Grid network charges also differ substantially between customers; volume- and capacity-based component (for large customers) are expected to further increase. As logistics companies state that they cannot forward additional costs to their clients, public funding is requested.

Dynamic tariffs and bidirectional charging can improve the business cases for depot owners

The expected increasing deployment of dynamic electricity tariffs, which are expected to become standard for depot charging, can incentivize the provision of flexibility. There are also incentives to combine depot charging and PV installation, which can make sense from an economical perspective but could have an even stronger effect when selling certificates in the context of the GHG quota. Nonetheless, it is unclear whether the provision of flexibility services will improve the business case of depot charging for all mobility providers and become attractive due to potential conflicts between flexibility and mobility requirements. Technical and regulatory barriers may also be an obstacle, while at least the problem of double taxation has been addressed by the amendment of Electricity Tax Law § 5a.

3 Depot charging in France

3.1 Factors on logistics

3.1.1 Description of transport industry

Status quo

The market of transport companies differs between companies transporting goods on their own account (for example companies producing and delivering their own goods) and companies that provide hire or reward services. These companies transport goods for remuneration, on behalf of third parties (Eurostat 2024b). In 2022, transport for hire or reward makes up 87.7% of the tonne-kilometres travelled in France (SDES 2023).

Most French road freight transport companies are classified as microenterprises (83%), i.e., companies employing fewer than ten people. Small and medium-sized enterprises represent 16% and large companies, having more than 250 employees, only 0.4% of the total number of companies registered in France. Nevertheless, large companies and SMEs generate a majority of the sector's turnover, as shown below.

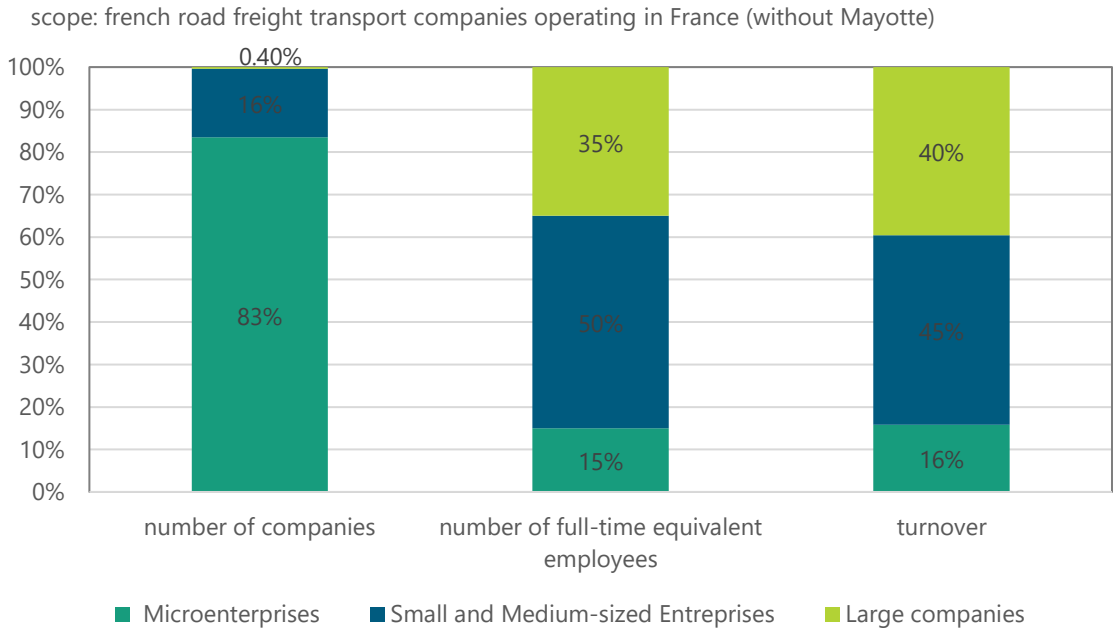


Figure 10: Characteristics of the French freight transport market in terms of company size in 2017 (Source: (Insee 2020))

The turnover of French transport companies is divided between two main types of operation: long-haul transport (mostly intercity road freight transport) represents 63% of the sector's turnover, and mainly use artic lorries (see glossary for definitions), while regional delivery represents 28% in 2017 (Insee 2020) and usually uses rigid lorries. In recent years, the regional delivery transport sector has developed partly thanks to e-commerce, while the turnover of French companies specialising in long-haul transport has been less dynamic, as they face competition from Eastern European companies (Insee 2020). Indeed, French companies handle 93% of national transport (in tkm). On

the other hand, over 90% of international transport to and from France is carried out by foreign carriers (SDES 2023). Thus, foreign transport companies operate 43% of the road haulage activity in France (in tkm) (SDES 2023).

Future prospects

The transport market is characterised by a large number of small companies (83% microenterprises), even if they do not account for the largest share of total turnover of the transport industry (respectively 16% of turnover). In addition, the majority of companies are exclusively involved in transport services, which generally have low margins.

The small fleet size, short contract terms and poor financing conditions for investments therefore pose particular challenges for the procurement of e-trucks for this relevant share of companies in the overall market. Higher freight rates and longer contract periods in the case of the use of BETs by subcontractors could partially offset these risks.

3.1.2 Vehicle Mileage

Status quo

The total distance covered by lorries depends greatly on the type of activity and company operating them. In the second trimester of 2023, around 77% of national road freight transport activity was carried out on routes with an average length of 150 km or more (SDES 2024). This means that less than a quarter of all transport activity is carried out in regional transport with a daily range of up to 150 kilometres. Typically, rigid trucks with lower payloads are increasingly used in regional transport and lorries and articulated lorries with high payloads in long-distance transport. Accordingly, rigid lorries travelled an average of 202 km/day in 2022, while articulated lorries achieved 399 km/day (see also Figure 10) (Delacroix et al. 2024).

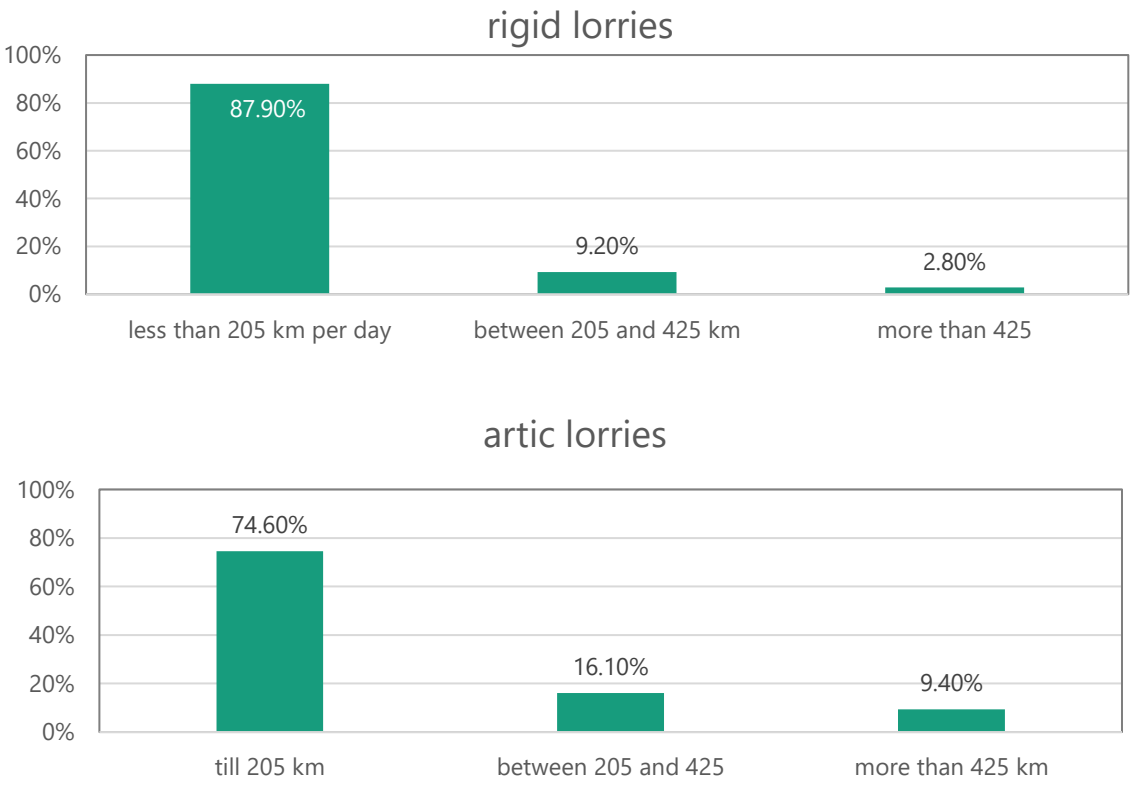


Figure 11: Freight transported (in millions of tonnes) by vehicle type according to their average distance between 2019 and 2021 (IDDRI, 2024)

Given the higher market share of French transport companies in regional transport than in long-distance transport, regional transport is therefore relevant to their business activities. In 2022, 46% of tonne-kilometres transported by French companies were provided by regional transport (i.e. transport where loading and unloading take place in the same region) (IDDRI, 2024).

Future prospects

As daily mileage increases, the importance of depot charging decreases and dependence on public charging infrastructure increases. The high market share of French companies in regional transport shows on the one hand the high potential of depot charging for French companies and at the same time the importance of dealing with the challenges of setting up charging infrastructure at these locations.

3.1.3 Vehicle Usage Pattern

Status quo

The vehicle usage pattern covered by lorries greatly depends on the type of activity and company operating them. Typically, vehicle downtimes are reduced with increasing mileage. High mileages are achieved in long-distance transport through long, uninterrupted journeys. In regional transport, high mileages are achieved in multi-shift operations.

For the potential electrification of trucks, the locations and idle times, which are decisive for battery charging, therefore play a role in addition to the daily mileage.

The stakeholders involved confirmed that in regional delivery transport, it is common for BET to spend long periods at night in the depot, which can then be used for battery charging. Conversely, reservations are still expressed for long-haul transport, as the lorries are sometimes in use both during the day and night (multiple shift operations) and therefore cannot be sufficiently supplied with energy with depot charging. There are also typical usage profiles in long-distance transport that only include driver breaks during the day and are characterised by long downtimes at night. However, these are mainly dependent on public fast-charging stations during the day, as they are not necessarily at their own depot at night.

Future prospects

The electrification of regional transport appears to be feasible in view of the typical usage profiles. According to a manufacturer's forecast, 90% of urban distribution transport and regional transport can be carried out with depot charging. According to this forecast, depot charging plays a much smaller role for long-distance transport, between 45 and 70% - depending on the intensity of use - and a high proportion of charging processes at external depots would also be necessary. If depot charging cannot be realised at suitable depot locations (e.g. due to a lack of space or insufficient grid connection power at the depot), this would further increase the need for public charging infrastructure. Some stakeholders expect that the associated space and energy requirements for the installation of public charging infrastructure along long-distance roads would already be high in the short term and represent a potential obstacle to expansion (Enedis, 2024).

3.1.4 Depot Ownership

Status quo

In the early market phase characterised by a relative absence of public charging infrastructure - access to charging infrastructure in depots is a prerequisite for the electrification of vehicles with generally suitable usage profiles. Reliable data on depot ownership of French transport companies is, however, not available. According to an expert assessment, it can be assumed that all vehicles in regional transport use have access to a depot at night and these are estimated to comprise around one sixth of the stock of HDVs. Estimates for vehicles in other application areas are associated with greater uncertainties. In any case, it is unclear whether and to what extent these depots are owned by transport companies.

Future prospects

In view of the poor data available on depot accessibility, it is not possible to make any reliable statements on the extent of the associated restrictions. In addition to general accessibility, the ownership structure also represents a restriction. If the depot is rented by the logistics company - which is often the case - the tenant must obtain the owner's agreement to install charging infrastructure on their premises. In many cases, the installation of a charging infrastructure also requires authorisations and permits issued by local authorities. The site owner can play a key role in this process by providing the information and documents needed to facilitate obtaining these permits (TLF and UDE 2023).

In this context, one expert also referred to the range of electricity prices at thedifferent truck depots, which vary significantly more than for diesel fuel and can therefore lead to increased distortions of competition. To address these concerns, certain analysts are exploring the possibility of creating an “electricity floater”, similar to the diesel floater, to cover changes in electricity costs. In this way

transport companies could base the transport costs they charge customers on this index, and thus limit exposure to electricity price volatility (Meunier and Sorret 2022).

3.1.5 Planning security

Status quo

Planning security, i.e. long-term contracts, is very important for transport companies to invest in electric lorries due to the high costs of vehicles and infrastructure. However, long-term contracts tend to be the exception in the transport industry. French transport companies often have medium-term relationships with their customers and negotiate pricing structures on an annual basis. According to experts, there is a non-negligible share of spot market activities. It is assumed that around 80% of transport activities are handled via real contracts and 20% via the spot market.

However, there is a differentiation according to the size of the transport companies: smaller companies are more likely to use spot contracts, SMEs tend to have short-term contracts, while large companies sometimes have contracts with shippers with a term of 3 to 5 years.

A survey of 220 companies operating in long-haul transport shows that the majority of companies' customers are direct customers (75.4%), i.e. customers who are not other transport companies (CNR 2023). But significant differences can be observed according to company size: The proportion of direct customers increases with the size of the logistics company from 66% (companies with less than 20 employees) to over 80% (companies with more than 50 employees). It can be assumed that transport companies with direct customers may have greater influence on the terms of the contracts.

Figure 12: Results of the CNR survey: customer profile in% (CNR, 2023)

Future prospects

The high proportion of short-term contractual relationships in the transport industry represents an obstacle to investment in e-trucks, particularly for small companies, which are already exposed to poorer financing conditions.

One possible solution, which has mainly benefited large companies so far, is to extend the contract terms, which can be agreed for up to 7 years in some cases, if customers are also interested in electrification. However, according to experts, this is only possible if the customer can also

guarantee the necessary transport demand far into the future, which is only the case in some sectors.

3.1.6 Restrictions for charging infrastructure

Status quo

The main challenges for the installation of depot charging infrastructure are the space required in the depot, the grid connection and the associated costs for expansion as well as insurance requirements.

For example, the positioning of charging infrastructure must be adapted to the conditions of existing buildings, meaning that charging infrastructure cannot always be placed in the ideal locations. In addition to the costs of charging infrastructure, high costs are often incurred in advance for the grid connection if a grid connection capacity expansion is required.

Insurances tend to add their own recommendations or requirements on top of existing regulations. Sometimes these requirements can be very restrictive (e.g. charging infrastructure away from building and from other vehicles when charging), which disturbs carrier operations. This makes it hard for customers and providers to know exactly what should be included in the project. In addition, implementation options are often restricted by the conditions imposed by the landlord of the premises (see Depot Ownership section).

Future prospects

In view of the different challenges depending on the depot situation, sharing depot charging points or setting up shared charging parks in commercial areas is seen as a solution. This would also allow high grid connection costs to be passed on to multiple users and ensure high utilisation of the infrastructure at an early stage.

