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From pilot projects to the roll-out of battery-electric trucks: Findings from the scientific monitoring of real-world deployment

Synthesis report on the ELV-Live research project.

Supporting research on the use of battery-powered heavy-duty vehicles in day-to-day logistics operations – ELV-Live (Grant Number 16EM6003-1)

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List of Abbreviations

Abbreviation	Meaning
AFIR	Alternative Fuels Infrastructure Regulation
BMWK	Federal Ministry for Economic Affairs and Climate Action (Bundesministerium für Wirtschaft und Klimaschutz)
BMUKN	Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Klimaschutz, Naturschutz und nukleare Sicherheit)
CO_2	Carbon dioxide
Electric truck	Battery-electric truck
ELV-Live	Project Acronym for Supporting research on the use of battery-powered heavy-duty vehicles in day-to-day logistics operations
EU	European Union
KsNI	Funding program for the Promotion of Climate-Friendly Commercial Vehicles and Infrastructure (Richtlinie zur Förderung klimaschonender Nutzfahrzeuge und Infrastruktur)
OEM	Original Equipment Manufacturer (vehicle manufacturer)
PV	Photovoltaics
TCO	Total Cost of Ownership
V2G	Vehicle-to-Grid

Executive Summary

The **ELV-Live** research project tracked the transition of battery-electric trucks (e-trucks) from the technological pilot phase to industrial-scale deployment over a three-year period (2023–2026). Drawing on a robust empirical data set – comprising vehicle telematics data from over 800 journeys, detailed case studies on the techno-economic aspects of fleet electrification, depot charging and long-haul transport potential, as well as three large-scale survey rounds – the project provides an up-to-date and independent assessment of the practical suitability of e-trucks and their potential for zero-emission heavy-duty logistics.

Key findings

1. **The 'experience gap':** The study identifies a significant gap in perception between expectations and reality. Whilst companies with no experience of electric trucks are sceptical about their range and cost-effectiveness, active pioneers report a **satisfaction rate of 93%** and a very **high** level **of acceptance among drivers**.
2. **Dominance of battery-electric trucks:** Among alternative propulsion technologies, battery-electric propulsion has established itself across all manufacturers as the **dominant key technology** for heavy road freight transport. Whilst hydrogen concepts are losing significance in manufacturers' and operators' plans, electric trucks are technically ready for regional transport and, with new 600-km models, are now also reaching long-distance transport.
3. **Infrastructure as a critical bottleneck: Depot charging** currently forms the technical and economic cornerstone for the operation of electric trucks. The biggest hurdles, however, are protracted grid connection processes and limited capacity. For long-distance transport, it is absolutely essential to consolidate the nascent development of a nationwide **high-power truck charging network**.
4. **Cost-effectiveness through regulation:** Competitiveness currently depends largely on **CO_2-differentiated** tolls in Germany. Without this lever and affordable charging electricity prices at depots, cost-effectiveness is not yet robust for many applications. SMEs in particular suffer from a lack of information regarding TCO calculations and face high initial investment costs as a key hurdle.
5. **Acceptance and change management:** Despite a general openness within the industry towards electric trucks, there is a significant knowledge gap and concrete plans for electrification are still the exception. Drivers rate the technology positively due to its quiet operation and driving comfort. In transport planning, complexity tends to increase due to the need to integrate charging times into route planning.

Recommendations for the market ramp-up

- **Policy:** In addition to securing **toll benefits** in Germany until 2031, reducing ancillary costs for charging electricity and accelerating grid connection processes through standardisation and transparency.
- **Vehicle manufacturers:** Modularisation of the model range to accommodate further applications and requirements (e.g. auxiliary units, axle loads).

- **Logistics companies:** Early (proactive) registration of grid loads with the supplier and the use of digital **planning tools** to manage the complexity of scheduling and to optimise integration into energy management.
- **Associations & Research:** Bridging the knowledge gap through impartial **TCO calculators** and promoting peer-to-peer learning formats. Continuous monitoring of developments amongst OEMs, suppliers and end-users in the logistics sector.

1 Introduction

1.1 Current market significance of electric trucks and historical development

- The **market** for battery-electric trucks is **growing rapidly** but remains **at an early stage.**
- Market development is **driven by technological progress, regulatory requirements, support schemes** and increasing demand for low-carbon transport.
- **Practical experience** and case studies are **essential to support further market ramp-up** and scaling.

The market ramp-up of battery-electric heavy goods vehicles (e-trucks) has gained significant momentum in recent years, but overall remains in an early market phase. Whilst the first production vehicles have only been available for a few years, a wider range from several manufacturers is now on the market, and the number of registered vehicles is growing – albeit still accounting for a small share of the overall market. In Europe, the market's significance is growing, though this has so far been concentrated primarily on applications in regional transport.

Historically, the development of electric trucks has lagged significantly behind that of battery-electric passenger cars. The reasons for this lie in particular in the higher demands on range, payload and operational flexibility, as well as in the hitherto limited availability of suitable battery technologies. It is only with the technological advances of recent years – particularly in terms of energy density, cost trends and charging capacity – that the commercialisation of heavy-duty battery-electric commercial vehicles has become possible. At the same time, regulatory impetus and initial support schemes have contributed significantly to the market launch.

Current market developments are driven by several key factors. Regulatory requirements at European level play a significant role, particularly the EU CO_2 standards for heavy commercial vehicles. These are complemented by national support schemes and regulatory incentives such as toll exemptions or CO_2-based differentiation. At the same time, corporate climate targets and increasing customer demands for low-carbon transport are becoming increasingly important. Operational factors – such as potential savings on energy and maintenance costs, as well as the appeal to driving staff – are also contributing to the technology's growing relevance.

Despite this positive development, there remains a significant gap between the current market ramp-up and the policy targets for 2030. For instance, the European targets for reducing CO_2 emissions from newly registered trucks, as well as the national targets for the increased use of electricity in road freight transport, require significant market penetration by zero-emission, electricity-based powertrains. Against this backdrop, it becomes clear that the current market ramp-up must be further accelerated in order to stay on track with the necessary transformation pathways.

An international comparison shows that, whilst Europe exhibits strong regulatory momentum and increasing market activity, it cannot be viewed in isolation. Markets such as China are characterised by a significantly earlier and, in some cases, more strongly policy-driven market development, and already boast significantly higher sales volumes of battery-electric heavy commercial vehicles. Overall, it can be concluded that the global market for battery-electric heavy-duty trucks is in a phase of accelerated development, although significant regional differences are still evident at present.

In this market phase, therefore, the analysis of initial practical applications and case studies is of particular importance, as they can provide concrete insights into the actual feasibility, economic viability and scalability of the technology under real-world conditions for the German market.

1.2 Objectives of the ELV-Live project

- The **project combines various methodological approaches**: expert interviews, on-the-job support for companies, vehicle data analyses, case studies and large-scale industry surveys.
- Over several years, **real-world operational data from electric trucks, as well as the experiences of drivers, dispatchers and fleet managers,** have been scientifically analysed.
- The **combination of qualitative and quantitative methods** enables both in-depth practical insights and conclusions regarding general industry trends and the scalability of the technology.

The ELV-Live project (duration: 01/2023 – 12/2025) addresses key issues relating to the introduction and scaling of battery-electric trucks in road freight transport through a close integration of scientific analysis and practical application. The focus is on monitoring real-world vehicle operations in routine service in order to gain reliable insights into the technical, operational and economic aspects of electric truck deployment.

The project consortium comprises several industry partners from various sectors of the transport and logistics industry, including large logistics service providers, medium-sized transport companies and firms with their own in-house transport operations. This deliberately broad structure reflects the heterogeneity of the sector and enables the results to be applied to a variety of use cases. Scientific oversight ensures a systematic evaluation of operational data and the contextualisation of the results within the wider market context.

