38th International Electric Vehicle Symposium and Exhibition (EVS38) Göteborg, Sweden, June 15-18, 2025

Projecting the Spatial Distribution of Charging Infrastructure Demand for Battery-Electric Trucks and Vans in the Netherlands

Nazir Refa[1], Jeroen Janssen, Gijsbert van der Geer, Paul Broos, Thomas Bos.

[1]*ElaadNL, Westervoortsedijk 73, 6827 AV Arnhem, nazir.refa@elaad.nl*

Executive Summary

The logistics sector is undergoing a significant transformation driven by the imperative to reduce carbon emissions. This paper presents an outlook on the electrification of light commercial vehicles (vans) and heavy-duty vehicles (trucks) in the Netherlands, based ElaadNL Outlook for logistic vehicles. Using a Applying a comprehensive four-step methodology the study explores adoption scenarios for battery-electric vehicles within the logistics sector. analyses their spatial distribution, identifies likely charging locations, and models corresponding charging profiles. Three distinct adoption scenarios (low, medium, high) are developed. Projections suggest that by 2050, a substantial majority of the logistics fleet will be battery-electric, resulting in an annual electricity demand of between 17 and 20 TWh, depending on the scenario. The paper underscores the critical necessity for the timely deployment of charging infrastructure, expansion of grid capacity, and implementation of supportive policy measures to effectively manage this transition.

Keywords: Heavy Duty electric Vehicles, Trends & Forecasting of e-mobility, Optimal charging locations, Modelling & Simulation.

1 Introduction

The global imperative to reduce carbon emissions is driving transformative change across multiple sectors, Transportation is responsible for approximately 23% of global energy-related CO_2 emissions. Mobility sector is being a primary focus with the energy transition perspective [1]. Within this landscape, the logistics sector is undergoing a significant shift toward electrification, driven by regulatory pressure, technological advances, and sustainability commitments.

The Netherlands, with its highly developed logistics infrastructure and central position in Europe's freight corridors, plays a pivotal role in this transition. The country is actively aligning its policies with the European Union's Fit for 55 package, which includes a target to reduce emissions by at least 55% by 2030 compared to 1990 levels [2]. Electrification of logistics operations is central to these ambitions.

The widespread adoption of battery-electric vehicles (BEVs) is increasingly seen as essential for decarbonizing freight transport. In particular, the deployment of BEVs in light commercial vehicles (LCVs), such as delivery vans used in urban logistics—and in heavy-duty vehicles (HDVs), including long-haul trucks and tractor-trailers, is crucial. According to the European Environment Agency (2023), road transport accounts for more than 70% of total greenhouse gas emissions from transport in the EU, underscoring the urgency of transitioning fleet operations to zero-emission alternatives [3].

Multiple Dutch initiatives, including city-specific zero-emission zones [4] set to begin implementation in 2025, further illustrate the country's leadership in logistics decarbonization.

This paper synthesizes the core findings of the ElaadNL Outlook Logistic Vehicles – 2025 [5]. It provides a detailed study assessing the anticipated growth of battery-electric logistics vehicles and their subsequent impact on the Dutch electricity grid.

ElaadNL, the Dutch knowledge and innovation center for smart charging infrastructure, regularly publishes Outlook reports to inform grid operators, regional governments, and other stakeholders involved in the energy transition.

The electrification of logistics vehicles presents both considerable opportunities and complex challenges. While offering zero tailpipe emissions and potential long-term operational cost reductions, widespread adoption necessitates substantial investment in charging infrastructure and raises critical questions regarding grid capacity and management. A thorough understanding of future electricity demand, primary charging locations, and temporal charging patterns is crucial for effective planning and infrastructure deployment.

This paper aims to provide a comprehensive overview of the projected growth of battery-electric vans and trucks, the spatial distribution of charging demand, the characteristics of different charging locations, and the potential implications for the electricity grid. It also highlights critical issues that require attention to ensure a successful and timely transition.

The paper is structured as follows: Section 2 details the methodology. Section 3 outlines the current status of battery-electric logistics vehicles, charging infrastructure, and policy in the Netherlands. Section 4 discusses relevant market developments. Section 5 presents the adoption scenarios. Section 6 explains the spatial distribution modeling. Section 7 delves into charging locations and electricity demand. Section 8 describes charging profiles. Section 9 highlights key points of attention. Section 10 concludes the paper.

2 Methods: from adoption scenarios to grid Impact

This research adopts a structured, four-component methodology to translate BEVadoption scenarios into tangible impacts on the power grid. The approach offers a comprehensive framework for examining the intricate relationships among vehicle adoption patterns, spatial distribution, charging behaviors, and resulting electricity demand. Figure 1 presents a visual overview of the four components, illustrating the input parameters for each model using letters and the corresponding outputs using numbers. This section outlines and explains each of the four core components in detail.

2.1 Adoption scenarios

The initial step involves developing scenarios for the expected number of BEVs required up to 2050. These scenarios are based on current trends, market developments, technological advancements, and policy assumptions. Key input variables include prognoses for the general development of the vehicle fleet, annual inflow and outflow, and the share of BEVs in inflow and outflow. Separate scenarios are developed for trucks and vans, reflecting their distinct characteristics and market dynamics.

2.2 Distribution model

The adoption of BEVs is not expected to be geographically uniform. The distribution model determines where trucks and vans are primarily located when not driving, as this is where most charging will occur. This involves distributing the projected national number of BEVs across CBS (Statistics Netherlands) neighborhoods. The distribution is based on CBS data on current vehicle locations, the spatial distribution of business parks, the location of existing charging infrastructure, and en-route locations such as rest areas and truck parkings.