In view of the often very restrictive design of insurance conditions for electric trucks, a national or European guideline for safe truck charging would be useful to avoid excessive requirements.

3.1.7 Safety / building regulations for commercial and industrial sites

Status quo

In the context of depot charging, the ICPE (Installation Classified for the Protection of the Environment) is the main driving regulation for charging infrastructures with a capacity of > 600 kW. The ICPE regulations require a declaration to the authorities, followed by their approval (Ineris and République francaise 2018). According to experts, this regulation defines requirements or restrictions regarding the locations of the charging infrastructure, accessibility and fire protection.

Future prospects

Experts involved are aware of the risk that overly strict regulations could slow down or prevent the development of charging infrastructure in depots. Since there is no generally higher safety risk compared to ICE vehicles, care should be taken to ensure that the design of the regulation does not result in "over-regulation".

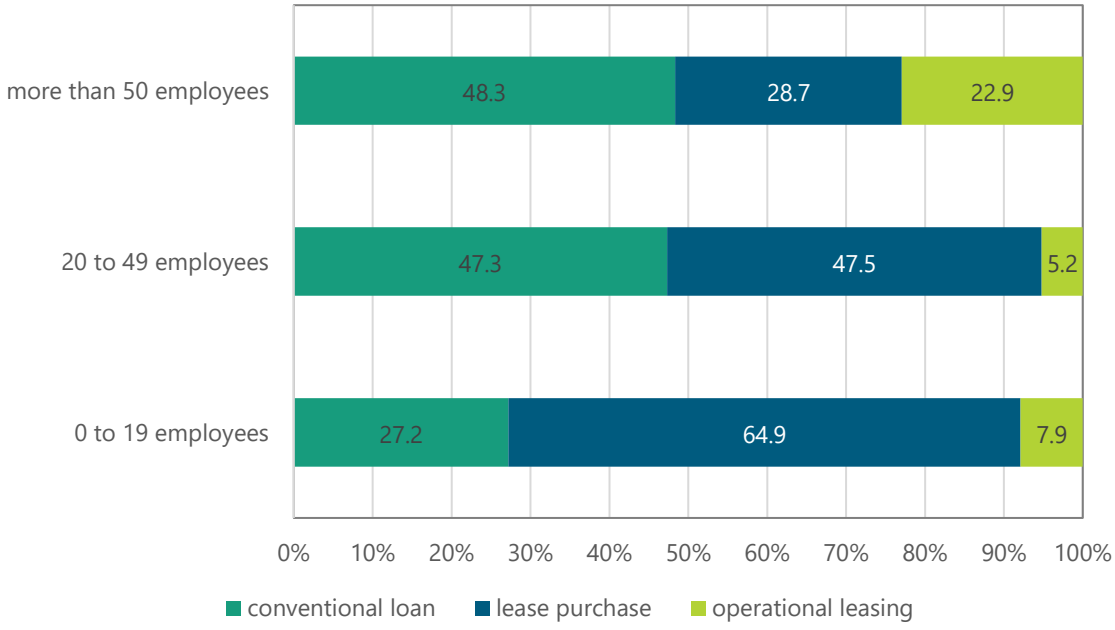
3.1.8 Financial conditions/Investment risks

Status quo

The French transport sector has low margins when delivering goods. For instance, the federation of French SME estimated that they were around 1% in average in 2021 (OTRE 2021). Since then, the situation has not really improved, and experts say the sector is currently in crisis in France. With business activity stagnating and persistent inflation impacting costs, companies are struggling to maintain profitability (Crocco 2024).

Companies finance their lorries differently depending on their size and the associated financing conditions. While large companies predominantly procure trucks on credit, smaller companies increasingly rely on the purchase lease model (see Figure 13).

There are also major differences in insurance costs depending on the size of the company: companies with between 0 and 19 employees spend 66.3% more on fleet insurance than companies with 50 or more employees. The latter benefit from a more favourable balance of power with their insurance providers. (CNR, 2023)



Lease purchase: lease with a purchase option at a price determined when the contract is

Figure 13: Results of the CNR survey: truck financing by company size (CNR, 2023)

Future prospects

Given the significantly higher vehicle prices of BET, electrification is associated with high investments. This is a particular challenge for SMEs, which have smaller profit margins, to raise the initial capital and they are therefore often already today unable to make credit-financed purchases. Although leasing models can provide a remedy, they are usually also very cost-intensive and reduce the flexibility available when purchasing vehicles. Even for large companies, electrifying their fleet by more than 10% could be difficult under the current framework conditions, according to experts.

The increase in initial investment means that it takes longer to reach the profit margin. For this reason, the length of leasing contracts for BETs can have a longer duration than for diesel vehicles and is often based on the warranty period of the battery (8 years) (Geffray et al. 2024).

The increased use of leasing is seen by experts as an obvious response to the procurement of e-trucks. This is already the case for the first BETs sold in France: in 2023, 67% of BETs were financed through leasing, compared to 58% for conventional trucks (Geffray et al. 2024).

Ultimately, however, experts see a reduction in the acquisition costs of BETs as a prerequisite for SMEs to start the transition on their own. It is therefore important to ensure that they are able to manage this transition in the future: to this end, government loans or subsidies should be targeted according to company size, if the BET prices do not drop fast enough (Geffray et al. 2024).

Residual value development is seen as a particularly high investment risk for companies, especially in the early market phase, and it is therefore suggested that studies be carried out on the residual values of BET (Geffray et al. 2024).

3.1.9 Regional coordination of charging infrastructure requirements / expansion

Status quo

In view of the increasing demand for power due to the development of depot charging infrastructure and the limited availability of additional grid connection power, regional coordination of demand is helpful.

Currently, the desired cooperation to coordinate the grid connection among users is not established yet. This means, among other things, that the first party to apply for a connection pays the costs for the grid connection if there was no previous or insufficiently powerful connection. In future, when developing commercial areas, whether public or private, a property developer could coordinate all grid connections and thus share the connection costs and optimise them for all customers. This is a solution that is not currently used for the lorry charging infrastructure and would need to be established.

Future prospects

The lack of coordination to date means that all parties involved lack essential knowledge for the expansion of network capacity. Grid operators lack information on where charging infrastructure is planned and therefore where grid expansion is required. At the same time, the individual transport companies have no planning certainty because they do not know whether neighbouring companies may also require free capacity for depot charging.

The experts involved therefore emphasise that it should be the task of the public sector to create a coordination regulation that prevents the first party from having to pay all connection costs and makes network expansion requirements transparent.

3.1.10 Accessible and hands-on information for transport companies

Status quo

There is a guide to the installation of charging infrastructure at the depot (TLF and UDE 2023). This detailed report contains technical information, a description of administrative process and different steps, subsidies and funding possibilities. No further document on the specific topic of "charging

at depots" was found online in French. However, many webpages from charging station companies and manufacturers provide information on this topic.

Future prospects

There is currently still a major lack of knowledge about the potential of BETs and the concrete implementation of charging infrastructure. Small companies in particular have little personnel capacity to build up knowledge. Communication of the economic benefits of BET and results of the total cost of ownership (TCO) studies directly to transport companies can be further improved.

3.1.11 Availability of consulting services related to e-trucks.

Status quo

Manufacturer consulting services on BET exist and truck manufacturers have included them in their customer journey. For example, Renault trucks offers its support to its customers for site analysis, and work with a set of preferred "turnkey solutions" providers for the charging infrastructure build-up. Additionally, some smaller players, such as start-ups are entering the market. They mostly started on passenger cars but are now also moving into HDVs.

Future prospects

In view of the early market phase and the very different framework conditions for transport companies, it is necessary to expand case-specific advisory services on BET.

3.1.12 Publicly available information on regional grid connection capacity

Status quo

Capareseau (2024) is a map-based online information platform, developed by Enedis provides information on grid capacity for electricity feed-in (renewable energy) as part of the S3RENR programme (www.capareseau.fr). Each company can use an Enedis company account to access the capacities available in the high- and low-voltage grids, but only for renewable energies. Enedis operates 95% of the grid in France, so Capareseau works for 95% of the country.

Future prospects

User-friendly and transparent information on available network capacities is of central importance for companies planning to set up charging infrastructure. Ideally, according to the stakeholders involved, an online map would be available that provides address-specific information on network capacity so that they can judge for themselves whether and where depot charging infrastructure can be connected.

3.1.13 National / regional incentives for purchase and operation of e-trucks

Status quo

There are currently both national and regional funding programmes for BET.

(1.) E-TRANS funding programme (Ministère de l'Écologie 2024) with a call for proposals for BET projects. Several rounds have already been completed or are in the review phase. Grants are awarded on the condition that a decarbonisation strategy is pursued (awareness-raising and training on modal shift issues, full fleet diagnosis, preliminary analysis, submission of a

comprehensive decarbonisation strategy). The amount of the subsidy for the purchase or lease of a BET or the retrofitting of an ICE vehicle can be up to 50% of the additional costs compared to a conventional vehicle, up to a maximum of:

- 65,000 € per category N3 vehicle (> 12t)
- 90,000 € per semi-trailer

(2.) Promotion of very small, small and medium-sized enterprises with a call in summer 2024 by the French Agency for Ecological Transition (ADEME Presse 2024). The result was a promotion of 248 BET for SMEs.

- 20,000 € for BET with 7.5 t < weight < 12 t
- 65,000 € for BET with 16 t < weight < 32 t
- 90,000 € per semi-trailer

The maximum amount of the subsidy is 1 million € or 20 vehicles per company. The subsidy is on a first-come, first-served basis. The final selection was made at the end of 2024.

Further subsidies are sometimes available at regional level. For example, in Ile-de-France subsidies of up to 9,000 € for lorries over 3.5 tonnes are available, and they can be combined up to the maximum amount specified in EU regulations (Région Île-de-France 2024).

Future prospects

The current financing of BET funding is planned for the period from 2024 to 2027. However, according to experts, the budget (130 million €) could already be used up by 2025. A total volume of 200-300 million € in 2026 would be desirable, as the market for electric trucks is expected to gain in importance then.

So far, these subsidies have generally gone to large companies. Therefore, in 2024, there was a demand for explicit SME funding. Experts also assume that vehicle prices will fall and then become increasingly affordable for small companies. It should therefore be decided at a later date whether public funding for SMEs should be retained. However, the aim of the funding should be to ensure fairness between companies of different sizes.

In principle, it is noted that transport companies need a simplification of the application process as an incentive. Current tenders are assessed as complex and time demanding, and the lack of long-term planning is criticised. Additionally, a single platform containing official information for transport companies about the subsidies available, as well as a simulation tool to identify the relevant financial aid for their businesses would be helpful (Meunier and Sorret 2022).

3.1.14 National / regional incentives for installation of charging infrastructure

Status quo

Funding programmes for building charging infrastructure are available at national and regional level.

(1.) The ADEME Advenir-programme (Advenir 2024) supports the first 1,000 charging stations in depots for municipalities or companies and has a 50% subsidy rate for the installation of charging stations, which is further differentiated according to the following performance classes:

- between 12 and 43 kW AC: 2,200 € excluding VAT
- between 20 and 40 kW DC: 3,300 € excluding VAT
- between 41 and 140 kW DC: 7,500 € excluding VAT

- over 140 kW DC: 15,000 € excluding VAT

(2.) The last ADEME call for funding applications for charging infrastructure took place in 2022. Due to budgetary constraints, the budget allocated to the 2023 call had to be reduced, making it impossible to award new subsidies under this scheme (ADEME 2023).

At the regional level, there are various support schemes for electric vehicle charging stations that are not specific to BET. See, for example, the Grand Est region, which provides grants of up to 50% of the project costs, with a maximum of 1,000 € per charging station (GrandEst 2024).

Future prospects

Given the difficulty to predict market dynamics of BET, these should be continuously monitored in order to adapt the Advenir-programme to market dynamics in terms of the allocated budget if necessary.

3.1.15 National / regional incentives for grid connection

Status quo

The Advenir programme also includes subsidies for the grid connection for the first 1,000 charging points in depots for municipalities or companies (Advenir 2024).

Subsidies are granted for the grid connection of the depot - i.e. for the connection application procedure, for the transformers, etc. The amount of funding is differentiated according to the following performance classes:

- ≥ 500 kVA: 100,000 € excluding VAT
- ≥ 1,000 kVA: 160,000 € excluding VAT
- ≥ 2,000 kVA: 240,000 € excluding VAT
- ≥ 4,000 kVA: 480,000 € excluding VAT
- ≥ 8,000 kVA: 960,000€ excluding VAT (but requirement to have a rapid charging point)

Future prospects

Given the difficulty to predict market dynamics of BET, these should be continuously monitored in order to adapt the Advenir-programme to market dynamics in terms of the allocated budget if necessary.

Additionally, an upfront cost cover mechanism to spread the connection costs over a longer period of time (no one-off payment) would be useful for companies that do not have access to large capital savings.

3.2 Factors on energy

3.2.1 Current electricity generation mix

Status quo

In France, 25% of the electricity was generated by renewable energy sources, 14% by fossil fuels and 62% by nuclear power in 2022 (EC and EU 2024). In 2023, the share of electricity generated from renewables increased slightly to 26% (Ember 2025).

3.2.2 Future electricity generation mix

Status quo

In the draft updated NECP, submitted on 17 November 2023, France aimed to reach a share of 33% renewable energy in gross final consumption by 2030. This target is below the 44% target resulting for France from EU legislation (EC 2023). With the Energy and Climate Law adopted in 2019, France has committed to achieve carbon neutrality by 2050 (légifrance 2019).

3.2.3 State of grid infrastructure

Status quo

The condition of the grid infrastructure, including available capacities at substations and the distances between substations and industrial estates, varies by region. Enedis, France's electricity transmission system operator, manages 95% of the distribution network (EEF 2024).

3.2.4 Grid extension scheme

Status quo

There is currently no publicly available information. However, a French DSO is currently carrying out a study to estimate charging needs and their impact on the electric distribution network. This study includes depots, on-route (e.g. at public charging stations) and destination charging (e.g. at third-party depots). First results are planned to be available by the end of 2024. Enedis is planning to integrate conclusions of this study into their plans for the development of high-voltage networks.

Future prospects

A report of a working group on the on-highway charging needs of nine companies suggested regulatory, administrative, and financial frameworks to proactively address connection requests and expedite administrative procedures. In addition, the report proposed to optimize joint investments in stopping areas and the need to clearly define roles and responsibilities of each stakeholder involved (Enedis et al. 2024).

3.2.5 Grid connection procedure

Status quo

Depending on factors such as location, the grid connection process can take between a few months for medium voltage to a few years if a new substation is required.

In industrial areas, however, grid capacity and access to a high-voltage grid are already available, while motorway service areas are further away from substations. Stakeholders have the impression that France has a better grid connection capacity and simplicity compared to other EU countries.

3.2.6 Electricity price

Status quo

Electricity prices have a significant impact on the economics of electric truck operation. Table 5 shows electricity prices for households and non-households.