The aim of the project is to gain sound insights into the practical suitability of battery-electric trucks and to identify key success factors and barriers to their wider adoption. These include, in particular, issues relating to technical performance (e.g. energy consumption and range in real-world operation), integration into existing logistics processes, requirements for charging infrastructure, and cost-effectiveness under various operating conditions.

Furthermore, the project aims to derive transferable insights for the next market phase. This encompasses both the assessment of scaling potential and the identification of areas requiring action in the fields of policy, infrastructure development and the industry. By combining empirical operational data, qualitative surveys and in-depth case studies, ELV-Live thus provides a comprehensive basis for assessing the further market development of battery-electric trucks.

1.3 Overview of publications

The key findings of the project and the resulting recommendations for action or further research questions are set out below, initially organised by topic and then summarised in the concluding chapter as an overview of the entire project. The findings are based primarily on previously published, more comprehensive reports from the project on the respective topics. References to these are provided in the relevant chapters for further reading.

Market Development and Manufacturer Strategies

This first project report discusses the current state of national and international market roll-out and, in particular, the perspectives of commercial vehicle manufacturers and charging infrastructure experts on technology strategies and the necessary framework conditions:

1. ***Report (German / English):***

Hacker, F., Le Corguillé, J., Göckeler, K., Minnich, L., Ziegler, L. & Dolinga, T. (2024, 16 September). *Elektrifizierung von schweren Nutzfahrzeugen und Aufbau von Ladeinfrastruktur - Entwicklungsperspektiven und Handlungsempfehlungen aus Sicht von Nutzfahrzeugherstellern und Ladeinfrastrukturexperten: 1. Teilbericht des Forschungsvorhabens „ELV LIVE – Begleitforschung zum Einsatz batterieelektrischer schwerer Nutzfahrzeuge im logistischen Regelbetrieb“ FKZ 16EM6003-1.* gefördert durch: Bundesministerium für Wirtschaft und Klimaschutz. https://www.oeko.de/publikation/elektrifizierung-von-schweren-nutzfahrzeugen-und-aufbau-von-ladeinfrastruktur-entwicklungsperspektiven-und-handlungsempfehlungen-aus-sicht-von-nutzfahrzeugherstellern-und-ladeinfrastrukturexperten/

Hacker, F., Le Corguillé, J., Göckeler, K., Minnich, L., Ziegler, L. & Dolinga, T. (2024, 16 September). *Electrification of heavy-duty vehicles and development of charging infrastructure – future trends and recommendations for action from the perspective of vehicle manufacturers and charging infrastructure experts: 1st sub-report of the research project “ELV LIVE – Accompanying research on the use of battery-electric heavy-duty vehicles in day-to-day logistics operations” FKZ 16EM6003-1.* Supported by: Federal Ministry for Economic Affairs and Climate Action. https://www.oeko.de/fileadmin/user_upload/Oeko-Institut_ELV-LIVE_Electrification_of_HDV_and_charging_infrastructure.pdf

2. ***Conference paper (English):***

Hacker, F., Le Corguillé, J [Juliette], Göckeler, K. & Schreiber, J. (2025). *Analysis of the challenges for the electrification of heavy-duty vehicles from a manufacturer and user perspective. EVS38*, 1–12. https://www.oeko.de/fileadmin/oekodoc/Challenges-for-electrification-of-heavy-duty-vehicles-manufacturer-user-perspective.pdf

The use of electric trucks by pioneering companies – insights from practice: motivation, experiences and acceptance

This conference paper presents and discusses, amongst other things, initial insights gained from the scientific monitoring of the case study partners.

3. Conference paper (English):

Hacker, F., Le Corguillé, J [Juliette], Göckeler, K. & Schreiber, J. (2025). *Analysis of the challenges for the electrification of heavy-duty vehicles from a manufacturer and user perspective. EVS38*, 1–12. https://www.oeko.de/fileadmin/oekodoc/Challenges-for-electrification-of-heavy-duty-vehicles-manufacturer-user-perspective.pdf

The further findings arising from the scientific monitoring of the case study partners are being published for the first time in this synthesis paper.

Electric trucks in practical use – vehicle characteristics and operational profiles

This report discusses the operational behaviour and usage profiles of electric trucks in the project, based on extensive telematics data from 19 electric trucks used in regional transport.

4. Report (English):

Le Corguillé, J., Hacker, F., Göckeler, K., Mottschall, M. & Dolinga, T. (2025). *Real-world data analysis of energy consumption, activity and charging patterns of battery electric trucks operating in Germany: 2nd report of the ELV-LIVE research project*. https://www.oeko.de/fileadmin/oekodoc/Real-world-data-analysis-of-battery-electric-trucks.pdf

5. Conference paper (English):

Le Corguillé, Juliette, Hacker, F. & Dolinga, T. (2025, 15 June). *Real-world data analysis of battery electric trucks operating in Germany: presented at the 38th International Electric Vehicle Symposium and Exhibition (EVS38)*, Gothenburg, 15–18 June 2025; https://www.oeko.de/publikation/real-world-data-analysis-of-battery-electric-trucks-operating-in-germany/

Analysis of future potential and challenges for the deployment of electric trucks based on case studies

A total of three case studies analyse the electrification of electric truck fleets using specific real-world examples.

This paper on the first case study analyses the techno-economic potential for the electrification of a truck fleet, with a focus on regional transport.

6. Conference paper (English):

Dolinga, T. & Hacker, F. (2025c). Electrification potential of an existing heavy-duty vehicle fleet – a techno-economic analysis: 38th International Electric Vehicle Symposium and Exhibition (EVS38), Gothenburg, Sweden, 15–18 June 2025. Öko-Institut e.V.; https://www.oeko.de/fileadmin/oekodoc/Electrification-potential-of-existing-heavy-duty-vehicle-fleet.pdf

The second case study examines the infrastructural and operational challenges involved in the full electrification of a logistics depot with over 250 vehicles.

7. ***Report:***

Dolinga, T. & Hacker, F. (2025a). *Auswirkungen der Vollelektrifizierung eines Lkw-Depots: Fallstudie im Rahmen des Forschungsprojekts ELV-LIVE.* Öko-Institut e.V.; https://www.oeko.de/publikation/auswirkungen-der-vollelektrifizierung-eines-lkw-depots/

The third case study examines the infrastructural and operational challenges associated with the deployment of electric trucks, based on real-world long-haul transport profiles.

8. ***Report:***

Dolinga, T. & Hacker, F. (2025b). Betriebliche Herausforderungen und Lösungsansätze für die Elektrifizierung des nationalen Lkw- Fernverkehrs: Eine Fallstudie anhand von realen Lkw-Einsatzprofilen im deutschen Fernverkehr. Begleitforschung zum Einsatz batterieelektrischer schwerer Nutzfahrzeuge im logistischen Regelbetrieb – ELV-Live (Förderkennzeichen 16EM6003-1). Öko-Instituts e.V.; https://www.oeko.de/fileadmin/oekodoc/ELV-Live_Fallstudie_Nationaler_Fernverkehr_E-Lkw.pdf

The transport sector's perspective on the electrification of trucks

Experiences with and perspectives on electric trucks were recorded in a total of three large-scale empirical survey rounds within the transport industry.

This publication documents the results of the first survey of companies with experience of electric trucks.

9. ***Presentation of results:***

Göckeler, K., Hacker, F., Dolinga, T. & Le Corguillé, J [Juliette]. (2025). *Akzeptanz von E-Lkw bei Early-Adoptern: Ergebnisse einer Online-Befragung von Transportunternehmen im Projekt ELV-LIVE.* Öko-Institut; https://www.oeko.de/fileadmin/oekodoc/ELV-LIVE_E-Lkw-Anwender_Online-Befragung.pdf

These two publications document the views of a representative sample of transport companies on electric trucks – regardless of their previous practical experience.