Table 5: French electricity price with and without taxes

Category	Annual Consumption according to source	Average price second half 2023 with taxes (€/kWh)	Average price second half 2023 w/o taxes (€/kWh)
Household	2,500 kWh - 5,000 kWh	0.25	0.21
Non-household	500 MWh - 2,000 MWh	0.22	0.22

Source: (EU 2024a)

One stakeholder reported that companies with depots requiring over 36 kVA of subscribed power frequently engage brokers to secure market deals with flexible tariffs. These tariffs are diverse and can fluctuate significantly due to factors such as price volatility influenced by geopolitical events and weather conditions, as well as the negotiating power of the companies. Over the past year, these tariffs have ranged from 0.15 € to 0.40 € per kWh, excluding VAT. Stakeholders reported that the electricity price for depots is approximately 0.12 € to 0.15 € per kWh.

3.2.7 Grid concession fee (for capacity extension)

Status quo

Companies that electrify their fleets and install charging infrastructure in their depot might require extensions of existing grid capacities. Costs for grid extension can vary significantly between depots, reaching up to 300,000 €(Fraunhofer ISI and Oeko Institute 2024b). While some grid operators have scales to estimate cost per meter of grid extension (i.e., cable) for high and low voltage, estimating the costs for adapting substations is more complex.

3.2.8 Grid network charge

Status quo

While the level of grid network charges generally affects the TCO for depot charging, some components of the structure of grid network charges, such as a capacity-based component, can be levered to reduce peaks by using smart charging or even V2X, thereby reducing the cost of electrifying depots. Grid network charges in France are a combination of volume and capacity-based charges (ACER 2023). Although the volumetric part is still predominant (smartEn and DNV 2023), the grid network charge depends on the utilisation; large customers typically have a relatively high capacity-based component and relatively low volume-based component (Fraunhofer ISI and Oeko Institute 2024b). This means that depots with high load peaks e.g., due to fast and/or simultaneous charging typically have to pay high cost due to their high (maximum) capacity requirements and, therefore, have an incentive to implement smart (bidirectional) charging to use the network more efficiently and reduce TCO.

3.2.9 Electricity tariff structure

Status quo

Dynamic prices can incentivise smart depot charging and can, therefore, help to reduce electricity costs, grid congestions and, in doing so, the TCO for depot electrification. In France and in general, there are non-regulated and regulated (only EDF) tariffs, which both can be advantageous or disadvantageous for the TCO for depot charging depending in their specific structure and design. On the one hand, regulated tariffs are divided into base, peak and off-peak tariffs (smartEn and DNV 2023) and can, hence, incentivize smart charging and result in lower TCO. Moreover, potential price limits that have been set by the government for regulated tariffs can protect customers from substantial increases in market prices. On the other hand, business customers not covered by the regulated rate negotiate their prices with their supplier and contracts might be more customized than regulated tariffs and potentially yielding in higher benefits for customers. These contracts typically last for one or more calendar years, and prices can be fixed, seasonal and/or indexed to the spot market (Dunand et al. 2023), meaning that customers can be affected by market developments. Some customers can adjust prices in real-time and hence, quickly react to beneficial market developments which can result in lower prices and reduce energy cost (Fraunhofer ISI and Oeko Institute 2024b) and therefore the TCO for depot charging.

3.2.10 Incentives for self-generation of electricity used

Status quo

Like in other countries, the self-generation of electricity, e.g., via photovoltaic power plants, can be interesting for depot charging. An economic incentive generally exists if self-generated electricity is cheaper than the electricity purchased from the grid. However, whether the usage of self-generated electricity is profitable or not depends on the specific situation, which includes the load profiles of the location, the overall demand and the driving profiles of the fleet vehicles.

In France, consumers are exempted from paying TICFE, the domestic tax on final electricity consumption (2.25 ct/kWh), for self-consumed photovoltaic power, which can substantially improve the profitability of photovoltaic systems (Donnell 2019) and hence also the TCO for depot charging.

In addition, the TIRUERT (Taxe Initiative Relative à l'Utilisation d'Énergie Renouvelable dans les Transports) incentivizes the use of renewable energy in transport. Since 2022, also renewable energy provided by public charging stations is eligible for the tax credits (Greenea 2024), which are multiplied by a factor of 4 in this case, allowing for tax credits around 80 EUR/MWh (Gouvernment and France Nation verte 2023). Private charging stations are not eligible yet.

Future prospects

High upfront investments might prevent depot owners, in particular small and medium-sized enterprises (SME), from installing a photovoltaic power plant. Unprofitable investments might endanger the existence of these companies more quickly than of bigger ones. Furthermore, keeping tax exemptions for the self-consumption of renewable power and extending tax credits for the use of renewable energy in transport also to private charging would be beneficial for the profitability of depot charging.

3.2.11 Taxation of stored energy

Status quo

Whether depot owners can financially benefit from offering the energy stored in their fleet also as flexibility source to the grid depends on the economics of bidirectional charging. Yet, taxation and payments of further fees and levies reduce the economic attractiveness of vehicle-to-grid (V2G). In France, the removal of double taxation was agreed by the government and has started to be implemented for stationary storage (smartEn and DNV 2023). This would improve the profitability of V2G and could further decrease the TCO for depot charging.

3.2.12 Possibility of joining the electricity market/flexibility markets

Status quo

Electricity and flexibility markets can provide options to generate additional revenues for depot owners, e.g., by delaying or postponing charging processes or by providing electricity to the grid (vehicle-to-grid, V2G). In France, distributed energy resources including V2G are allowed to participate in wholesale and balancing markets. RTE (Réseau de Transport d'Electricité) announced the first aggregator qualified for flexibility provision in ancillary markets in 2022. Local flexibility markets exist but V2G participation is still scarce (smartEn and DNV 2023).

While vehicles capable of V2X are still scarce in Europe, many OEMs have started to implement V2G or announced V2G-capability in the European market (Kühnbach et al. 2024) with a focus on electric cars. European truck manufacturers have also started to investigate V2G and plan to adapt their vehicles.

3.2.13 Smart meter rollout

Status quo

France has successfully rolled out smart meters which are compatible to communicate with energy management systems with a penetration rate of >92% (smartEn and DNV 2023).

3.2.14 Standards/protocols for flexibility provision

Status quo

For bidirectional charging, ISO 15118-20 regulates the standardized communication between the vehicle and the charging infrastructure. The protocol OCPP regulates the communication between the charging infrastructure and the backend. OCPP versions 2.0 and more advanced increasingly focus on bidirectional charging (smartEn and DNV 2023). OCPP 2.1 is expected to be released in Q1 2025 and includes a new functional block on smart charging (Open Charge Alliance 2024). In the future, IEC 63110 is expected to replace OCPP (NOW 2024b).

Future prospects

Despite the availability of these standards/protocols, a common interpretation is still needed of ISO 15118-2X to ensure the interoperability between the vehicles, charging stations, and distribution grids—a target that is also being pursued by the International Energy Agency's Task 53 - Interoperability of Bidirectional Charging (INBID) (Task 53 2024). This interoperability means that different vehicles are compatible with different charging infrastructures, which can be of importance

for the implementation of bidirectional charging in particular for depot owners with heterogenous fleets and/or semi-private or semi-public depot charging cases.

3.3 Summary for France

Depot charging is sufficient for a large number of French trucks

80% of French lorries drive less than 205 km per day, 46% focus on regional transport. Large shares of these transport activities will use and require depot charging. Overnight charging at low power will often be sufficient due to long downtimes and be more challenging in case of multi-shift operation and long-haul transport. Limitations exist, however, due to space restrictions and a high power demand is already expected in the short term. The depot ownership remains unclear but may be a downside if authorizations and permits are required and the depot is rented. Different depot electricity prices between transport companies could also lead to distortion of competition among logistics companies.

A large number of small companies with short-term contracts makes it especially challenging to switch to electric trucks

The French transport industry is characterised by a large share of small companies (83%). Further, regional transport is dominated by French companies, while there is a high share of foreign companies in long-haul transport. The small fleet size, short contract terms and poor financing conditions for investments therefore pose particular challenges for the procurement of e-trucks for this relevant share of companies in the overall market. Most French transporting companies have medium-term contracts with annual price negotiations and about 80% of shipments are procured via contracts, 20% are traded on the spot market. SMEs usually hold short-term contracts which makes it especially challenging to invest in expensive electric trucks, while contracts of large shippers often last 3-5 years. One way out is to increase the use of truck leasing on one side. On the other side agreements on seven-year contracts instead of 5 for large companies for example would guarantee the demand, in a challenging market where competition is high, with margins around 1%.

Charging infrastructure setup faces challenges and coordination is requested

The main restrictions for setting up charging infrastructure are space, grid connection capacity, grid connection cost and insurance requirements. In such cases, shared depot charging points could be an option to still provide access to charging infrastructure. In addition, the ICPE requirements (environmental protection standards) could be simplified in order to reduce the restrictions on the installation of charging infrastructure. A coordination for grid extension and connection does not exist and would be helpful.

Grid access seems less problematic in industrial areas, yet coordination would help

There are future grid extension schemes that focus on energy generation and several grid operators work on determining and integrating the demand for truck charging at the moment. Further, there is a need for regulatory, administrative and financial frameworks to proactively address connection requests in particular for on-highway charging. Roles and responsibilities also need to be defined: to identify which stakeholder is in charge of planning, applying for grid capacity, setting up a semi-public charging infrastructure and of operating it. The grid connection procedure can take long,

but industrial areas typically have good access to grid capacity and a high voltage grid. The grid concession fee strongly depends on the location and might be costly in some cases.

The information availability and funding options are high compared to other countries

There are some information/guidelines about charging infrastructure installation available, but more would be helpful. A map-based online information platform on grid capacity for RES feed-in is also available and can be used. There is also an explicit depot charging programme with charging point and grid connection funding for first 1,000 charging points installed. Furthermore, there are subsidies for e-trucks on national and regional level, yet their applying conditions are complex and currently mainly used by large companies.

Conditions for vehicle-to-grid seem relatively favourable, an extensive use also depends on the technical development on the vehicle side

Incentives for self-generation of electricity used exist, i.e. lower production cost or an exemption from domestic tax for final electricity consumption. Public charging stations with RES are also eligible for tax credits. Although the smart meter rollout is at more than 92% and V2G is allowed to participate in wholesale and ancillary markets as well as local flexibility markets, V2G is still scarcely used, which might be caused by a lack of technically capable vehicles or by hurdles regarding economic attractiveness.

4 Depot charging in Spain

4.1 Factors on logistics

4.1.1 Description of transport industry

Status quo

Like the other European countries, the Spanish road freight transport market is structured around two company types: The companies specialised in transportation of goods on behalf of third parties, that providing hire or reward services, that own 80,3% of the HDVs registered in Spain, and the companies transporting goods on their own account, account for the remaining 19,7% (MITMA 2022).

The Spanish structure of the road freight transport sector is heavily fragmented. There are around 60,000 Spanish companies specialised in heavy road freight transport, and they have on average 4 vehicles per company. Half of them have only one vehicle and about 80% have less than 5 vehicles (MITMA 2022).

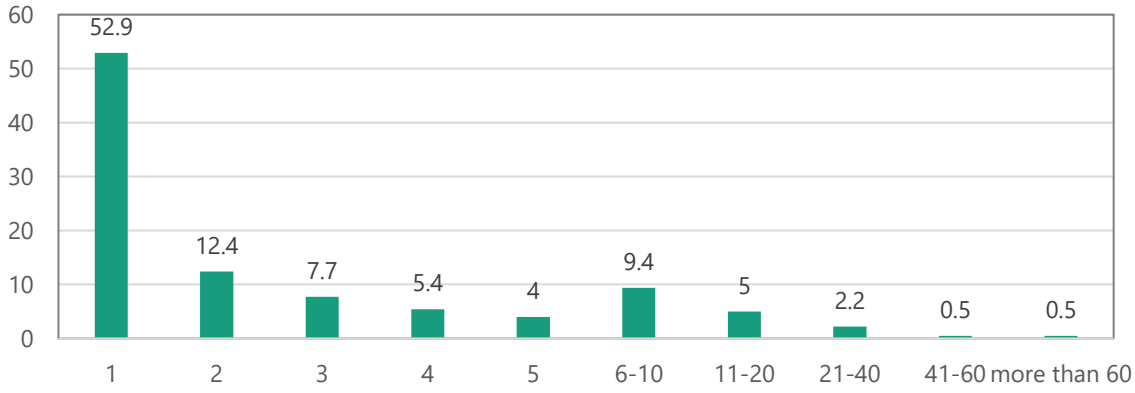


Figure 14: Distribution of road freight transport companies providing hire or reward services according to the number of registered HDV per company in 2022 (MITMA 2022)

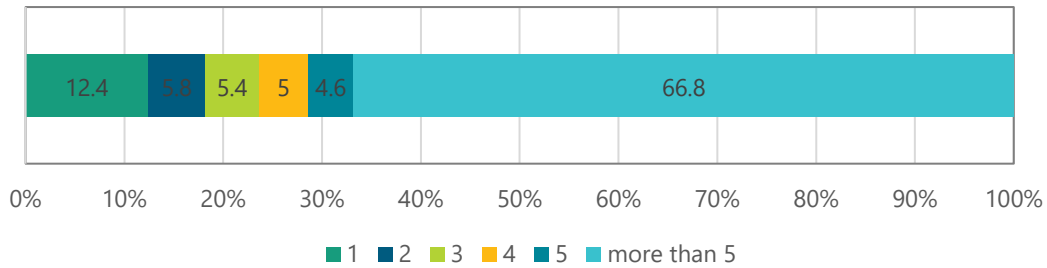


Figure 15: Distribution of HDV according to the number of vehicles authorised per company providing hire or reward services in 2022 (MITMA 2022)

An expert reports that in 2022, only the fifty largest companies in this sector had an annual turnover of more than 50 million euros.

Spain is one of the countries with the highest volume of goods transported by road among EU countries (Stenning et al. 2022). Moreover, the share of international road freight transport versus domestic transport is significant. In 2023, around 70% of transport performance in national traffic and 30% in international traffic was provided by national transport companies (MITMA 2024b).

Future prospects

With regard to the electrification of HDVs, the high number of small companies represents a challenge. Low flexibility in the vehicle fleet, poor financing conditions and lower personnel capacities for knowledge building are relevant in this context.

4.1.2 Vehicle Mileage

Status quo

It's worth highlighting that Spain is one of the countries with the highest daily mileage among EU countries (T&E, Cambridge econometrics, 2022) (Stenning et al. 2021). The total distance covered by lorries depends greatly on the type of activity and company operating them.

Available data (MITMA 2024b) shows the following average annual mileage by type of vehicle in 2024:

- general semitrailer tractor (= artic lorry): 120,000 km/year, of which 102,000 km/year loaded and 18,000 km/year empty, 225 days on the road per year with an average daily mileage of approx. 533 km.
- semitrailer tractor in international transport: 150,000 km/year, 250 days on the road per year with an average daily mileage of approx. 600 km.
- lorry with trailer: 120,000 km/year, 225 days on the road per year with an average daily mileage of approx. 533 km.
- 3 axes rigid lorry: 95,000 km/year, 225 days on the road per year with an average daily mileage of approx. 422 km.
- 2 axes rigid lorry: 90,000 km/year, 225 days on the road per year with an average daily mileage of approx. 400 km.
- 2 axes rigid lorry making regional delivery: 70,000 km/year, 225 days on the road per year with an average daily mileage of approx. 311 km.

Of the 178,000 tkm transported in Spain on the national territory by LDV and HDV in 2023, 1% takes place in the same city, around 26% takes place in the same region, and the rest is interregional transport (MITMA 2024d). We can assume that most of intracity transport is realised with LDV, and that transport happening in the same region corresponds to regional delivery transport, mostly transported with HDV among others by rigid lorries.

Future prospects

In general, the importance of depot charging is likely to become more demanding as the daily driving distance of trucks increases. This is because on longer routes and in long-distance transport, the time spent in the depot is reduced and high charging capacities are required for longer ranges. The requirements for depot charging will also depend on how quickly a public charging network will be available and whether longer transport routes will be electrified at an early stage.

Since the Spanish transport market is characterised by a relatively high proportion of trips with high ranges, it can be expected that the development of public charging infrastructure will be of great importance very soon.

4.1.3 Vehicle Usage Pattern

Status quo

The vehicle usage pattern of lorries greatly depends on the type of activity and company operating them. In general, the deployment profiles differ between regional and long-distance traffic as well as between single and multiple shift operations. In addition to the range requirements, the downtimes and locations are particularly relevant for assessing the suitability for the use of BET and depot charging. For Spain, there is data on general vehicle use, which shows a high proportion of long-distance traffic (see vehicle mileage), but no detailed information on usage profiles.

Future prospects

As already discussed with regard to the influencing factor of vehicle mileage, the high proportion of long-distance traffic in the overall transport performance means particularly high demands on the charging infrastructure. The high proportion of vehicles with high daily mileage requires high charging capacities per vehicle at an early stage for the electrification of depots.

4.1.4 Depot Ownership

Status quo

There are no reliable figures on the availability and ownership of depots by transport companies. According to expert assessments, small companies in particular often do not have their own depots; these are primarily owned by larger companies. Industry associations do not have clear information on that matter either.

Future prospects

For the early use of BET, the ownership or at least access to depot charging infrastructure is crucial. Given the current situation, the conditions for small companies in this regard seem particularly unfavourable. In addition, however, the availability of a depot does not necessarily enable the development of charging infrastructure, as the land is often owned by third parties and the consent of the landowner is necessary for the set-up of charging points. In addition, investing in depot charging infrastructure can represent a high investment risk if the depot lease period is short.

4.1.5 Planning security

Status quo

As in other European countries, short-term contracts are most common in the Spanish road freight transport sector, especially for small transport companies. Experts emphasise that only larger transport companies sometimes have contracts with a contract duration of 2 years or more.

Future prospects

The usual short contract duration represents an investment risk for transport companies when purchasing electric trucks, as these cannot be used across the board in the early market phase due

to a lack of infrastructure and also require considerable additional investment. After a contract expires, their use – especially for small companies with small fleet size – is therefore subject to risks on an operational and financial level.

4.1.6 Restrictions for charging infrastructure

Status quo

The available grid capacity is seen as the main restriction for the development of depot charging infrastructure, but the experts involved point to regional differences. It is pointed out that some companies already share grid connections and, if they do not have a reservation in the grid, they can only use the variable available capacity.

The expansion of grid capacities is considered to be very time-consuming in some cases, with experts citing implementation periods of up to 2 years. The administration generally has a period of 3 months to decide on and register a procedure for grid expansion.

Due to the topology of the country, there are fewer logistics centres compared to other countries with a similar population in Europe, but these are larger. This means that the electrification of trucks in many of these logistics centres will most likely require the construction of a grid substation at these locations, the costs, operation and maintenance of which will be borne by the logistics centre operators (AEDIVE 2024).

Future prospects

In view of the high costs for the logistics operator for the grid connection, stakeholders believe that the logistics operator should not be obliged to install, operate and maintain relevant grid facilities, such as electrical substations, but that these should be financed elsewhere (AEDIVE, 2024).

4.1.7 Safety / building regulations for commercial and industrial sites

Status quo

There is no specific regulation for the construction of HDV charging stations. The plan for the charging points should follow the technical regulation for low-voltage electrical installations ITC-BT-52 (Boletín Oficial del Estado 2014), which establishes a series of technical requirements that must be met by charging facilities for electric vehicles, e.g. in relation to the location of the charging points, fire safety, signalling, etc.

In addition, prior authorisation from the authorities is required for the installation of charging stations with a capacity of more than 3,000 kW (gencat 2024).

4.1.8 Financial conditions/Investment risks

Status quo

In general, expensive purchases (e.g. of lorries) are a challenge in the industry due to low margins and a high number of small companies. According to a study by Crédito y Caución, small Spanish transport companies were among the most indebted companies in the country in 2022 (Aspuru 2023).

When companies want to buy a truck with credit, they are often turned down by conventional banks because the investment is considered to be too risky. This is why vehicle manufacturers often offer

services from their own specialised banks. In principle, several financing systems are available to companies: loans, purchase leasing and operating leasing.

Future prospects

The price of BETs is currently still very high, as is the charging infrastructure, meaning that electrification is associated with high additional investment costs for companies. This poses a particular challenge for SMEs, which have lower profit margins and therefore have to increasingly switch to leasing offers as they cannot realise the purchase with credit financing.

In Spain, one possible option for SMEs could be to work together by forming a 'mutual guarantee society' in order to gain access to favourable credit terms. The public authorities can then support these societies by proposing information programmes tailored to the SMEs (MITMA 2022).

With regard to charging infrastructure, experts also see the financing of semi-private or semi-public charging infrastructure by a charging infrastructure provider as a solution.

4.1.9 Regional coordination of charging infrastructure requirements / expansion

Status quo

In view of the challenges posed by the grid connection and the additional capacities required, early coordination of future requirements is helpful in order to ensure that the grid is expanded and connected in line with demand and to avoid competition between different users. However, according to the stakeholders involved, such cross-company cooperation or regional demand coordination has not yet been established.

Future prospects

Without regional and cross-company coordination of future power requirements through the development of depot charging infrastructure, there is a risk that potential bottlenecks will be recognised too late, and the necessary network expansion and connection will be initiated too late. This could slow down the market ramp-up of BETs and lead to competitive situations between users.

4.1.10 Accessible and hands-on information for transport companies

Status quo

To date, no application-oriented documents on the specific topic of "charging at depots" are available online in Spanish. However, there are many websites of charging infrastructure companies and manufacturers on this topic.

According to the experts, existing information on the nation-wide network of public charging stations is insufficient, as the databases provided for this purpose are not complete and up to date. For example, not all stations are registered and there is no information on availability and accessibility for lorries.

Future prospects

The experts involved recognise the need for independent and 'official' information on technical details of electrification of the truck fleet, a description of the administrative process and standards,

subsidies and funding opportunities available. This information is seen as very relevant to reduce the knowledge deficit among transport companies and increase interest in BETs.

4.1.11 Availability of consulting services related to e-trucks.

Status quo

According to the experts involved, there are still only a few consultants in Spain on the electrification of truck fleets and their knowledge is very limited as there is still a lack of practical experience.

Future prospects

Given the early stage of the market, only a few advisory services are available so far. However, such services are of great importance for the electrification of fleets for transport companies, as they do not have this knowledge themselves and often do not have the capacity to build up this knowledge.

The Spanish Association of Companies for the Promotion of Electric Mobility (AEDIVE) is calling among other things for logistics companies to be given easily accessible information about the electric lorries available on the market (AEDIVE 2023).

4.1.12 Publicly available information on regional grid connection capacity

Status quo

This is the most needed information when planning charging infrastructure deployment. Each DSO should publish a map with available capacity of each of its connection points (e-distribucíon 2024), according to the Royal Decree 1183/2020 (Boletín Oficial del Estado 2020). This decree states that "Operators of the electricity distribution networks must have web platforms dedicated to the management of connection requests, processing, and information on the status of the request. […] Platforms referred to in the previous section shall provide information on the existing access capacity at each node". However, this information is not yet available via a centralised online platform.

Future prospects

In view of the great importance of the available network capacity for the installation of charging infrastructure, the relevant information should be available as easily and transparently as possible. In this context, the experts involved call for the data to be made available to the public in an aggregated form wherever possible.

CPOs and logistics companies should be provided with the network capacity map as a basis for planning at connection point level wherever possible (AEDIVE, 2024). The mandatory publication of grid capacities in Europe starting mid of 2025 will address this issue (Rosslowe et al. 2024).

4.1.13 National / regional incentives for purchase and operation of e-trucks

Status quo

The Spanish Ministry of Transport, Mobility and Urban Affairs has approved the transfer of 400 million euros of European funds to the autonomous communities of Spain and the cities of Ceuta and Melilla to stimulate the electrification of road freight transport. The programme was launched in 2021 (MITMA 2024e) and ended in April 2024. The programme for the transformation of road freight transport vehicle fleets provided subsidies defined through the Royal Decree 983/2021 to

help the decarbonisation of road freight transport (Boletín Oficial del Estado 2021b). The terms and conditions of the grants have been changed in 2022 (Boletín Oficial del Estado 2022) and 2023 (Boletín Oficial del Estado 2023).

This programme provided financial support for the purchase of BETs. The amount of financial support depended on the size of the company (MITMA 2024a).

For example, for a N3 BET > 16T subsidies went up to:

- 190,000 € for small companies and freelancers
- 160,000 € for medium size companies
- 130,000 € for large companies

By August 2024, 470 BETs have been funded by this programme (MITMA 2024c).

Future prospects

With regard to the funding programme, the communication of the responsible authorities is criticised. It is said that there was no clear and uniform official communication channel, and that manufacturers and logistics companies received no information during the application process as to whether funds were available or not, whether the applications were being processed, approved and paid out and whether or when the aid amounts would change (AEDIVE, 2024).

Reference is made to cases where autonomous regions and cities have not approved a single dossier and or are months behind schedule. Additionally, each autonomous region required different justification documents. Stakeholders indicate that this procedure should be harmonised.

The workshop participants added that the funds were not distributed in proportion to the volume of registered lorries per region, which in some cases made it impossible to obtain sufficient subsidies. Furthermore, it was emphasised that the subsidies do not even cover 30% of the vehicle costs.

It is still unclear whether the funding programme will be continued after 2024.

4.1.14 National / regional incentives for installation of charging infrastructure

Status quo

The same programme that subsidises vehicle procurement (see previous section) also offered financial support for charging infrastructure (MITMA 2024e). The installation of charging points for electric vehicles of types M2, M3, N2 and N3 purchased under the same programme is subsidised.

The amount of the subsidy may not exceed 40% of the total eligible costs. This limit can be increased by a certain percentage depending on the business size (MITMA 2024a).

- 60% for small companies and freelancers
- 50% for medium-sized companies
- 40% for large companies (MITMA 2024a)

The subsidy corresponds to the lower of the following values:

- 10,000 € for 50 kW ≤ power <100 kW; 25,000 € for 100 kW ≤ power <150 kW; 40,000 € for 150 kW ≤ power <350 kW; 70,000 € for power ≥ 350 kW.
- 40% (50% or 60%, depending on the type of company) of the eligible costs.

By August 2024, 174 applications for funding were approved and financed through this programme: 60% of them for charging infrastructure with a capacity between 150 and 250 kW, around 13% for capacities above 350 kW and the rest for capacities below 150 kW (MITMA 2024c).

Future prospects

The profitability of BETs depends on the one hand on the price of the vehicles and on the other hand on the level of operating cost benefits. In the context of the existing funding scheme, it was therefore suggested by the stakeholders involved, that in a first phase, support for the purchase of trucks should be complemented by measures to reduce the price of electricity in order to make the vehicle's TCO competitive with that of the diesel counterpart.

4.1.15 National / regional incentives for grid connection

Status quo

The programme MOVES III (IDAE 2024), that supports electric mobility, includes in its programme of incentives II, subsidies for the grid connection. In fact, it provides support for "The installation of electrical elements, including the transformer and the connection work to the distribution network" (Junta de Extremadura 2024). In June 2024 the programme MOVES was extended until the end of December 2024.

The subsidy quota depends on the grid connection capacity:

- If capacity ≥ 50 kW, up to 20% of total costs for large companies, 40% for medium size companies and 50% for small companies.
- If capacity < 50 kW, up to 20% of total costs for large companies and 30% for SME (40% if installation is located in a municipality of less than 5000 inhabitants).

Future prospects

The programme for national funding came to an end at the end of 2024. However, according to a workshop participant, a new programme is planned for 2025. It has been criticised that companies have to make financial advance payments and only receive the funding afterwards.

In addition, it is generally considered that transport companies should not actually be obliged to install, operate and maintain relevant grid systems, such as grid substations, in the course of fleet electrification, but that these responsibilities should lie with other stakeholders. (See the restrictions for charging infrastructure section)

4.2 Factors on energy

4.2.1 Current electricity generation mix

Status quo

In 2022, 44% of Spain's electricity was generated by renewable energy sources, 36% by fossil fuels and 20% by nuclear power (EC and EU 2024). Renewable production increased in 2023, thus registering the highest historical production with 134,321 GWh. The share of renewable electricity generation increased to 50% and has also reached an all-time high (red eléctrica 2024).

4.2.2 Future electricity generation mix

Status quo

The draft update of the National Energy and Climate Plan (NECP) from June 2023 indicates that Spain aims to achieve an 81% share of renewable energy in its electricity generation mix by 2030 (Seifert 2023). For 2050, the target is 100% renewable energies and greenhouse gas neutrality for the entire economy by 2050 according to the draft bill on Climate Change and Energy Transition (LCCTE) (Instituto para la Transición Justa, O.A 2020; Boletín Oficial del Estado 2021a).

4.2.3 State of grid infrastructure

Status quo

A substantial portion of the distribution grid in Spain is over 30 years old. There is currently no public information available regarding its condition. However, plans are in place to release this information soon, following the closure of a consultation of the National Commission on Markets and Competition (CNMC). According to stakeholders, the grid is often already saturated and not ready to integrate high shares of new loads.

Future prospects

There is a need to anticipate infrastructure demand and network planning, as the backlog of grid connection application has reached almost 200 GW in Spain.

4.2.4 Grid extension scheme

Status quo

Every 4 years, a new Transmission Network Development which is covering a period of six years is drawn up, as established by the legislation in force (Ley 24/2013 del Sector Eléctrico). The projected investment for the initiatives outlined in the Transmission Network Development Plan for 2021-2026 amounts to approximately 6,964 million €. This includes around 1,260 million € allocated for enhancing international interconnections with France (Biscay Gulf), Portugal (Northern interconnection), Morocco (third interconnection), and Andorra. The remaining 5,704 million € are designated for strengthening the transmission network that comprises the national electricity system, which encompasses both the STARTINGS GRID and the planned network (MITECO 2024b).