10. ***Presentation of results (English):***

Schreiber, J., Göckeler, K. & Hacker, F. (2026a). *Acceptance of electric trucks in the German logistics industry: Results of a standardised survey.* Öko-Institut e.V. https://www.oeko.de/fileadmin/oekodoc/Acceptance-of-electric-trucks-in-the-German-logistics-industry.pdf

11. ***Report:***

Schreiber, J., Göckeler, K. & Hacker, F. (2026b). *Akzeptanz von E-Lkw in der Logistikbranche: Ergebnisse einer standardisierten Befragung.* Öko-Institut. https://www.oeko.de/fileadmin/oekodoc/Akzeptanz-von-E-Lkw-in-der-Logistikbranche.pdf

This publication presents the longer-term experiences and further procurement plans drawn from a follow-up survey of pioneering electric truck companies.

12. Presentation of results:

Schreiber, J., Hacker, F., Reiche, M. & Göckeler, K. (2026). *Akzeptanz von E-Lkw nach längerer Praxiserprobung: Ergebnisse einer Online-Befragung von Transportunternehmen im Projekt ELV-LIVE.* Öko-Institut. https://www.oeko.de/publikation/akzeptanz-von-e-lkw-bei-early-adoptern/

This synthesis paper compares the findings from the three surveys – particularly with regard to temporal effects and differences between the groups surveyed – and places them in the context of an earlier survey conducted in 2021.

13. Report (German/English):

Hacker, F., Schreiber, J. & Göckeler, K. (2026). *Zwischen Orientierung und Optimierung: Status quo und Perspektiven von batterieelektrischen Lkw in der Transportwirtschaft: ELV-Live Synthesebericht: Empirische Analyse zur Einführung batterieelektrischer Lkw – Ein Vergleich von Pionierunternehmen und Gesamtbranche*. Begleitforschung zum Einsatz batterieelektrischer schwerer Nutzfahrzeuge im logistischen Regelbetrieb – ELV-Live (Förderkennzeichen 16EM6003-1). Öko-Institut. https://www.oeko.de/fileadmin/oekodoc/ELV-Live_%E2%80%8BZwischen-Orientierung-und-Optimierung.pdf

Hacker, F., Schreiber, J. & Göckeler, K. (2026). Between orientation and optimisation: the status quo and prospects for battery-electric trucks in the transport sector: ELV-Live synthesis report: Empirical analysis of the introduction of battery-electric trucks – a comparison of pioneering companies and the sector as a whole*. Accompanying research on the deployment of battery-electric heavy goods vehicles in routine logistics operations – ELV-Live (funding reference 16EM6003-1). Öko-Institut.* https://www.oeko.de/fileadmin/oekodoc/ELV-Live_Between-Orientation-and-Optimization.pdf

2 Market developments and manufacturer strategies

- **Manufacturers** are clearly focusing **on battery-electric trucks** as the key technology for decarbonisation; in the short term, hydrogen plays only a minor role.
- The **roll-out of high-capacity charging infrastructure** is regarded **as a crucial success factor** and, increasingly, as a greater obstacle than vehicle availability itself.
- **Reliable regulatory frameworks**, falling costs and the synchronisation of vehicle and infrastructure roll-out are key to the market's ramp-up.

2.1 Background

Prior to the in-depth examination of the user perspective, the project examined the views of commercial vehicle manufacturers and charging infrastructure providers on the market ramp-up of battery-electric trucks (see 1. (Report) / 2. (Conference paper)). These findings were obtained through expert interviews and a subsequent workshop involving representatives from commercial vehicle manufacturers covering more than 90% of the European market, as well as participating charging infrastructure experts.

The focus is particularly on technological development pathways, infrastructure requirements and the assessment of key framework conditions for scaling up electric mobility in heavy goods transport. The analysis is thus deliberately conducted from a supply-side perspective and complements the user perspective presented later.

2.2 Findings

From the perspective of commercial vehicle manufacturers, there is a largely clear technological focus on battery-electric powertrains as the key strategy for decarbonising road freight transport. Other fuel- and drive alternatives – in particular the use of hydrogen and fuel cells – continue to be monitored and, in some cases, tested, but play a significantly lesser role in manufacturers' short- to medium-term strategies.

This assessment is based in particular on the higher energy efficiency of battery-electric powertrains and the anticipated improved cost-effectiveness. Accordingly, manufacturers' development activities are primarily focused on the further development of battery-electric vehicles and the associated charging infrastructure.

A key area of development concerns battery technology. Further progress in energy density and cost is anticipated here, although a fundamental trade-off remains: larger batteries increase range and operational flexibility and reduce dependence on public charging infrastructure, but are associated with higher costs and potential payload restrictions.

In parallel, the roll-out of high-performance charging infrastructure is seen as a critical success factor. In long-distance transport in particular, there is expected to be a need for high-power charging systems in the megawatt range in order to integrate charging times into existing operational workflows. At the same time, it is emphasised that the roll-out of infrastructure must precede the ramp-up of vehicle deployment in order to provide planning certainty for fleet operators.

From the perspective of infrastructure providers, key challenges include, in particular, lengthy planning and approval processes, limited grid connection capacity and high investment costs. Consequently, from the stakeholders' point of view, the bottleneck is increasingly shifting from vehicle availability to infrastructure.

Regulatory frameworks play a key role in this context. Manufacturers and infrastructure providers unanimously emphasise the importance of clear, long-term and reliable regulatory conditions. In particular, the EU CO_2 standards for heavy-duty vehicles (EU) 2024/1610, 2024) and regulatory requirements for infrastructure development (e.g. under the AFIR) (EU) 2023/1804, 2023) are highlighted as key drivers for investment decisions.

At the same time, it is clear that the industry is under considerable pressure to act for competitive reasons. Global competition – particularly with regard to markets such as China – requires early positioning in the field of zero-emission commercial vehicles. Stakeholders view a market ramp-up that is too slow as a risk, as technological gaps and competitive disadvantages could be difficult to overcome in the long term.

Overall, this paints a relatively consistent picture among the surveyed stakeholders from the vehicle manufacturing and charging infrastructure sectors. The technological foundations for market ramp-up are assessed as largely in place, and a clear prioritisation of battery-electric propulsion is evident. At the same time, from the manufacturers' perspective, the speed of implementation depends significantly on infrastructure development, regulatory reliability and economic conditions.

2.3 Analysis and Outlook

Despite the clear technological focus, manufacturers and infrastructure providers continue to face key uncertainties regarding future market developments.

A major challenge lies in synchronising the ramp-up of vehicles and infrastructure. Whilst manufacturers are increasingly electrifying their product portfolios, there remain uncertainties regarding the speed and regional availability of charging infrastructure. A lack of infrastructure can therefore become a limiting factor for vehicle deployment.

Future cost trends also remain a key source of uncertainty. This concerns both the development of battery costs and the costs of charging infrastructure and grid connections. In particular, the question of when and under what conditions economically viable operation across the market as a whole will be possible without subsidy schemes is considered to be unresolved.

Furthermore, there are differing views on the optimal design of the charging infrastructure, particularly for long-haul transport. The specific role of public, depot-based and semi-public charging infrastructure, as well as its geographical distribution along key transport corridors, has not yet been conclusively clarified from the perspective of manufacturers and infrastructure experts. Monitoring the market ramp-up is therefore of great importance in order to be able to draw conclusions from practical experience in the short term for further strategy development.

Finally, the long-term shape of the regulatory framework is considered crucial, but in some respects still uncertain. Investment decisions require, in particular, stable and reliable guidelines over extended periods. Uncertainties regarding future requirements (e.g. the debate on adjusting EU CO_2 standards for new vehicles) or funding structures (e.g. delays in the implementation of funding programmes or their premature termination) can delay investment and thus slow down the market ramp-up.

Overall, it is evident that, from the manufacturers' perspective, the focus is less on fundamental technological feasibility and more on the question of how the framework conditions for rapid and cost-effective scaling up can be shaped.

3 E-truck deployment at pioneering companies – insights from practice: motivation, experiences and acceptance

3.1 Background

The deployment of battery-electric trucks was scientifically monitored over a three-year period as part of the project, using a total of six industry partners as case studies. When selecting the case study partners, the aim was to achieve the greatest possible diversity in order to reflect as comprehensively as possible the heterogeneity within the transport sector and the associated, varying conditions for the procurement and deployment of electric trucks. Despite the companies' differing business sectors and sizes, they share a key commonality in the early adoption of electric trucks in regular operations, which can provide early indications of the technology's practical suitability and acceptance in various applications (see also 3. conference paper).

The following companies acted as case study partners:

- **DSV:** one of the world's largest transport and logistics companies, headquartered in Denmark and operating in more than 90 countries. The company was represented in the project by a logistics site near Cologne.
- **Dachser:** an internationally active logistics service provider with numerous sites and its headquarters in Germany. The company operates in the fields of warehouse, contract and general cargo logistics. The majority of transport services are provided by service partners and their vehicles.
- **Rigterink Logistics Group**: a family-run, medium-sized company headquartered in Nordhorn. The company employs more than 1,000 staff and operates around 300 tractor units and 100 trucks. The company specialises in food logistics and operates throughout Germany.
- **Schmitt-Logistik:** a family-run logistics company based in Bietigheim. The company employs around 330 staff and has several branches in southern Germany, as well as just under 100 trucks operating in both local and long-haul transport.
- **REWE Group (Dortmund logistics centre):** A retail group headquartered in Cologne with around 6,000 stores in Germany. The Dortmund logistics centre, which supplies around 400 REWE stores in North Rhine-Westphalia and neighbouring regions, was involved in the project.
- **Rothaus Staatsbrauerei:** A company based in the Upper Black Forest at an altitude of 1,000 metres, with around 240 employees, which has its own fleet of trucks used to supply the regional catering industry, regional retailers and wholesalers.

As part of the project, the framework conditions for the deployment of electric trucks and the motivation and perspectives of various stakeholder groups within the company (including senior management, fleet management, dispatch, driver trainers and drivers) were assessed using a range of methods (including on-site visits, guided and semi-standardised surveys). Company representatives were also involved in the project throughout its duration via regular workshops and selected thematic case studies.

3.2 Findings

Motivation

- The **key motivation** for the pioneering companies is **ambitious climate protection targets**, as well as increasing customer demands for low-carbon transport.
- Expected **tightening of access regulations and environmental zones** plays a particularly important role in urban delivery transport.
- Companies with direct customer contact also regard visibly **emission-free deliveries as an image and competitive advantage**.

The case study partners are pioneering companies that began testing the use of electric trucks in regular operations at an early stage. In many cases, the companies had already gained experience with battery-electric pre-production vehicles before the commercialisation of heavy-duty battery-electric trucks. As part of the government's KsNI funding (KsNI-Richtlinie, 2021), the majority of the electric trucks used in the project and the associated depot charging infrastructure were procured and will be subject to scientific monitoring within the project from 2023 until the end of 2025.

A key driver for testing the vehicles among the participating companies is their own ambitious climate protection targets, or increased customer demand for low-carbon transport. In particular for companies with a high proportion of inner-city deliveries, stricter requirements for access to these zones also play a major role, as does the expectation that these regulations – following the example of European countries – could become even stricter in the future. For companies whose core business is not in the transport of goods but which have direct customer contact, the visibility of zero-emission deliveries also plays a major role; it is a positive factor that the necessary investments in vehicles and charging infrastructure do not have to be financed through the traditionally low-margin provision of transport services.

On-site implementation

- **Electric trucks** were already being used regularly in day-to-day logistics operations as part of the project, **replacing diesel trucks particularly in local and regional transport**.
- Electrification was heavily influenced by **available ranges as well as limited depot and public charging infrastructure**.
- **Grid connection capacity, space requirements and infrastructure costs** proved to be **key constraints** on the expansion of fleet electrification.

The use of the vehicles during the period under review was largely determined by their maximum electric range of 400 kilometres and the charging infrastructure that could be implemented or was publicly available during the project period. This means that, given the electric range and the lack of public charging infrastructure coverage, the vehicles were used exclusively for local and regional transport during the project period. Unlike in the early phase of commercial trials of electric passenger cars, the procured electric trucks were used as standard in day-to-day logistics operations from the outset and have replaced conventional diesel trucks to date. When assigning operational profiles, particularly suitable, less demanding applications were initially selected. However, as the project progressed, more demanding operational profiles were also selected in some cases based on experience, and the electric range was utilised to the full – partly for economic reasons. The majority of the vehicles were used in single-shift operation; however, in some applications, two-shift operation was also implemented, with batteries being recharged at the loading bay whilst goods were being loaded and unloaded.

Given the scope of the electrification of the truck fleet in this first phase, the depot charging infrastructure – which could be implemented in the short term – played a key role. Key constraints included the grid connection capacity available at short notice, the costs of the structural work (including the length of the supply cables at the depot) and the availability of space for charging infrastructure at the depot, in order to ensure the charging process could be meaningfully integrated into vehicle operations. In some cases, further electrification of the fleet was initially postponed, as the necessary depot charging infrastructure could not have been implemented at short notice, or only at significantly higher costs.

Practical experience

- Following initial problems, the companies report **high reliability and operationally suitable driving ranges of the electric trucks**.
- **Depot charging** was **clearly preferred** from both a logistical and economic perspective; public charging infrastructure has so far played only a supplementary role.
- For the next phase of the market**, increased driving ranges, further infrastructure development and a stable policy framework** are considered crucial.

In day-to-day practice, following isolated teething problems and technical breakdowns of vehicles at the start of the further trial phase, very high vehicle reliability and a high degree of reliability in the manufacturers' range specifications were reported during regular operation. The early identification and planning of operational profiles ensured the reliable deployment of electric trucks on the selected routes. With regard to depot charging infrastructure, varying levels of reliability were reported depending on the technology provider, and, particularly in the early stages, there were complaints about what were, in some cases, lengthy processing times for fault rectification.

Charging batteries at the depot has proved its worth from a logistical perspective; however, it was also preferred from an economic standpoint in day-to-day practice, given the significantly lower electricity prices compared with public charging infrastructure. Public charging infrastructure was used for battery charging only in exceptional cases – e.g. during exceptionally long daily routes or when electricity consumption was higher due to weather conditions. By contrast, the toll advantage of electric trucks has so far played only a minor economic role in local and regional transport applications – which have predominated in recent years and were the primary focus of the project – given the low proportion of journeys made on toll roads and therefore did not represent a relevant incentive for companies in this very early market phase.

The high level of driving comfort offered by electric trucks and their popularity amongst drivers were highlighted as particularly positive aspects (see also the following section); in this context, reference was also made on several occasions to the targeted use of this advantage when recruiting drivers in a challenging market environment.

In order to open up further applications – particularly in long-haul transport – next-generation vehicles with a range of around 600 kilometres are seen as an important prerequisite. Interestingly, users also regard a longer range as beneficial for the next phase of expanding their own fleets, even for driving profiles involving lower mileage, in order to allow for greater flexibility in battery charging. In addition to the challenge of further expanding depot charging infrastructure, the persistently high additional costs of electric trucks and the substantial investment requirements for charging infrastructure are also regarded as key challenges; reliable political framework conditions in this context are called for as an important basis for planning, in order to achieve greater investment security. Whilst some individual companies view other propulsion technologies (particularly hydrogen-based ones) in part as a potential technological complement in selected applications, the majority of fleet managers at the participating companies regard battery-electric trucks as the future standard technology. The main challenge is seen less in the vehicles themselves and more in the charging infrastructure and grid connection. The perceived lack of clarity regarding the future primary propulsion technology for heavy commercial vehicles (keyword: 'technology neutrality') is even regarded by some companies as a major obstacle to the accelerated market roll-out of electric trucks and the necessary expansion of charging infrastructure and grid connection.