In Spain, Distribution System Operators (DSOs) are required to publish Distribution Network Development Plans annually, with a forecast horizon of three years. However, these plans do not appear to be publicly accessible and do not include capacity maps. The regulator evaluates and approves these plans. Currently, it is discussed to anticipate those investments based on future needs. In October 2024, an official circular was published stating that network operators must keep detailed information on available capacities accessible and up to date on their website in order to maximize transparency in the process (Boletín Oficial del Estado 2024).

Future prospects

To enhance grid extension, it is essential to shift from a predominantly backward-looking investment approach to one that emphasises anticipatory investments. According to stakeholders, the energy transition requires a new mindset, necessitating a supportive regulatory framework that facilitates proactive grid extension and reinforcement. Incorporating grid extension and

reinforcement costs into the regulated asset base of distribution system operators was identified as being of crucial importance. In addition, socialising the costs associated with infrastructure, is asked for by stakeholders because freight transport is a vital service benefiting all European citizens.

4.2.5 Grid connection procedure

Status quo

The grid connection procedure is challenging in Spain. Depending on the location and the network capacity needed, it can take between two and five years. For high-voltage connection with an independent transformation centre, the waiting time with the DSO can be from 1 to 3 years. Furthermore, the 17 "comunidades autonomas" each require a unique set of procedures. This non-harmonized process that varies between local and regional administration can lead to complications for depot owners to connect to the grid. This means they must navigate different administrative processes, documentation, and timelines depending on the specific region. Depending on where the charging point is going to be installed, the number of administrations varies. Up to seven different administrations may be involved: City Council, Ministry of Transport (MITMA), Ministry of Ecological Transition (MITERD), regional councils, hydrographic confederations and Heritage Conservation. A circular published in October 2024 promotes improving efficiency in the process of access and connection to electricity grids, by structuring, simplifying and homogenising the information that applicants are required to submit. It aims to ensure enhanced processing of information, speed up the processing of applications and promote transparency for network operators and owners (Boletín Oficial del Estado 2024).

Future prospects

There is a significant lack of information on where grid capacity is available. A governmental project is aiming at improving transparency and the unification of how the DSOs work. The CNMC consultation closed some time ago. This project will also enable increased power availability at locations during non-peak hours. Start is planned for the end of 2024. Furthermore, DSOs should be obliged to increase the transparency of the process, as today applicants don't know why an access has been denied. AEDIVE, a business association for the development and promotion of electric mobility, made a number of suggestions. One of them is the request to provide CPOs and logistics operators with a network capacity map at the level of connection points (AEDIVE 2024, 2023). Stakeholders criticise the long-lasting bureaucratic process required to put the chargers in operation. Furthermore DSOs cannot integrate specific customer requests into their grid extension plans. When a customer wishes to install a charging point, they contact the distributor, who attempts to provide service at an existing or planned power point or directs them to the most suitable connection point. If this connection point is located far from where the power is required, the customer is responsible for covering the costs of necessary infrastructure, such as cables and transformers. In cases where a transformer installation is needed, the customer must finance the installation; however, ownership of the transformer remains with the distributor, necessitating ongoing maintenance. If another customer connects to the same transformer, the associated costs can be shared.

4.2.6 Electricity price

Status quo

Electricity prices have a significant impact on the economics of electric truck operation. Table 6 shows electricity prices of households and non-households.

Table 6: Electricity price with and without taxes

Category	Annual Consumption according to source	Average price second half 2023 with taxes (€/kWh)	Average price second half 2023 w/o taxes (€/kWh)
Household	2,500 kWh - 5,000 kWh	0.23	0.20
Non-household	500 MWh - 2,000 MWh	0.15	0.15

Source: (EU 2024a)

The industry electricity price is fluctuating. A stakeholder mentioned a price between €0.10 and €0.15 per kWh. The designated electricity market operator OMIE publishes the current market price (OMIE 2024).

4.2.7 Grid concession fee (for capacity extension)

Status quo

Depots that electrify their fleets and expand their charging infrastructure might require extensions of existing grid capacities. In this case, customers have to pay connection, hook-up, installation verification and actions on measurement and control equipment charge (UFD 2023): Extension charge has to be paid if the requested power is below 100 kW in low-voltage or below 250 kW in high voltage grids, and on land categorized as urban. For power requests higher than 100 kW in low voltage or 250 kW in high voltage grids, or to non-urban land, depot owners have to pay for the installation necessary for the power supply. While some grid operators provide information for residential customers on their websites (Endesa 2024a), publicly available information on the cost for grid extension for business customers on non-urban land, which might be the dominant case for depot charging, is scarce (cost for residential customers are provide at some grid operator websites).

4.2.8 Grid network charge

Status quo

While the level of grid network charges generally affects the TCO for depot charging, the structure of grid network charges, in particular the existence of a capacity-based component of grid network charges can represent an incentive for reducing peaks using smart charging or even V2X and thereby provide a lever to further reduce the depot's cost. Grid network charges in Spain consist of a volume and a capacity-based component (smartEn and DNV 2023), which can incentivise the flexibilization of demand. While the capacity-based component depends on the voltage level of connection, the energy-based component depends on the contracts of the wholesale prices. This

means that depots with high load peaks e.g., due to fast and/or simultaneous charging typically have to pay high cost due to their high (maximum) capacity requirements but are also incentivized to implement smart (bidirectional) charging, potentially reducing TCO and supporting peak load reduction for a more efficient network use.

4.2.9 Electricity tariff structure

Status quo

Dynamic prices can incentivize smart depot charging and hence, help to reduce grid congestions and reduce electricity cost and, in doing so, the TCO for depots. Dynamic prices are available in Spain (smartEn and DNV 2023). The rates depend on the months, days (weekend / weekday) and on hours. Typically, electricity prices are relatively cheap during nights or on weekends. According to stakeholders, the tariff structure is expected to change to take the increasing amount of photovoltaic power during the day into account.

4.2.10 Incentives for self-generation of electricity used

Status quo

For depots, it can be interesting to self-generate electricity, e.g., via photovoltaic power plants. According to stakeholders, solar photovoltaic power is already cheaper than electricity provided by the grid in Spain – even when including an on-site stationary battery. Collective self-consumption of solar photovoltaic power using the public grid is allowed until a maximum distance of 500 meters between production and consumption points or 2 km when production is located on roofs, industrial land and artificial structures (Climate Action Network Europe 2024). Generation surpluses are compensated (maximum installed capacity is 100 kW) either with an agreed price with the supplier or the market price but substantial financial uncertainty remains due to the lack of a feed-in tariff or premium (Climate Action Network Europe 2024).

Future prospects

One challenge is to match the electricity demand from the depot with the renewable energy generated. Moreover, the approval and installation of renewable power plants requires substantial time and expertise from the fleet operators or CPOs. Collective self-consumption currently makes up about 1% of the self-consumption and is hindered by several barriers (Energías Renovables 2023) such as bad practices at DSOs delaying installation processes and administrative procedures (Climate Action Network Europe 2024).

PPAs might be an alternative but typically require larger capacities than what is needed for depot charging making them more expensive and, hence, less attractive for small depots. Fleets could potentially pool to get access to PPAs.

4.2.11 Taxation of stored energy

Status quo

Whether depot owners can financially benefit from offering the energy stored in their fleet also as flexibility source to the grid depends on the economics of bidirectional charging. Taxation and payments of further fees and levies, reduce the economic attractiveness of vehicle-to-grid. In Spain, double charges have been removed since 2020 (smartEn and DNV 2023). VAT is among the highest

in Europe with 21%. In addition, the electricity tax (IEE, calculated before the application of VAT) is 5.113% of the amount of the consumption and power capacity (Endesa 2024b). In addition, Spain has a tax on electricity production (IVPEE), 7% on the gross incomes generated with the production and feed-in of electricity into the system (Endesa 2024b).

4.2.12 Possibility of joining the electricity market/flexibility markets

Status quo

Electricity and flexibility markets can provide options to generate additional revenues for depot owners, e.g., by delaying or postponing charging processes or by providing electricity to the grid (vehicle-to-grid, V2G). In Spain, V2X can participate in ancillary markets. Yet, there is a minimum bid size of 1 MW to participate in the "restricciones técnicas" market in Spain, potentially requiring an aggregator for V2X to access the market. There are no local flexibility markets (smartEn and DNV 2023).

There was a recent public consultation for regulation on charging points aggregation (MITECO 2024a) but a law is not enforced yet.

In addition, vehicles capable of V2X are still scarce in Europe but many OEMs have started to implement V2G or announced V2G-capability in the European market (Kühnbach et al. 2024) with a focus on electric cars. European truck manufacturers have also started to investigate V2G and plan to adapt their vehicles.

4.2.13 Smart meter rollout

Status quo

In Spain, nearly 100% of connection points have smart meters (smartEn and DNV 2023); the usage of smart meters is a connection requirement.

4.2.14 Standards/protocols for flexibility provision

Status quo

For bidirectional charging, ISO 15118-20 regulates the standardized communication between the vehicle and the charging infrastructure. The protocol OCPP regulates the communication between the charging infrastructure and the backend. OCPP versions 2.0 and more advanced increasingly focus on bidirectional charging (NOW 2024b). OCPP 2.1 is expected to be released in Q1 2025 and includes a new functional block on smart charging (Open Charge Alliance 2024). In the future, IEC 63110 is expected to replace OCPP (NOW 2024b).

Future prospects

Despite the availability of these standards/protocols, a common interpretation is still needed of ISO 15118-2X to ensure the interoperability between the vehicles, charging stations, and distribution grids—a target that is also being pursued by the International Energy Agency's Task 53 - Interoperability of Bidirectional Charging (INBID) (Task 53 2024). This interoperability means that different vehicles are compatible with different charging infrastructures, which can be of importance for the implementation of bidirectional charging in particular for depot owners with heterogenous fleets and/or semi-private or semi-public depot charging cases.

4.3 Summary for Spain

High share of small companies and one of the highest European daily mileages make electrification of HDVs challenging

In Spain, the majority of companies specialised in road freight transport are small companies, a similar situation to other European countries. Half of the companies providing hire or reward services have only one vehicle. One main difference with other countries is the very high vehicle mileage, as more than 50% of the vehicles drive more than 500 km/day. This is especially challenging for electrification due to on-route charging needs apart from depot charging, and difficult financing conditions for small companies. Like in other countries, the depot ownership is higher for large companies which requires cooperation at the depot for smaller companies. Generally, the logistics sector is characterised by short-term contracts while only large companies may have contract durations of more than two years.

The Spanish topography leads to fewer and larger logistic areas than in other countries and that could facilitate cooperation

An expansion of grid connection capacity may take up to two years, while administration time is comparably low (3 months). There are fewer, but larger logistics centres compared to other European countries due to the settlement structure which implies more centralised and shared charging facilities. The legal requirements contain electrical installation requirements to be considered (covering fire prevention, signalling, etc.). Because of the structure of the sector, a shared charging infrastructure would be the preferred solution.

Information on available grid capacity and funding programmes are obtainable

There is currently no cooperation on charging infrastructure with the grid operator and there is hardly any information on the setup. However, each network operator is obliged to publish a map with available capacity of each of its connection points. Although this information is not available in a centralised way, this is certainly an advantage compared to other countries. Some programmes to fund the purchase of e-trucks, charging infrastructure and grid connection exist, but administrative issues need to be addressed.

Plans for the extension of the Spanish grid may underestimate the need for extension for e-trucks

The Spanish distribution grid infrastructure is partly over 30 years old, and its condition is unclear. Grid extension plans are mandatory in Spain at different voltage levels, but they are not publicly available to date. Further, they are predominantly backward-looking and may underestimate the need for extension due to the additional power demand from electric trucks. Grid connection takes between two and five years at medium voltage level and one to three years at high-voltage level.

The conditions for smart charging are favourable, yet mostly only possible for large consumers or via aggregators

Dynamic prices for electricity are available and tariffs will be changed to also cover the high share of photovoltaics. The consumption of self-generated solar power is often cheaper than using electricity from the grid; collective self-consumption using the public grid is allowed until a distance of 500 m (2 km if production is located on the roof) between production and consumption. The installation and approval of renewable power plants requires substantial time and expertise though.

In Spain, nearly 100% of all connection points have smart meters and obstacles like double taxation have been erased. However, the use of V2G is still very limited as a minimum bid size of 1 MW is required in the ancillary market and local flexibility markets do not exist.

5 Depot charging in the United Kingdom

5.1 Factors on logistics

5.1.1 Description of transport industry

Status quo

In 2020, hire and reward transport represented 71% of total road freight tkm in the UK, the remaining 29% corresponds to transport on own account (Piecyk et al. 2023). The road freight transport sector in the UK, as in other European countries, is characterised by a wide range of company sizes with a high share of small companies. For instance, results of a survey (see Figure 17) done on random sample of 1,500 participants in 2001 shows that 44% of transport companies had only one or two trucks in their fleet but represent only 6% of the nationwide HDV fleet. In terms of the share of all HDVs, companies with more than 50 vehicles represent the most important part with 42%. At the same time, they only represent 3% of all companies.

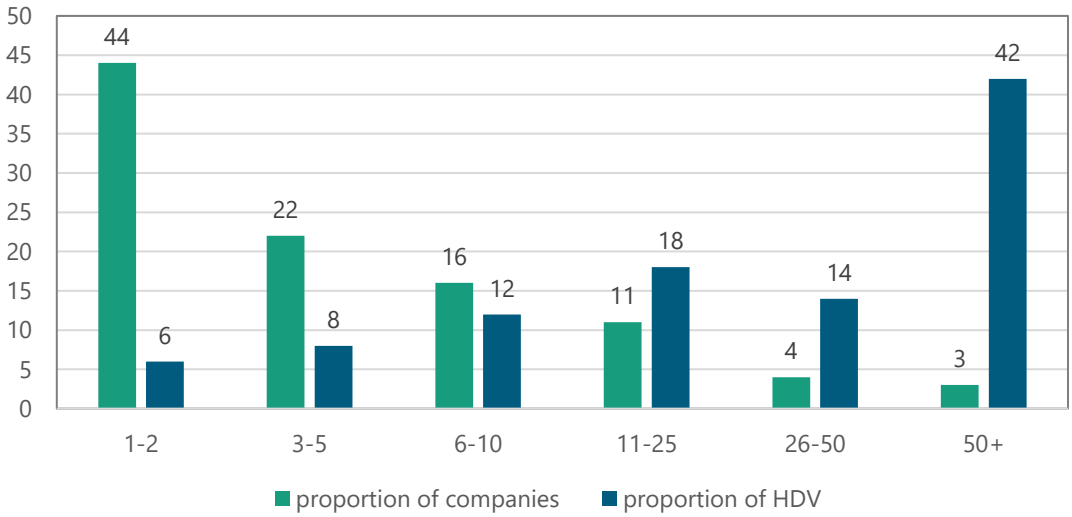


Figure 16: Share of companies [%] providing hire or reward transport services by fleet size in the UK in 2001 (Piecyk et al., 2023)

Further, the results of surveys show that fleet size of companies providing hire or reward services increased over time (Piecyk et al. 2023).