Acceptance of electric trucks among drivers and dispatchers

- **Drivers rate electric trucks very positively overall**; driving comfort and working conditions are highlighted in particular.
- **Dispatchers** also view electric trucks positively, but report that **range and charging requirements result in** greater **planning effort.**
- **Range and the lack of public charging infrastructure** continue to be seen as the biggest **challenges,** particularly **for long-distance transport.**

As part of the project, a total of 7 drivers and 8 dispatch staff from the participating case study partners were interviewed in face-to-face sessions lasting approximately 60 minutes each about their personal experiences of using electric trucks within their companies. The survey comprised guiding questions with open-ended response options as well as standardised quantitative elements.

Feedback from electric truck drivers paints a very positive overall picture and indicates a high level of satisfaction with the vehicles. The significantly improved driving comfort (quieter, more relaxed driving) and the associated, markedly better working conditions were cited as particularly positive and consistently positive aspects. All drivers described the switch to electric trucks as ‘mostly easy’ or ‘very easy’. Only in isolated cases was a brief period of adjustment reported, due to the modified cockpit with a new dashboard. In addition, drivers reported the switch to just two driving modes instead of a manual gearbox, and the increased focus on energy consumption and range as a consequence of the transition process. For most of the case study participants, the transition was supported by targeted training or guidance from in-house driver trainers. On average, the drivers rated the vehicles on the German school grading scale with 1.7 (where 1 = very good and 6 = insufficient). This positive assessment is remarkable given that these were the first production vehicles, which – particularly during the early testing phase – were still prone to technical faults. Only two drivers reported that they were sceptical at the start of the transition; the majority of drivers, however, had shown great interest in switching to electric trucks right from the outset. Curiosity and positive experiences reported by other drivers in their circle were the prevailing factors. Some scepticism was expressed regarding range and the expectation that the new technology might initially be associated with frequent technical problems. Drivers also reported a high level of interest in the technology within both their professional and private circles. Only one driver reported encountering scepticism towards electric trucks in his circle. In some cases, people in the drivers’ circles asked questions about the environmental footprint and the lifespan of the batteries, or about the potential of hydrogen in trucks.

Given the very positive overall impression, it is hardly surprising that the drivers would unreservedly recommend the use of battery-electric trucks. Only one driver would personally prefer to switch back to a diesel truck. The key advantages of electric trucks in day-to-day work cited include low noise levels, the cleanliness of the powertrain (e.g. no oil changes, no ‘greasy’ fuel nozzles at the petrol station) and a more relaxed driving experience. The current inability to tow a trailer, as well as the limited range and lack of charging infrastructure, are still seen by some as drawbacks. Looking to the future, the drivers surveyed paint a positive picture – the majority see electric trucks as the standard or in widespread use in the future, whilst a minority envisage them being used only sporadically. There is a high level of confidence in the technology (“electric is the future”) and, from the drivers’ perspective, a high degree of suitability, particularly for local transport. Reservations are linked in particular to their use in long-distance transport, the lack of public charging infrastructure, and the still high procurement costs.

The transport planning staff surveyed also paint a positive picture of the electric truck trials, though on average they are somewhat more sceptical than the drivers. This may be primarily due to the fact that, given the restrictions imposed by electric range and the need to recharge batteries, electric trucks involve greater planning effort for transport dispatchers. It is also reported that the integration of electric trucks has increased the workload in the dispatching department. The initial scepticism centred on range under varying weather conditions and certain operational restrictions on the available models (including tow bars, tail lifts and payload restrictions). At the same time, a keen curiosity and enthusiasm for new challenges in route planning arising from the introduction of e-trucks, as well as the positive environmental impact and the opportunity to use self-generated, renewable electricity, were cited as motivating factors. The majority of respondents reported a need to adjust routes, but also noted that there was sufficient flexibility within the fleet to implement these changes. In this context, it is also reported that the restrictions had to be partially offset by the greater flexibility of the diesel trucks in the fleet. Generally speaking, the limited range and high dependence on charging infrastructure are frequently cited as the greatest constraints in route planning and for the further electrification of the fleet.

Unlike the drivers, the majority of the dispatchers surveyed believe that electric trucks will continue to be used only sporadically in the future. Their suitability is called into question, particularly with regard to long-distance transport. Some dispatchers therefore expect to see a mix of battery-electric and hydrogen trucks in the fleet in the future. Many respondents were positively surprised by the overall maturity and performance of the technology and see major advantages in terms of environmental protection and the impact on customers. The vast majority of dispatchers do not wish to return to an all-diesel fleet, and not a single dispatcher would fail to recommend electric trucks.

3.3 Analysis and Outlook

Even after trialling the first electric trucks during the project period, it is becoming apparent that the participating case study partners wish to significantly expand the electrification of their truck fleets. Key drivers include the reduction of greenhouse gas emissions and, increasingly, economic considerations, as companies anticipate both rising CO_2 and operational benefits if they can offer low-CO_2 transport services. With the extension of the truck toll exemption in Germany and an emerging reduction in the sale prices of electric trucks, some companies already see competitive advantages in the short term in using electric trucks over diesel trucks.

The expansion into long-haul transport is seen as particularly significant for the further electrification of the vehicle fleet. The next generation of vehicles, the increasing availability of long-haul-capable tractor units with a range of around 600 kilometres, and the expansion of public charging infrastructure are regarded as key prerequisites for this. The significantly higher electricity costs at public charging stations compared to charging at depots are seen as the most critical factor for cost-effective operation in long-distance transport, despite the significant toll advantages. In this context, semi-public charging options (e.g. at depots belonging to other transport companies) are therefore reported to be a sensible addition. Furthermore, as operational profiles in long-distance transport are often less predictable, the demands on vehicle dispatching are increasing, and intelligent planning tools are increasingly being used.

At the same time, the expansion of depot charging infrastructure continues to be regarded as of central importance, as it is still seen as a key energy supply infrastructure for the company's own electric truck fleet and, through smart integration with energy management systems and on-site electricity generation, can enable the procurement of low-cost electricity. Grid restrictions and space constraints are seen as significant barriers to further electrification – not least in terms of the pace of expansion. Particularly in the case of logistics companies that primarily work with service partners to provide transport services and have only a small fleet of their own, questions also arise as to how the electrification of fleets can be achieved in the long term for these often smaller subcontractors. The more favourable driving characteristics of electric trucks, on the other hand, are regarded as an important factor in successfully recruiting drivers and are already being actively utilised by companies.

Key research questions for the next market phase therefore centre primarily on the prerequisites and potential applications of electric trucks in long-distance transport, the further expansion of depot charging infrastructure and its optimised integration into the energy system, as well as the electrification of the fleets of contracted, mostly smaller transport companies with limited financial scope and flexibility regarding their vehicle fleets.

4 Electric trucks in practical use – vehicle characteristics and operational profiles

- The **actual consumption figures** for the electric trucks studied largely **correspond to the manufacturers' specifications**.
- Energy consumption and range are **influenced** in particular **by vehicle weight, temperature, topography and speed**.
- **To date**, the vehicles have been **used almost exclusively in regional transport**; charging is predominantly depot-based and often carried out conservatively without optimised load management.

4.1 Background

Heavy-duty battery-electric trucks have only been available as production vehicles for a few years. Consequently, there is as yet little empirically based data on the operational behaviour of electric trucks in everyday use. At the same time, experience with battery-electric passenger cars shows that operational behaviour (including energy consumption and electric range) can, in some cases, differ significantly from the manufacturers' specifications in practice. However, for reliable use in day-to-day logistics operations, robust data on actual energy consumption and available vehicle range are key planning parameters and a central prerequisite. Against this background, the ELV-Live project investigated the deployment of battery-electric trucks, using the eActros300 and eActros400 models with different axle configurations and body types as examples, over the period from September 2023 to January 2025 for a total of 19 vehicles in operation at five partner organisations (see 4. Report, 5. Conference paper). Vehicle operating data (including vehicle activity type, vehicle mass and payload, GPS data, start and end times, distance travelled, total and average energy consumption, and battery charge level) from a total of over 800 journeys were available for this purpose, covering all seasons and thus a wide range of weather conditions. In particular, the energy consumption of the vehicles under different operating conditions (including usage profiles and external factors) and the resulting electric range, as well as the general usage and charging profiles, were analysed.

4.2 Findings

The average consumption in real-world driving conditions for the vehicles under consideration is 0.96 kWh/km for heavy goods vehicles with a gross vehicle weight of between 11 and 18 tonnes, at an outside temperature of between 19 and 21°C and with an elevation gain of less than 200 m during the journey. This calculated consumption figure deviates only slightly from the official manufacturer's specification (0.97 kWh/km under these optimal conditions) and aligns well with other available measurement data for comparable electric truck models.

In-depth analyses reveal a statistically significant influence of vehicle weight, ambient temperature, topography and average speed. For instance, energy consumption increases by an average of 0.18 kWh/km for every additional 10 tonnes of vehicle mass or payload. An outside temperature 10°C higher reduces energy consumption by an average of 0.13 kWh/km. Vehicles fitted with a refrigeration unit (for food transport) have an average additional electricity consumption of 0.092 kWh/km.

Analysis of the operational profiles shows that the trucks analysed – primarily due to their electric range – have so far been used exclusively for regional transport. The average journey length is 220 km, ranging from an average of 115 to 350 kilometres per day. In most applications, operations take place exclusively on weekdays, with fixed and relatively inflexible routes. In single-shift operation, charging usually takes place once a day upon return to the depot and is often completed well before the start of the next shift. Two-shift operation requires more complex strategies, including interim charging whilst the truck is being loaded with goods and a higher charging capacity. To date, charging strategies have been primarily guided by logistical processes and the available charging infrastructure. Whilst some vehicles are recharged after every journey, others are charged only once a day – predominantly at night. Vehicles operating on a single-shift basis are charged on average 1.4 times a day, whereas for vehicles operating on a multi-shift basis, this figure is 4.1 times a day on average. Charging times vary depending on the number of charging operations and are influenced by the varying available charging capacity. However, the total charging time is always significantly shorter than the vehicles' total time spent in the depot. To date, there has been no optimisation of charging strategies in line with the framework conditions of the electricity grid in these applications. Often, the vehicle is connected to the charging point immediately after the journey ends and the charging process begins, even if – particularly at night – the battery charge is already fully replenished well before the start of the first journey in the morning.

Despite technological limitations, the vehicles demonstrated a high level of reliability during the period under review, with few operational failures and, in most cases, short downtimes.

4.3 Analysis and Outlook

The analyses provide initial insights into the operation of battery-electric trucks under real-world conditions. The results confirm that the consumption figures stated by the manufacturer and the associated electric ranges are realistic under optimal conditions. However, the energy consumption data also reveal considerable fluctuations due to speed, topography, outside temperature and payload, which have an immediate and significant impact on the already critical electric range.

Charging strategies remain conservative and offer scope for optimisation. As electric trucks currently account for only a small proportion of the total fleet, future challenges will arise in relation to scaling up depot infrastructure, load management and the availability of public charging points – particularly in long-haul transport.

Future studies would benefit from larger and more diverse datasets, additional vehicle types and longer observation periods in order to further refine energy consumption models and operating strategies. Nevertheless, this analysis provides a solid empirical basis to support the transition to electric heavy-duty transport.

5 Analysis of future potential and challenges for the deployment of e-trucks based on case studies

To complement the practical experience gathered in the ELV-Live project, key questions regarding the further market development of battery-electric trucks were examined as part of in-depth case studies. Whilst previous analyses have focused in particular on real-world operation under current conditions, the case studies specifically address the transferability and scalability of the technology to further use cases.

The focus is on three complementary perspectives: the technical and economic electrification of existing fleets based on real-world driving profiles; the infrastructure and electricity grid requirements involved in converting entire depot sites; and the potential applications of electric trucks in national long-distance transport.

Although the results are strongly influenced by the specific case studies examined, taken together they allow for robust conclusions regarding key influencing factors, interactions and remaining challenges for the next market phase.

5.1 Techno-economic success factors for fleet electrification

- A large proportion of existing **regional truck routes** can already be **electrified** using electric trucks**.**
- **Cost-effectiveness** depends heavily on low battery charging rates and a **high proportion of depot charging**.
- **Larger batteries** can offer economic advantages through **greater flexibility and fewer intermediate charging stops,** despite higher initial costs.
- **High investment costs** for vehicles and charging infrastructure remain a **key challenge.**

5.1.1 Background

Using the fleet of the Badische Staatsbrauerei Rothaus as a case study, the study investigated the extent to which the complete electrification of an existing fleet is technically and economically feasible under real-world operational conditions. The fleet under consideration comprises a total of 20 heavy goods vehicles with a gross vehicle weight of between 26 and 40 tonnes. A height difference of 900 metres must be overcome between the company’s two sites.

The analysis is based on real-world driving profiles (including start and end times, GPS data from the stations, payload, and duration of journey interruptions) and ties in directly with the operational patterns observed during the project. The aim was to systematically assess the electrifiability of the entire fleet and to identify key factors influencing economic viability (see 6. Conference paper).

5.1.2 Findings

The analysis shows that a large proportion of existing routes can, in principle, be electrified. In particular, regionally oriented, predictable operational profiles with depot connections demonstrate a high degree of compatibility with electric trucks with typical ranges of between 300 and 400 kilometres. This confirms the picture observed in the project, according to which electric trucks can already be used in routine operations in many applications today.

At the same time, it is clear that electrifiability depends heavily on individual operational profiles. Routes with high daily mileage, unfavourable idle times or additional energy requirements continue to pose challenges and can currently only be electrified to a limited extent.

With regard to cost-effectiveness, clear influencing factors are evident. The price of electricity plays a central role: whilst depot charging typically enables costs of around €0.15–0.25/kWh, prices for public charging are often €0.40–0.70/kWh or higher. Accordingly, a high proportion of depot charging is crucial for cost-effective operation.

Against this backdrop, it is evident that larger batteries can offer economic advantages despite higher acquisition costs. They increase operational flexibility and make it possible to charge a larger proportion of the energy cost-effectively at the depot, thereby avoiding expensive intermediate charging.

In addition to energy costs, the persistently high investment costs for vehicles and charging infrastructure represent a key challenge. At the same time, suitable operational profiles can yield advantages in terms of operating costs, particularly where vehicle utilisation is high and operational patterns are stable.

5.1.3 Analysis and Outlook

The case study shows that the electrification of existing vehicle fleets is already possible on a significant scale today, particularly in regional transport. At the same time, the requirements increase significantly as soon as more complex or less predictable operational profiles are taken into account.

For further market development, falling vehicle costs, improved integration into operational processes and high availability of cost-effective depot charging are particularly crucial. Electrification can thus take place gradually, starting with particularly suitable applications.

5.2 Options for developing depot charging infrastructure

- The **electrification of large fleets** is technically feasible, but requires **considerable energy and grid capacity**.
- **Smart load management** can significantly reduce peak loads and grid connection requirements.
- The design of the charging infrastructure requires a careful **balance between charging power, space requirements and operational complexity**.

5.2.1 Background

Using the example of a large logistics depot with over 250 vehicles, a study was carried out to examine the infrastructural and operational requirements associated with the electrification of an entire truck fleet (see 7. Report).

The focus was particularly on the necessary charging infrastructure, the requirements for grid connection capacity and the integration of charging processes into existing operational workflows. The analysis concentrates on the technical aspects of electrification and the derivation of charging and infrastructure requirements. A detailed examination of practical implementation and the specific investment costs for the infrastructure was not the subject of the study.