In 2020 1% of road freight transport activities on national territory was performed by HDVs registered abroad (so called cabotage) (GOV.UK 2023b). This is lower than the EU average. The top 3 countries from which cabotage hauliers are registered in the UK are Poland, Romania, and Ireland.

Future prospects

The high proportion of small transport companies poses a challenge for the electrification of HDVs, as small companies with small fleets often have unfavourable financing conditions, short contract terms and limited flexibility in their fleets, as well as little capacity for obtaining information on alternative powertrains and their associated infrastructure.

5.1.2 Vehicle Mileage

Status quo

The mileage of HDVs varies greatly depending on the vehicle class and transport type. Statistical data from the Department of Transport, presented in a report of element energy, indicates that the HDV fleet in the UK consists to two thirds of rigid trucks and one third of artic trucks (see Figure 16) (Drake et al. 2023):

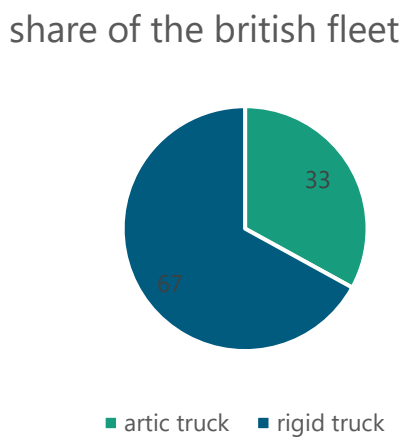


Figure 17: Composition of the British fleet (Drake et al. 2023)

Generally rigid trucks are mostly used for regional delivery transport whereas artic trucks are mainly used for long-haul transport (Government Office for Science and Foresight 2019). Artic lorries usually cover larger distances, meaning that the number of ton-kilometres transported in long-haul is probably more than 33% of the total.

Analyses on truck mileage show that 90% of trips covered by artic truck are less than 360 km (element energy, T&E, 2023). Compared to mainland Europe, these are lower mileage values, which can be explained mainly by the geography of the UK. Several hauliers have established their hubs in the midlands, which is central and allows to deliver the rest of the UK in relatively short distances. (Government Office for Science and Foresight 2019). Rigid trucks cover shorter distances and experts indicate that in the UK most rigid lorries cover between 100 and 300 km per day.

Future prospects

In general, the challenges for the operation of electric HDVs increase with increasing daily kilometres travelled. In principle, local and regional transport is particularly suitable for depot charging in view of the relatively low mileage, the usual return to the depot at the end of the tour and the long downtimes overnight.

In multi-shift operation and long-distance transport, the demands on the charging infrastructure increase in view of shorter downtimes and more frequent downtimes outside depots. However, the high proportion of vehicles with relatively low daily mileage suggests a generally high potential for depot charging in the UK.

5.1.3 Vehicle Usage Pattern

Status quo

Truck vehicle usage patterns depend heavily on the type of activity and the company that operates them. In principle, a distinction can be made between typical usage profiles in regional and long-distance transport. In regional transport, vehicles usually return to the depot at night. In long-distance transport, however, this is not the norm and there are shorter downtimes.

According to the Road Haulage Association (RHA), 70% of UK electric trucks currently return to the depot overnight to charge. This is probably very closely linked to the fact that the UK does not yet have a public charging infrastructure network (O'Carroll 2024). A study shows that around 2/3 of rigid HDVs can complete their operations by charging entirely at home depots. Over 80% of 44 t HDVs could get at least 70% of their energy from depot charging (Drake et al. 2023).

Future prospects

The experts consulted are a bit less optimistic than the study mentioned above and estimate that half of rigid truck operations could complete journeys with a single battery charge in depots, with maybe small top up charge at other locations. With the availability of top up charging on routes the majority of rigid truck operations is estimated to be able to be fulfilled with BET. In contrast some stakeholders assume that artic truck operation will probably only be covered by 10-15% with depot only charging considering current battery size and associated vehicle range. It is also expected that, given the higher investment costs for BET, more intensive use of the vehicles will be necessary to achieve economic efficiency. This will be accompanied by an increased need for double-shift operation of the vehicles, which will lead to reduced downtime of the vehicles at the depots and require more powerful depot charging.

5.1.4 Depot Ownership

Status quo

For the UK, there is no reliable data available on the depot availability of transport companies and ownership structures. It is likely that there are significant differences in depot availability depending on company size. Experts report that large operators tend to own or long-term lease premises, which makes investment cases viable.

The choice of depot locations has historically always been based on geography, with most major logistic sites located in the centre of the country. This might make it necessary to have charging infrastructures in various small remote pockets of the UK for top-up charging.

Future prospects

In principle, access to a depot is a key prerequisite for the installation and use of depot charging infrastructure. Better data would be desirable in order to make reliable statements on this matter. The experts involved also pointed out the fact that the landlord of the depot must agree to the construction of charging infrastructure in accordance with the usual agreements, which often entails additional costs and administrative effort for the logistics company.

5.1.5 Planning security

Status quo

In view of the high investment costs for BET and charging infrastructure, long-term contracts with clients are a key element for transport companies in terms of planning security and the reduction of investment risks. Experts involved currently see only a small share of long-term contracts in the transport market. According to a report, large companies in particular, such as providers of logistics services, tend to secure long-term contracts, e.g. directly with customers. (Government Office for Science and Foresight 2019).

Future prospects

With the current contract terms, investments in BET and charging infrastructure represent a significant investment risk in view of the low planning reliability. It is particularly important for small companies with few customers and little flexibility.

Experts believe that one possible solution is that customers who want to make their supply chains more sustainable and want their contractors to use BET will increasingly have to commit to longer contract periods in order to secure the necessary investments by the transport companies.

5.1.6 Restrictions for charging infrastructure

Status quo

The experts involved see the necessary power supply, the size of the depot and insurance issues as the main obstacles to setting up charging infrastructure at depots. With regard to the power supply, the grid connection capacity represents the most significant risk if it is not available. The size of the depot determines whether charging infrastructure can be set up without space restrictions. In addition, the development of charging infrastructure can be restricted by insurance requirements.

Future prospects

Since power supply can be a significant problem, experts say companies should check the available grid capacity before choosing to build or install a new depot. Otherwise, there is a risk that the site will not have the necessary grid connection potential when they consider installing charging infrastructure at the depot in the future. First start-ups have built a platform that compares this data with property portfolios to identify locations with high potential for logistics depots with charging stations set-up (Camion 2024).

5.1.7 Safety / building regulations for commercial and industrial sites

Status quo

According to an insurance (Allianz 2024), the regulatory reform (fire safety) order (and/or equivalent legislation in Scotland and Northern Ireland) and the dangerous substances and explosives atmospheres regulations represent relevant regulations in the context of BET deployment and the set-up of depot charging infrastructure.

The experts involved also point out that additional requirements from insurance companies also have an influence on the implementation of charging infrastructure and must be taken into account.

5.1.8 Financial conditions/Investment risks

Status quo

The freight transport sector is highly price competitive and characterised by low-profit margins (Piecyk et al. 2023). Companies have therefore to be highly efficient to remain profitable. Margins are usually low, around 3% in 2019 (Government Office for Science and Foresight 2019). However, studies show that after the covid crisis they dropped to 1-2% (Piecyk et al. 2023). SMEs in particular have low profits. As third-party logistics providers tend to secure long term contracts with customers, they secure a long-term revenue flow, and they therefore have greater opportunities to invest in new HDVs (Government Office for Science and Foresight 2019). Finally, SMEs have less access to investment finance than larger operators, as banks may have concerns about their ability to repay the loans. Additionally, a study shows that SMEs may be reluctant to borrow money (Piecyk et al. 2023).

Several forms of HDV ownership exist, for example outright purchase or lease. Outright purchase can be financed by cash reserves, profit, or loans. In the UK, 44% of HDVs were purchased outright (both new and second hand) (Piecyk et al. 2023). Meaning that most of vehicles are leased or rented (see Figure 17).

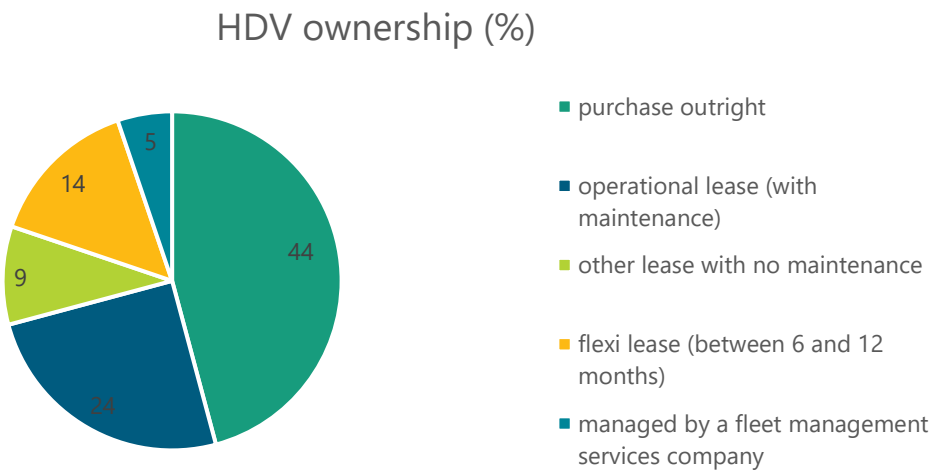


Figure 18: HDV ownership of vehicles held by BVRLA members in the UK in 2020 (Piecyk et al., 2023)

Future prospects

Under the current conditions, the procurement of BET is associated with considerable financial risks, especially for small companies. Particularly in the early market phase, there are high vehicle costs and considerable uncertainties regarding the development of residual values.

A higher share of leasing could therefore also represent an option for smaller companies in the current market phase. With regard to the financing of the charging infrastructure, the stakeholders involved also mentioned Charging as a Service (CaaS) as an option. In this case, a charging infrastructure operator would set up the infrastructure at the depot and the logistics company would pay for its use via a monthly rate, thus avoiding high initial investments.

5.1.9 Regional coordination of charging infrastructure requirements / expansion

Status quo

In view of the great importance of grid connection capacity for the development of depot charging infrastructure, regional coordination of requirements makes sense. On the one hand, this can help to communicate relevant grid expansion requirements to the grid operator at an early stage and, on the other hand, it reduces the risk of competition arising between potential customers.

Experts report that currently this kind of cooperation is not standard practice. There are some cooperations examples though, for instance as part of the zero-emission heavy good and infrastructure programme, there was coordination across consortium members. Furthermore, experts report that a project funded by the state is currently investigating the shared use of depots as a possible solution.

Future prospects

For the expansion of the depot charging infrastructure, strategic planning of cooperation is required for the realisation of the necessary grid connection.

With the opening of National Grid NESO, experts believe there is an opportunity to refocus this area and designate charging infrastructures as critical national infrastructures (as has just been decided for data centres, for example). The coordination of requirements could be facilitated as a result. In addition, natural partnerships within the industry or between the sectors could take place.

In addition, according to experts, companies could get in touch with an aggregator that can combine the capacities of several organisations (REA 2024).

5.1.10 Accessible and hands-on information for transport companies

Status quo

Building up knowledge among transport companies on the subject of BET and depot charging is of great importance. Several documents are available online in English and/or for the UK market or will be published shortly. These include, for example:

- Document on the electrification of fleets: a practical resource for fleet managers (REA 2024)
- Report of first BET deployment trial in the UK. An Introduction to Deploying Battery Electric Trucks (cenex 2024)
- Information on the set-up of charging infrastructure at the depots "Guidelines – Charging Infrastructure for Truck Depots" of the Technical University of Denmark (Engelhardt et al. 2023).

What's more, it has been reported that IET (Institution for engineering and technology) has a working group on the topic and will release soon another report on the electrification of HDV.

Future prospects

The workshop participants pointed out that the available reports and information are not yet sufficient and that the challenge is to reach SMEs in particular. In this context, reference was made to organisations such as Greenfleet and events such as the Road Transport Expo, which can build bridges between operators and suppliers on the subject of fleet electrification - as examples.

5.1.11 Availability of consulting services related to e-trucks.

Status quo

According to the experts involved, consultancy services for transport companies on the electrification of fleets are currently offered primarily by vehicle manufacturers. Independent consultants are also involved in the implementation of BET projects in British companies.

Future prospects

In view of the early stage of the market, a further expansion of advisory services on BET for companies is considered necessary in order to take account of the respective case-specific framework conditions on site and to develop suitable solutions.

5.1.12 Publicly available information on regional grid connection capacity

Status quo

The availability of information on network capacity is an important basis for planning the development of charging infrastructure. Network capacity maps are available online at region scale (SP Energy Networks 2025; UK Power Networks 2025; Electricity Northwest 2025).One expert suggests that requests submitted to the Distribution Network Operator (DNO) should be made publicly available.

5.1.13 National / regional incentives for purchase and operation of e-trucks

Status quo

The purchase of low-emission HDVs is supported by the government's Plug-in Vehicle Grant Programme (PIVG) and includes the following grants:

- Grants of 20% of the purchase price up to a maximum of £16,000 for vehicles with a gross weight between 3.5 tonnes and 12 tonnes.
- Grants of 20% of the purchase price up to a maximum of £25,000 for vehicles with a gross weight of over 12 tonnes.

To qualify for a grant, lorries must have CO_2 emissions at least 50% lower than an equivalent conventional Euro VI vehicle and must be able to travel at least 96 km (60 miles) with zero emissions.

In total, grants are available for 100 large lorries across the market each year. The grant is applied for by the manufacturer at the time of purchase, so the buyer does not need to apply. The Office for Zero Emissions Vehicles (OZEV) then pays the grant applications back to the vehicle manufacturers on a monthly basis (GOV.UK 2023c).

Future prospects

The experts involved refer to the uncertainty regarding the continuation of national subsidies under the PIVG programme beyond March 2025. In view of the persistent cost difference between BETs and diesel lorries, the continuation of the subsidy is considered necessary. As the cost difference is currently significantly higher than £25,000, an increase in the subsidy amount per vehicle is recommended. In addition, the process for OEMs to register vehicles for the programme should be simplified as it is considered complex and costly.

Furthermore, it is pointed out that local administrations may have complementary funds to support companies in purchasing zero-emission lorries or establish 'ultra-low emission zones' at a local level. So far, the measures taken at the local scale vary greatly across the country and bring therefore a planning difficulty.

5.1.14 National / regional incentives for installation of charging infrastructure

Status quo

There is currently no funding programme available that explicitly addresses the development of charging infrastructure for HDVs. However, funding programmes for charging infrastructure aimed at SMEs, which run until March 2025, may be used for this purpose (GOV.UK 2022).