5.2.2 Findings

The analysis shows that extensive electrification of even larger fleets is technically feasible, but is associated with considerable demands on the energy infrastructure.

In the case study examined, uncontrolled charging of vehicles immediately upon their return to the depot results in very high peak loads of over 20 MW, which significantly exceed the grid connection capacity of around 7 MW that is expected to be available at the site in question. However, intelligent charging management can significantly reduce these peak loads without restricting vehicle operations. In the case study, the power requirement was reduced to around 4–5 MW and, through the use of stationary battery systems, further to below 4 MW.

A key trade-off arises when designing the charging infrastructure. On the one hand, a small number of high-power charging points enable short charging times and a high degree of operational flexibility, whilst requiring little space; on the other hand, they necessitate frequent repositioning of vehicles, which is operationally demanding. Alternatively, a larger number of lower-power charging points can be installed; however, this entails a significantly greater space requirement within the depot and increases operational complexity. These aspects become considerably more important as the fleet size increases and space availability is limited.

In addition to the technical requirements, there is also a need for operational adjustments. These include, in particular, the integration of charging processes into dispatch planning, the prioritisation of charging operations according to the vehicles’ operational profiles, the coordination of re-parking manoeuvres, detailed shift planning, and the consideration of public charging infrastructure as a supplementary charging option.

Furthermore, there is the issue of integrating subcontractors, who often provide a significant proportion of transport services but do not necessarily have access to depot charging infrastructure. This gives rise to new requirements for organisational and, where necessary, contractual solutions regarding the use of the charging infrastructure.

The infrastructure also plays a central role from an economic perspective. The costs of grid connection, charging infrastructure and, where applicable, storage can be substantial, but can be reduced through optimised load management and efficient design.

5.2.3 Analysis and Outlook

The case study shows that the scale of electrification depends largely on feasibility at the depot. The expansion and intelligent control of the charging infrastructure will become key success factors for further market development.

For the next phase of the market, early planning of the infrastructure and close coordination with grid operators are particularly essential. At the same time, load management and energy management systems offer considerable potential for reducing costs and the required connection capacity.

In the present analyses, some highly simplified assumptions regarding implementation were made. To arrive at reliable conclusions regarding practical implementation, the next step must involve in-depth analyses that specify the necessary implementation steps and examine the identified challenges in greater detail.

5.3 Expansion into long-distance transport

- **The use of electric trucks in long-distance transport** is, in principle, **possible**, but significantly **more challenging than in regional transport**.
- Crucial to the electrification of long-haul transport is the **expansion of high-capacity public charging infrastructure** along key transport corridors.
- **Charging processes** can, **to some extent,** be **integrated into statutory driving and rest periods**; in particular, **a lack of charging facilities at the end of a journey** leads to **conflicts with** maximum **driving times.**

5.3.1 Background

During the project period, given the range and infrastructure constraints, trials of electric trucks focused on applications in regional transport. However, long-haul transport is particularly relevant for further electrification, given the significantly higher mileage and the resulting higher CO_2 emissions, as well as economic considerations due to the greater significance of operating costs. Using real-world journey profiles from national long-distance transport as an example, the study investigated the extent to which battery-electric trucks can already be deployed today in these more demanding applications. Data sets were available for 23 daily operation profiles from a total of 5 diesel trucks with an average daily mileage of 515 kilometres, which are in use in national long-distance transport.

In particular, the study took into account the constraints imposed by range, currently available – primarily public – charging infrastructure, and legal frameworks such as driving and rest periods (see 8. Report).

5.3.2 Findings

The analysis shows that the use of electric trucks in long-distance transport is, in principle, possible, but significantly more challenging than in regional applications. Key challenges arise from the high daily mileage and the limited downtime available for charging. At the same time, the current public charging infrastructure is not yet sufficiently developed to enable widespread deployment.

The evaluation of the driving profiles shows that a significant proportion of the long-distance journeys examined could, in principle, be electrified, provided that sufficiently high-capacity charging infrastructure is available along the routes. Technical feasibility is currently hampered primarily by the sometimes inadequate infrastructure coverage.

Of particular relevance here is the possibility of integrating charging processes into existing driving and rest periods. Assuming suitable charging capacities, the available time slots can make a significant contribution to meeting the required energy requirements, and intermediate charging can be carried out during the legally prescribed driver breaks at public charging stations already available along motorways. With the electric range of 500 to 600 kilometres now available, 40% of the journeys examined can even manage entirely without an intermediate charge. The biggest hurdle, however, is charging at the end of the day, as the majority of vehicles in the use case examined do not return to their own depot at night and are reliant on public charging infrastructure. Given the limited network coverage, however, significant detours are still necessary, which would often result in driving times being exceeded.

In terms of cost-effectiveness, there is a high degree of dependence on electricity costs at public charging points. The significantly higher prices compared to depot charging have a particularly strong impact on long-distance transport and currently represent a key economic challenge. At the same time, it is evident that, for long-distance transport to operate economically, a high degree of planning certainty regarding the availability and reliability of charging infrastructure is required, as unplanned deviations have a significantly greater impact than in regional applications.

The case study thus confirms the fundamental feasibility of electrifying long-distance transport, whilst at the same time demonstrating that the nationwide expansion of public charging infrastructure is absolutely essential for realising the potential of long-distance transport.

5.3.3 Analysis and Outlook

Three developments in particular are crucial for the electrification of long-distance transport: longer vehicle ranges, the nationwide roll-out of high-capacity public charging infrastructure, and competitive electricity prices at these locations. Furthermore, it is clear that, in addition to the mere expansion of the infrastructure, its targeted placement along relevant transport corridors is also crucial in order to actually realise the identified potential. The integration of charging and operational planning is becoming increasingly important. Digital planning tools and optimised operational strategies are becoming increasingly necessary to manage existing constraints efficiently. The case study thus demonstrates that long-distance transport can be electrified in the long term, but currently still faces the greatest challenges in the transformation process.

6 The transport sector's perspective on the electrification of trucks

- There is a clear **'experience gap' between the sceptical transport sector as a whole and the experienced pioneering companies.**
- Pioneering companies report **high** levels of **satisfaction, high reliability and very positive driver acceptance** of electric trucks.
- **Depot charging** currently forms the central **operational and economic cornerstone** of electrification.
- The **biggest future challenges** lie in **expanding the charging infrastructure**, the electrification of **long-haul transport** and **addressing knowledge gaps** regarding cost-effectiveness.

6.1 Background

To provide a representative overview of developments in the freight transport sector and identify strategic barriers to electrification, three large-scale empirical surveys were conducted as part of the ELV-Live project. These methodologically interlinked surveys shed light on market developments from two perspectives: The pioneer perspective was captured through repeated surveys of early adopters at the outset (B1: early 2024, n=51) and after at least 12 months of practical testing (B3: late 2025/early 2026, n=57) (see 9. and 12. under 'Results Presentation'). The industry perspective reflects a representative snapshot of sentiment across the entire sector in a cross-sectional analysis (B2: summer 2025, n=204) (see 10. Results presentation and11. Report). In addition, a comparative survey from 2021 (B0) (Göckeler et al., 2022) was used to highlight temporal effects in technology assessment since the phase prior to the market availability of battery-electric production models. While the pioneer groups are dominated by large transport operators, the overall sample reflects the fragmented structure of the German road freight transport sector, with SMEs accounting for more than 90% of respondents.

6.2 Findings

The analyses reveal a significant 'experience gap' between the industry as a whole, which is characterised by scepticism, and the mature practical reality of the pioneering companies.

This practical experience leads to an exceptionally positive assessment of the satisfaction and reliability of electric trucks. The overall satisfaction of the pioneers rose with increasing usage from 88% (B1) to 93% (B3). Whilst in the sector as a whole (B2) only 9% expect electric trucks to be more reliable than diesel vehicles, 74% of the pioneers (B1) confirm their high technical reliability in real-world operation.