The grant covers 75% of the cost of installing charging infrastructure up to a maximum of £15,000.

Specifically, the grant covers:

- up to £350 per charging socket installed
- up to £500 per parking spot equipped with the relevant infrastructure.

Future prospects

The experts involved criticise the lack of a special funding programme for charging infrastructure for HDVs.

It is pointed out that some local authorities have funds to support companies in installing charging points in depots, but that this does not represent a standardised and nationwide offer.

5.1.15 National / regional incentives for grid connection

Status quo

There is currently no funding for the grid connection of lorry charging infrastructure.

Future prospects

The experts involved suggested that, in the event of high grid expansion costs, funding should be provided for the installation of charging infrastructure, as financing can otherwise be problematic for companies.

5.2 Factors on energy

5.2.1 Electricity generation mix

Status quo

The share of electricity produced from renewable energies rose in 2022 to 41.8%, supported by improved weather conditions and enhanced capacity compared to 2020 (DESNZ 2023c). By 2023, this proportion further increased to 46.1%. Despite a minimal growth in renewable generation of just 0.3%, the overall increase in the renewable share was influenced by a decrease in total electricity consumption. Wind energy (61%), biomass (25%) and photovoltaics (10%) are the main sources of renewable energy in 2023 (DESNZ 2024).

The British Energy Security Strategy and the 'Net Zero Strategy: Build Back Greener' aim to decarbonize the electricity system by reaching net zero emissions by 2035 including nuclear power

and carbon capture and storage (HM Government 2022, 2021). However, whether the target can be achieved is debated (Helm 2023). On a wider scale the Climate Change Act of 2008 set a target for the UK to reduce territorial carbon emissions by 80 percent by 2050. This target was subsequently amended in 2019 to achieve net zero greenhouse gas emissions by the same date and considers nuclear power and CCU (GOV.UK 2008).

5.2.2 State of grid infrastructure

Status quo

The state of UK's grid infrastructure varies highly between regions. Costs are also different depending on the region. Furthermore, from depot to depot, there are differences in the availability of high voltage cables. While some are available on site, others are located several kilometres away from the designated depot. Substation capacity and headroom data are available from National Grid and DNOs (nationalgrid 2024d).

5.2.3 Grid extension scheme

Status quo

The Network Development Plan (NDP) is part of the Clean Energy Package's introduction into UK law and outlines a ten-year strategy for network development and investment for distribution networks. It evaluates the distribution network's suitability for future energy scenarios, identifies sites needing intervention due to constraints, and considers solutions like flexibility services or reinforcement. The NDP also provides Ofgem, the Office of Gas and Electricity Markets—a non-ministerial government department and an independent National Regulatory Authority—, and stakeholders with clear plans to support the transition to net zero (nationalgrid 2024c).

A broader initiative is the Great Grid Upgrade. It represents a significant transformation of entire electricity transmission system in the UK, which was initially designed to facilitate the distribution of electricity produced by fossil fuel power stations. This initiative includes 17 major infrastructure projects distributed across the country which aim at expanding and modernizing the current networks (nationalgrid 2024e). The installation of new and upgraded power lines, substations, and both underground and underwater cables, along with other infrastructure are planned to enhance the grid's ability to transmit clean electricity more efficiently throughout the country and facilitate the connection of additional wind and solar farms. Additionally, the development of high voltage offshore 'electrical superhighways' shall link regions of Scotland to northern England (nationalgrid 2024a). To support the nation's net zero and decarbonization objectives, National Grid is committing over £30 billion to projects between 2025 and 2029 (nationalgrid 2024e).

The National Electricity System Operator (NESO) plans in its "Beyond 2030" report to invest £58 billion in the electricity grid to meet the growing and decarbonising demand for electricity in Great Britain by 2035 (NESO 2024b).

5.2.4 Grid connection procedure

Status quo

The process of establishing a grid connection is time consuming and can often take up to a decade. How much time is needed depends very much on the capacity needed and on how much electricity

is self-generated. Furthermore, Distribution Network Operators (DNO) quote extremely long lead times even with recent improvements to the process.

Future prospects

The Connections Action Plan addresses the issue of significant delays in grid connection and late connection dates offered to customers. It intends to strengthen incentives, obligations and requirements to speed up grid connection applications (DESNZ 2023a).

Stakeholders recognise improvements in the grid connection and extension process but express that the context remains unclear. They also highlight the need for greater transparency and simplification in the application process, which is currently perceived as complex and time-consuming. In addition, a strategic approach to planning grid connections would be highly beneficial, as it would eliminate the need for fragmented applications submitted on a depot-by-depot basis.

5.2.5 Electricity price

Status quo

Electricity prices have a significant impact on the economics of electric truck operation. Table 7 shows electricity prices of household, non-household and industrial consumers.

Table 7: Electricity price without taxes

Category	Annual Consumption according to source	Average price second half 2023 w/o taxes and without Climate Change Levy (€/kWh)
Household	2,500 kWh - 5,000 kWh	0.33 (0.42 with taxes)
Non-household	500 MWh - 2,000 MWh	0.36
Industry	> 2,000 MWh	0.25 - 0.33

Source: (GOV.UK 2013)

5.2.6 Grid concession fee (for capacity extension)

Status quo

The amount of the grid concession fee depends on the required capacity and the type of assets needed to enable the connection. Different fees apply in each licence area. (nationalgrid 2024b)

5.2.7 Grid network charge

Status quo

While the level of grid network charges generally affects the TCO for depot charging, the structure of grid network charges, in particular the existence of a capacity-based component of grid network charges can represent an incentive for reducing peaks using smart charging or even V2X and thereby provide a lever to further reduce the depot's cost. All users of UK's electricity network, including generators and demand users, are required to pay for its usage. Although the focus is on

volume-based charges, users are encouraged to spread their grid usage across the day and avoid peak times (smartEn and DNV 2023). There are four different types of charge: Transmission Network Use of System charge (TNUoS), recovering the costs of installing and maintaining the transmission system, Balancing Services Use of System Charge (BSUoS), recovering the costs of the day-to-day operation of the transmission system, Distribution Use of System Charge (DUoS), recovering the cost of building and maintaining the local distribution network, and Assistance for Areas with High Electricity Distribution Costs (AAHEDC), recovering the costs for area specified to receive assistance, i.e. currently the north of Scotland (NESO 2024a, 2024c). Figure 18 shows the shares of the bill that different grid network charges typically amount to; cost for the Assistance for Areas with High Electricity Distribution Costs is published annually in July and currently amounts to 0.042 p/kWh (NESO 2024a).

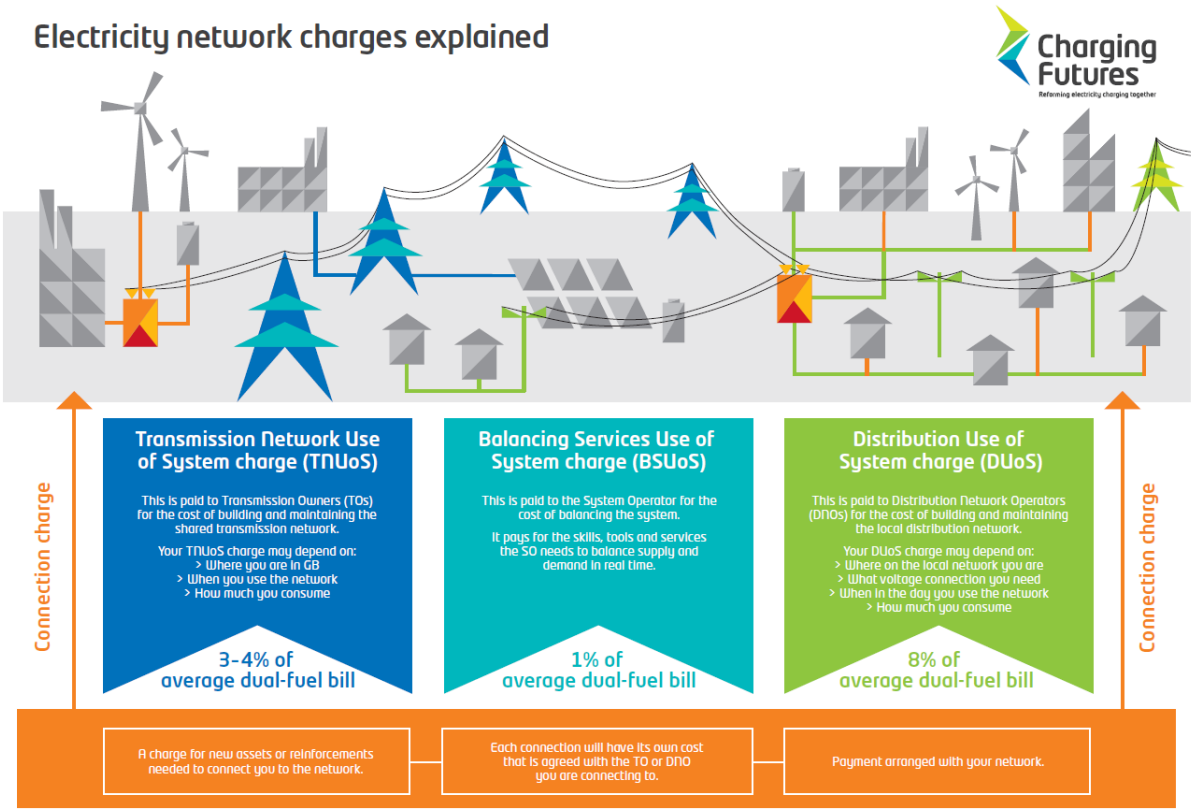


Figure 19: Electricity network charges explained, Source: (NESO 2024c)

According to stakeholders, DSOs have a monopoly on the grid system and associated costs, which can differ substantially.

5.2.8 Electricity tariff structure

Status quo

Dynamic prices can incentivise smart depot charging and hence, help to reduce grid congestions and reduce electricity cost and, in doing so, the TCO for depots. In the UK, residential consumers with specific meters can choose a time-off-use (ToU) tariff, which is currently not very common (smartEn and DNV 2023). For industrial customers, commercial ToU tariffs are available (smartEn and DNV 2023), e.g., by energy suppliers such as Octopus Energy also for small businesses (octupusenergy 2024), but are still limited in number due to a still nascent commercial interest in

flexibility provision and can require commitments over years. In general, there is high electricity price volatility.

Future prospects

An increasing availability of ToU tariffs would be beneficial for stakeholders—as well as the possibility for businesses to tailor packages to their needs including smart metering etc. Moreover, the new British governmental investment body and publicly owned energy generation company, GB Energy, could catalyse price stability for the industry.

5.2.9 Incentives for self-generation of electricity used

Status quo

Like in other countries, the self-generation of electricity, e.g., via photovoltaic power plants, can be interesting for depot charging. An economic incentive generally exists if self-generated electricity is cheaper than the electricity purchased from the grid. However, whether the usage of self-generated electricity is profitable or not depends on the specific situation, which includes the load profiles of the location, the overall demand and the driving profiles of the fleet vehicles.

Additionally, in the UK, Smart Export Guarantee tariffs, which have to be provided by all licenced utilities with 150,000 customers or more and which customers have to sign up to, ensure a fixed payment for self-generated renewable electricity exported to the grid for customers with generation capacities up to 5 MW (renewable power plants such as photovoltaic or wind) or 50 kW (micro-CHPs) (Energy Saving Trust 2024; ofgem 2024). While this incentive relates to grid exports, the self-consumption of self-generated energy can be incentivized by the typical long-term fixing of energy prices between suppliers and large customers, who might aim to reduce the amount of energy purchased from the supplier and, for depot owners, reduce the TCO for the depot.

5.2.10 Taxation of stored energy

Status quo

Whether depot owners can financially benefit from offering the energy stored in their fleet also as flexibility source to the grid depends on the economics of bidirectional charging. Taxation and payments of further fees and levies reduce the economic attractiveness of bidirectional charging services to the grid. In the UK, double taxation for energy stored in mobile storages, i.e., electric vehicles, still occurs. Taxes on electricity for charging electric vehicles are either on standard (currently 20%) or reduced (currently 5%) rate; the latter occur if consumption is smaller than 33 kWh/day (GOV.UK 2016).

5.2.11 Possibility of joining the electricity market/flexibility markets

Status quo

Electricity and flexibility markets can provide options to generate additional revenues for depot owners, e.g., by delaying or postponing charging processes or by providing electricity to the grid (vehicle-to-grid, V2G). In the UK, with the amendment P415 to the Balancing and Settlement Code (BSC), implemented in November 2024, aggregated behind-the-meter assets can participate in wholesale markets via Virtual Lead Parties and not only through their supplier (ELEXON 2020). Balancing markets are also accessible for vehicle-to-grid (V2G), which has been demonstrated by

trials such as the Powerloop project (ESO and Octupus Energy Group 2023), however, some services have specific requirements hindering participating of V2G (smartEn and DNV 2023). Recently, local flexibility markets allowing electric vehicles to participate have also started to scale up (smartEn and DNV 2023).

While vehicles capable of V2X are still scarce in Europe, many OEMs have started to implement V2G or announced V2G-capability in the European market (Kühnbach et al. 2024) with a focus on electric cars. European truck manufacturers have also started to look into V2G and plan to adapt their vehicles.

5.2.12 Smart meter rollout

Status quo

According to the UK government targets, ideally 100% (minimum coverage 74.5%, tolerance level of 25.5%) of homes and 100% of small businesses (minimum coverage 68.7%, tolerance level of 25.5%) should be equipped with smart meters by the end of 2025 (DESNZ 2023b). 63% of all meters in the UK were smart or advanced meters (GOV.UK 2024b).

5.2.13 Standards/protocols for flexibility provision

Status quo

For bidirectional charging, ISO 15118-20 regulates the standardised communication between the vehicle and the charging infrastructure. The protocol OCPP regulates the communication between the charging infrastructure and the backend. OCPP versions 2.0 and more advanced increasingly focus on bidirectional charging (NOW 2024b). OCPP 2.1 is expected to be released in Q1 2025 and includes a new functional block on smart charging (Open Charge Alliance 2024). In the future, IEC 63110 is expected to replace OCPP (NOW 2024b).

Future prospects

Despite the availability of these standards/protocols, a common interpretation is still needed of ISO 15118-2X to ensure the interoperability between the vehicles, charging stations, and distribution grids—a target that is also being pursued by the International Energy Agency's Task 53 - Interoperability of Bidirectional Charging (INBID) (Task 53 2024). This interoperability means that different vehicles are compatible with different charging infrastructures, which can be of importance for the implementation of bidirectional charging in particular for depot owners with heterogenous fleets and/or semi-private or semi-public depot charging cases.

5.3 Summary UK

A large share of trucks can solely rely on depot charging

Most rigid lorries are used for regional transport and cover 100-300 km/day, while artic lorries have higher daily mileages. Especially for that first category, depot charging should be sufficient, as was confirmed by a recent study showing that 2/3 of rigid heavy duty vehicles (HDVs) can complete their operation by charging entirely at home depots. Regarding charging infrastructure setup, depot ownership or long-term lease premises make investments viable. Further restrictions stem from power supply, site size (space and manoeuvrability constraints) or insurance requirements.