A striking contrast emerges in the assessment of driving personnel. 59% of inexperienced companies (B2) anticipate resistance from drivers. In reality, however, driving comfort, low noise levels and a positive driving experience rank among the top satisfaction factors for the pioneer companies.

Charging at their own depots currently forms the operational backbone and, on average, covers 82.5% of the energy requirements of the electric fleets among the surveyed electric truck pioneer companies. Successful pioneers also ensure their cost-effectiveness through on-site electricity generation (e.g. PV systems), enabling them to achieve average electricity prices of approximately 24 ct/kWh. In contrast, 83% of companies across the sector as a whole have not yet made any investments in charging infrastructure and are characterised by generally higher average electricity prices.

With regard to the assessment of promising drive and fuel alternatives for 2030, a trend towards consolidation is emerging from the transport sector's perspective. Battery-electric trucks (e-trucks) are regarded as the dominant technology across both groups. Hydrogen-based concepts have seen a significant decline in relevance since 2021 and now rank only on a par with biofuels.

The assessments and practical experiences from the two-stage survey of pioneering companies show very strong overlaps with the findings from the in-depth analyses described above, carried out with the six industry partners in the project.

6.3 Analysis and Outlook

The continued market ramp-up is on the cusp of the transition from the pioneering phase to broad-scale deployment. The following trends and challenges are emerging in this context.

With the introduction of new generations of vehicles (range > 500 km), the focus of use is increasingly shifting from regional to long-distance travel, as already indicated by a significant rise in average daily mileage to up to 432 km.

Whilst vehicle-related aspects dominated during the initial phase, systemic barriers are coming to the fore as usage becomes more widespread. These include, in particular, the insufficient availability of public charging infrastructure, restrictions on grid connection capacity for depots, and complex route planning requirements.

The industry's overall willingness to invest is hampered by a distorted perception of economic viability. 57% of the industry as a whole (B2) anticipate a higher TCO (Total Cost of Ownership), even though the majority of these operators have never carried out their own TCO calculation. Less than one-third of companies can correctly identify the current toll exemption for electric trucks. A key focus must therefore be on addressing this information gap in order to disseminate the positive economic experiences of the pioneers – in particular the benefits of toll discounts and the use of self-generated electricity – more widely.

The expansion of the charging infrastructure remains the bottleneck for scaling up, particularly with a view to opening up use cases beyond depot-based regional transport.

7 Conclusion and recommendations for action

- **Battery-electric trucks** have established themselves **as the dominant technology of the future** in heavy goods transport.
- The **key bottleneck** is increasingly shifting from vehicle technology to **charging infrastructure, grid connection and operational integration**.
- **Economic viability and market ramp-up** depend largely on **stable policy frameworks, toll incentives and low electricity costs**.
- **Knowledge transfer, digital planning tools and collaboration on infrastructure development** are crucial for **widespread scaling**.

The ELV-Live project has provided scientific support for the transition from the technological pilot phase to the industrial scaling of battery-electric trucks over a three-year period (2023 to early 2026). By combining real-world vehicle operating data, in-depth case studies and large-scale surveys, a robust empirical database was created that goes beyond theoretical model calculations heavily based on assumptions. The project served as a neutral platform for bringing together the perspectives of manufacturers, infrastructure operators and logistics companies, thereby narrowing the ‘experience gap’ between a sceptical industry and satisfied pioneers, and identifying empirically grounded areas for action.

1. Vehicle technology and market development

Conclusion: The battery-electric truck (e-truck) has established itself across all manufacturers as the dominant key technology for heavy road freight transport, whilst other drive and fuel alternatives (particularly hydrogen) have lost significant ground in terms of their market potential up to 2030 among manufacturers and within the transport sector during the period under review. Electric trucks are already technically mature for regional transport and, with ranges of 500–600 km, are now also becoming viable for national long-distance transport. Early adopters report high reliability and a very positive response from drivers due to improved driving comfort. The range of models has already expanded considerably in recent years; at the same time, competitive pressure on European manufacturers is increasing, driven in part by the strong trend towards electrification in the Chinese market.

Recommendations for action:

- **Vehicle manufacturers (OEMs):** The model range must be further modularised and expanded to better meet specific requirements, such as trailer couplings or maximum payloads.
- **Policy:** Ensuring a stable framework through EU CO_2 standards and AFIR, in order to offer manufacturers and users long-term investment security. A reduction in the level of ambition that goes beyond the flexibility currently agreed for the EU CO_2 standards would risk causing sustained uncertainty amongst market players.

2. Charging infrastructure and grid connection

Conclusion: Infrastructure is currently the critical pillar of the transition. Depot charging forms the economic anchor and currently covers approximately 82% of the energy requirements of early adopters. For long-distance transport, a comprehensive public high-power charging network is absolutely essential, as on-the-road and overnight charging away from the depot represents the greatest operational hurdle in this context. The availability of space along motorways presents a key challenge in this regard. Grid expansion and grid connection capacities are the main bottleneck due to long lead times.

Recommendations for action:

- **Network operators & policymakers:** Introduce forward-looking network expansion plans for logistics hotspots and standardise grid connection applications to synchronise planning cycles between the logistics and energy sectors. Improve the conditions for bidirectional charging, thereby increasing the system benefits of electric trucks.
- **Logistics companies:** Early (proactive) registration of power requirements with the grid operator and the use of intelligent charging management to significantly reduce peak loads at the site and make optimal use of the batteries' potential through integration into the electricity system (V2G).
- **Charging infrastructure providers:** Expansion of public sites suitable for trucks (access roads, through-traffic facilities) and introduction of booking systems for overnight charging bays.

3. Cost-effectiveness and policy framework

Conclusion: The cost-effectiveness (TCO) of electric trucks is heavily dependent on regulatory incentives, in particular CO_2-differentiated tolls, which currently represent the most important lever in Germany. Whilst pioneers are already capitalising on these advantages, there is a significant 'experience gap' across the market as a whole. Many companies with no experience of electric trucks underestimate the cost benefits and have patchy knowledge of electricity prices and TCO calculations.

Recommendations for action:

- **Policy:** The extension of toll benefits for zero-emission trucks until 2031 has already stabilised a key planning factor. Reducing ancillary costs for charging electricity would robustly secure operational cost advantages. For SMEs in particular, the provision of low-interest loans would lower the high barrier to entry posed by higher acquisition costs.

- **Shippers & logistics:** Integration of CO_2 targets into long-term transport contracts to share the investment risks of the transition on a partnership basis.

4. Acceptance and knowledge transfer

Conclusion: The market ramp-up requires comprehensive change management. Despite a general openness within the industry regarding electric trucks, the knowledge gap remains considerable in some cases compared to pioneering companies, and concrete plans for electrification are still the exception. Practical experience shows that drivers quickly accept the technology, but that dispatchers face greater workload due to more complex route planning. There is a lack of standardised blueprints for the mass market, particularly for SMEs.

Recommendations for action:

- **Industry associations & research:** Develop manufacturer-independent TCO calculators and best-practice guides to bridge knowledge gaps across the market. Promote peer-to-peer learning formats to disseminate the ‘tacit knowledge’ of pioneers throughout the industry. Continuous monitoring of developments among OEMs, suppliers and end-users in the logistics sector.

- **Companies:** Early training of drivers and dispatchers, as well as the use of digital planning tools, to optimise the integration of charging times into route plans.

Summary and outlook

Electrification is already technically and organisationally feasible in many use cases. The next phase requires a transition from the pioneers’ individual, isolated solutions to systemic cooperation models, such as opening up depot charging infrastructure to third parties or the joint development of industrial estates. Achieving climate targets depends largely on whether the regulatory framework remains stable and whether infrastructure development consistently precedes the ramp-up in vehicle numbers.

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