Regulations that have to be considered when setting up charging infrastructure at depots contain fire prevention obligations and the regulation on dangerous substances and explosives.

Small companies make up two thirds of the logistics sector with small financial operating range

Almost 70% of UK logistics companies own five trucks or less and are thus small companies that have difficulties in adopting electric trucks with high upfront investments. While smaller companies usually have shorter contracting times, long-term contracts are more common for large companies. Usually, the transporting goods sector has 1-2% margins and often at the lower bound for small companies. Thus, a large number of vehicles are leased or rented.

Initiatives for the joint development and use of infrastructure could lead to new business models

Coordination and cooperation in the development of charging infrastructure between companies is still very rare. Within the framework of the programme for zero-emission heavy goods and infrastructure, there have been initial approaches that could be a starting point for further comparable activities. This could also lead to joint charging hubs with charging-as-a-service as a business opportunity. There is some hands-on information available and consulting services from OEMs and other independent experts are available. So are grants for purchase of vehicle and infrastructure, yet not for grid connection.

Information about grid capacities and extension plans is available for some regions, but not for the entire country.

In the UK, the substation capacity and headroom data - indicating how much additional energy is available to meet demand - are available from National Grid and for some distribution network operators. They also have a 5-year development plan for grid extension. In addition, the Great Grid Upgrade will close gaps and renew transmission lines in the UK, and also better link offshore wind parks. The grid network charge contains elements for transmission and distribution grid charge as well as a charge to balance the system. They add up to 12% of the end user's electricity bill.

Very long lead times for grid connection in UK shall be improved

New grid connection can take up to a decade. Distribution network operators quote extremely long lead times even with recent improvements to the process. The Connection Action Plan was settled to address this issue, and first improvements have been recognized by stakeholders, yet simplification of the process is still necessary. The grid concession fee depends on capacity, assets needed, and the distinct area.

Flexibility and vehicle-to-grid potentials are delayed by the vehicle capabilities

For flexibility, several ToU-tariffs are available for commercial users, but they lack price stability. A fixed payment for self-generated energy has to be provided by the energy suppliers. A new national law taking effect in November 2024 allows for participation in flexibility markets via aggregators as virtual lead parties. As the smart meter rollout is between 60 and 70% in the UK today, the main obstacles come from the vehicle side and the double taxation of smart electricity.

6 Country comparison

Logistics and vehicles

The transport industry has a very similar structure in all four countries under consideration. The majority of companies have only a few vehicles and belong to the category of small companies. However, the majority of transport performance is provided by larger companies with larger fleets, which also account for a significant number of registered trucks in the respective countries. In view of low profit margins and usually short contract terms, the procurement of capital-intensive trucks represents a relevant investment risk for companies. This is of comparatively greater significance for small companies in view of their lower financial strength and smaller fleets.

The use of e-trucks in combination with depot charging infrastructure is particularly advantageous in regional transport in the early market phase, when no relevant public charging infrastructure is yet available. With the increased use of e-trucks in long-distance transport, public fast charging will become more important in future. The UK has a particularly high proportion of deployment profiles that are suitable for exclusive depot charging, mainly due to its island location. Spain, with the highest proportion of long-distance transport, has the least favourable conditions. Germany and France are in between.

Definitive assessment of the potential for the electrification of depots are only possible to a limited extent, as there is currently a lack of sound data on the availability of depots at transport companies and their facilities. Restrictions due to regulations and insurance requirements for depot areas are mentioned as obstacles, but a systematic overview is still lacking. The main challenges are the high grid capacity required and the space restrictions for setting up charging infrastructure in depots across all countries.

Overarching coordination of regional grid connection requirements through depot charging would be necessary but has not yet taken place in any of the countries under consideration. Information on locally available grid capacity is available for France, the UK and Spain, while this is not yet available for Germany, making it difficult to plan charging infrastructure in advance. This lack of information should be clearly reduced with the revision of EU Electricity Market Regulation and the EU Electricity Market Directive which require DSOs and TSOs to publish available grid capacities by mid of 2025 (Rosslowe et al. 2024).

Public information and counselling services for companies on depot charging already exist extensively in Germany, while they are still virtually non-existent in Spain. In the UK and France, the offer is satisfactory, but there is still room for improvement.

The most comprehensive range of public funding for e-trucks, depot charging infrastructure and the associated grid connection is currently available in France, supplemented in some cases by regional funding. In the UK, vehicles and infrastructure are currently subsidized, but not the grid connection. In Germany, on the other hand, comprehensive federal funding for vehicles has ended in 2024. Funding for depot charging infrastructure and grid connection is being continued to a certain extent and in some cases supplemented by regional funding programmes. In Spain, too, the national program to subsidize electric trucks and the necessary charging infrastructure expired in 2024.

Energy system

The energy system conditions relevant for depot charging differ substantially between the four countries considered. The energy systems of all four countries have individual advantages and disadvantages covering the energy production, the electricity grid, grid and electricity costs, as well as the framework conditions for the flexibilization of energy supply and demand. Hence, none of the countries' energy systems generally provide best or worst conditions.

Regarding energy production, Germany and Spain will meet their 2030 targets for renewable energies as these are comparable to the 2022 values. In contrast, France's target is above the EU level and not ambitious enough, while experts mention the British 2030 target to be too ambitious and unfeasible. The long-term targets for carbon neutrality are 2045 in Germany and 2050 in France and the UK, while for Spain a direct RES target of 100% in 2050 exists.

The grid availability strongly depends on local conditions. While there are about 10-20% grid connection capacities in Germany, the grid is already quite saturated in Spain. Although strategic reports on grid extension planning are available in all countries, the grid connection times are long and take from a few months to a few years in France and Germany, up to five years in Spain and up to a decade in the UK.

Electricity costs for non-household consumers are the lowest for Spain, average for France and Germany and highest for the UK. Grid concession fees always depend on local conditions within the countries and network charges are either customer-specific (Germany, France) or less transparent (Spain, UK). In addition to potential lower cost for PV power than for grid electricity, incentives for PV self-consumption exist in Spain e.g., via supporting collective self-consumption or in the UK e.g., due to the typical structure of energy contracts. France supports operating public charging stations in combination with PV power while Germany provides incentives for EV owners and the operators of (semi-)public charging points more generally.

While smart charging is or will be incentivized and standards (and their common interpretation) for bidirectional charging are needed in all countries, the situation for smart meters as a prerequisite for smart charging is very different. The best technical conditions for smart charging exist in Spain (100%) and France (>92%), the UK is lagging slightly (~63%) and Germany strongly behind (<10%).

Table 8: Country comparison with factors of observation

Cat.	Criteria	Germany	France	Spain	UK
Logistics and vehicles	**Description of transport industry**	- high share of small companies - majority of trucks owned in large and medium-sized companies	- high share of small companies - large companies have large share of turnover	- high share of small companies - large companies have large share of turnover	- high share of small companies - 40% of trucks operated by medium-sized and large companies
	Vehicle usage	- considerable share of regional transport (33%) - but also high share of transport with higher daily mileage	- considerable share of regional transport (~25%) - but also high share of transport with higher daily mileage	- high average daily milage in Europe - high proportion of long-distance transport	- lower average mileage compared to EU - 90% of daily mileage less than 360 km
	Transpor-tation industry structure	- depot accessibility unclear - limited planning security and financial resources - limited grid capacity and high costs - space restrictions	- depot accessibility unclear - limited planning security and financial resources - high grid connection costs - space restrictions	- depot accessibility unclear - limited planning security and financial resources - high grid connection costs - need for additional grid substations	- depot accessibility unclear - limited planning security and financial resources - limited grid capacity and high costs - space restrictions
	Legal context and regulations	- restrictive warehouse insurance conditions	- restrictive warehouse insurance conditions	- safety conditions (no info on if restrictive or not)	- restrictive warehouse insurance conditions
	Informa-tion provision and services available	- no regional coordination of grid connection - very good availability of information and counselling offers - no public information of regional grid capacity	- no regional coordination of grid connection - good availability of information and counselling offers - no public information of regional grid capacity	- no regional coordination of grid connection - poor availability of information and counselling offers - public information of regional grid capacity	- no regional coordination of grid connection - good availability of information and counselling offers - public information of regional grid capacity
	Incentives	- BET national promotion programme ended - some regional BET funds - national funding of infrastructure and grid connection	- BET national funding programme - some regional BET funds - national funding of infrastructure and grid connection	- BET national funding programme ended - some regional BET funds national funding of infrastructure and grid connection	- BET national funding programme - national funding of infrastructure - no funding for grid connection

Energy system	**Energy production**	- comparable share of renewables in 2022 and target for 2030 - commitment to achieve net GHG neutrality by 2045	- comparatively low share of renewables in 2022, target for 2030 below the EU target; commitment to achieve carbon neutrality in 2050	- comparable share of renewables in 2022 and target for 2030, commitment to achieve 100% renewable energies by 2050	- comparable share of renewables in 2022, (too) ambitious target for 2030, commitment to achieve net zero GHG emissions by 2050
	Electricity grid	- current capacity availability is estimated be of 10-20%, rolling process of grid expansion planning; grid connection procedure between 3 months to several years	- condition of the grid infrastructure varies by region, grid connection process can take between a few months to a few years, in industrial areas grid capacity and a high-voltage grid are already available	- the grid is often already saturated, every 4 years, a new Transmission Network Development is drawn up, the grid connection procedure can take between two and five years.	- costs and state of the grid infrastructure depend on the region, ten-year strategy for network development, the grid connection procedure can take up to a decade
	Grid and electricity costs (tariffs)	- comparatively medium energy price for non-household consumers, location specific grid concession fees, customer-specific grid network charges, incentives for operating EVs and charging stations	- comparatively medium energy price for non-household consumers, location specific grid concession fees, customer-specific grid network charges, incentives for operating public charging stations with PV	- comparatively low energy price for non-household consumers, little information on level of grid concession fees and grid network-charges, good conditions for collective self-consumption of solar PV for some cases	- comparatively very high energy price for non-household consumers, location specific grid concession fees, little information on level of network charges, PV grid exports are incentivized for some cases, typical structure of energy contracts incentivize PV self-consumption
	Framework conditions for the flexibilization of supply and demand	- smart charging is/will be incentivized by some tariff/price structures, participation in flexibility markets not regulated, very low smart meter rollout, standards for bidirectional charging still need common interpretations	- smart charging is/will be incentivized by several tariff/price structures, participation in flexibility markets possible, >92% smart meter rollout, standards for bidirectional charging still need common interpretations	- smart charging is incentivized by several tariff/price structures, participation in flexibility markets possible but hurdles still exist, nearly 100% smart meter rollout, standards for bidirectional charging still need common interpretations	- smart charging is incentivized by some tariff/price structures, participation in flexibility markets (global and local) theoretically possible, >63% smart meter rollout, standards for bidirectional charging still need common interpretations

7 List of abbreviations

AAHEDC	British Assistance for Areas with High Electricity Distribution Costs
AC	Alternating Current
ADEME	French Agency for Ecological Transition
AEDIVE	Spanish business association for the development and promotion of electromobility
AFIR	Alternative fuel infrastructure regulation
BALM	German Federal Logistics and Mobility Office
BET	Battery-electric truck
BEV	Battery-electric vehicle
BImSchV	German Bundes-Immissionsschutzgesetzes
BMDV	German Federal Ministry for Digital and Transport
BMWK	German federal ministry for economic affairs and Climate action
BSC	British Balancing and Settlement Code
BSUoS	British Balancing Services Use of System Charge
CaaS	Charging as a service
CNMC	Spanish National Commission on Markets and Competition
CNR	Comité national routier - French National Road Committee
DC	Direct Current
DE	Germany
DNO	Distribution network operator
DSO	Distribution System Operators
DUoS	British Distribution Use of System Charge
EDF	Électricité de France
EEG	German Energy Sources Act
EnWG	German Energy Industry Act
ES	Spain
EU	European Union
FCEV	Fuel cell electric vehicle
FiT	Feed-in-tariff
FR	France
GB	Great Britain

GHG	Greenhouse gas
HDV	Heavy-duty vehicles
ICE	Internal combustion engine
ICPE	Installation Classified for the Protection of the Environment (France)
KfW	German state-owned investment and development bank
KsNI	German programme for climate protecting heavy-duty trucks and their infrastructure
LDV	Light-duty vehicle
NECP	National Energy and Climate Plan
NESO	British National Electricity System Operator
OCPP	Open Charge Point Protocol
OEM	Original Equipment Manufacturer
OTRE	Organisation des Transporteurs Routiers Européens
PHEV	Plug-in hybrid electric vehicle
PV	Photovoltaics
Q1	First quarter of the year
RES	Renewable Energy Sources
RTE	Réseau de Transport d'électricité
RLM	Registering power metering („registrierende Leistungsmessung" in German)
SDES	French Data and Statistical Studies Department
SME	Small and medium-sized enterprises
T&E	Transport and Environment
TCO	Total cost of ownership
TEN-T	Trans-European Transport Network
TICFE	French domestic tax on electricity end-use consumption
TIRUERT	Taxe Incitative Relative à l'Utilisation d'Énergie Renouvelable dans les Transports
Tkm	Tonne-kilometre
TNUoS	British Transmission Network Use of System charge
ToU	Time of use
UK	United Kingdom
V2G	Vehicle-to-grid
V2X	Vehicle-to-everything
VAT	Value Added Tax
VETS	Vehicle Emissions Trading Scheme
ZEV	Zero-emission vehicles

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10 Glossary

Regional transport refers to transport services that are carried out exclusively at regional level. The trucks usually return to their starting point at the end of the tour. The upper limit for daily mileage is in the range of around 150 to 200 km.

A **rigid lorry** is a lorry that is not designed or constructed for the towing of a semi-trailer (EU 2024b).

An **artic lorry**, also called tractor means a tractor unit that is designed and constructed exclusively or principally to tow semi-trailers (EU 2024b).

Road freight carriers transport goods between the place of loading and unloading, with their own or chartered vehicles.

A **freight forwarder** on the other hand organises the shipments of goods on behalf of its customer and does not necessarily own trucks.

The **transport for hire and reward** is the carriage for remuneration of persons or goods, on behalf of third parties (Eurostat 2024b).

Cabotage is road transport by a motor vehicle registered in a country performed on the national territory of another country (Eurostat 2024c).

A **tonne-kilometre**, abbreviated as **tkm**, is a unit of measure of freight transport which represents the transport of one tonne of goods (including packaging and tare weights of intermodal transport units) by a given transport mode (road, rail, air, sea, inland waterways, pipeline etc.) over a distance of one kilometre (Eurostat 2024a).

In the large majority of cases transport charges are negotiated in the context of longer-term or annual contracts. Apart from that, short-term contracts for transport services are also concluded on the **spot market** at current market conditions, depending on shipping space demand in a related period of time (BAG 2006).

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