2.3 Charging location model

Charging behavior and requirements vary significantly by potential charging location. The charging location model forecasts electricity and power demand per neighborhood, considering different charging location types: depot charging, corridor charging, logistics charging plazas, urban fast charging, and other (fast) charging locations. The model forecasts the number and type of charging points needed at each location type within each neighborhood.

2.4 Charging profiles

To quantify the grid impact, it is necessary to understand the temporal patterns of electricity and power demand. Charging profiles illustrate power demand over time. These profiles are developed based on real-world charging data, prognoses of future mobility and charging behavior, and simulation models. By combining projected vehicle numbers and charging points with characteristic charging profiles, the methodology allows for assessing total electricity and power demand at national and local levels, providing critical input for grid operators.

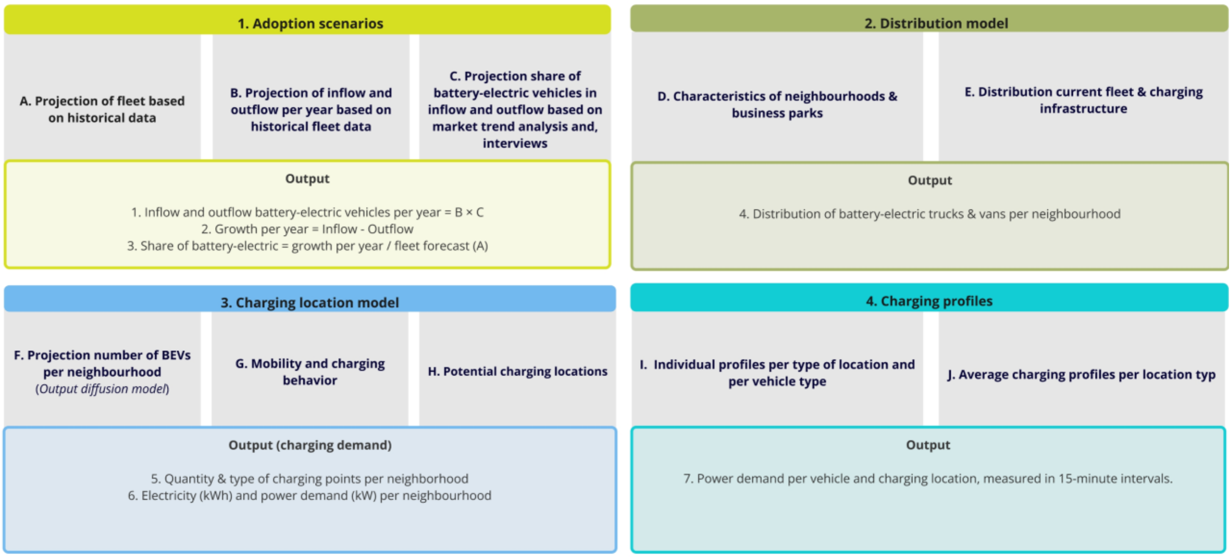


Figure 1: From adoption scenarios to grid impact

3 Current state of logistics fleet electrification

As of early 2025, the electrification of the Dutch logistics fleet is still in its early stages, particularly for heavy-duty trucks. However, significant policy drivers and market developments are poised to accelerate the transition.

3.1 Adoption of battery-electric logistic vehicles

The adoption of battery-electric trucks has been slower than previously anticipated. By the end of 2024, only 1,160 battery-electric trucks were registered, representing 0.7% of the total truck fleet. Electric trucks accounted for only 4% of new truck sales in 2024 [6]. High purchase prices and concerns about range and charging infrastructure remain significant barriers.

Battery-electric vans show slightly more progress, with 34,340 registered vehicles, constituting 3% of the total van fleet. The abolition of the BPM exemption in 2025 led to a surge in van purchases in late 2024, with electric vans accounting for 10% of new sales. The Total Cost of Ownership (TCO) for some battery-electric vans use cases is already competitive with diesel vans. A temporary legal exemption allowing B license holders to operate electric vans up to 4,250 kg is a key development.

3.2. Charging infrastructure

The charging landscape is evolving. Larger trucks primarily use Combined Charging System (CCS) with fast charging (250-400 kW), with the Megawatt Charging System (MCS) expected to become increasingly important. AC charging for trucks is less common. Battery-electric vans use charging technology similar to passenger cars (AC and DC via CCS). Depot charging is dominant for trucks, but en-route charging is essential for longer distances. As of early 2025, there are 52 (semi-)public charging locations suitable for trucks, offering 270 charging points. Electric vans can utilize existing passenger car charging infrastructure.

3.2. **Policy landscape**

Both national and EU policies are driving electrification. Table 1 includes an overview of key policy related measures.

Table 1: Overview of key policy measures supporting the electrification of logistics vehicles

EU CO_2 reduction targets for truck manufacturers: Mandating significant reductions in emissions from new trucks by 2030, 2035, and 2040.
Zero Emission Zones (ZE-zones) in Dutch cities: Phased introduction of ZE-zones in urban areas, starting with 18 cities in 2025 and expanding to 12 more in 2026, restricting access for non-zero emission vehicles.
EU Emissions Trading System (ETS2): Including road transport in the emissions trading system, making fossil fuels more expensive.
Corporate Sustainability Reporting Directive (CSRD): Requiring companies to report on their environmental impact, which is expected to lead to increased demand for sustainable transport solutions from clients.
Renewable Energy Directive (RED 3): Obligating fuel suppliers to increase the share of renewable fuels, potentially benefiting electric transport through the trading of Renewable Fuel Units (HBEs).
Truck toll system (Vrachtwagenheffing): Introduced from 2026, this kilometer-based levy includes differentiated tariffs based on emissions, making electric trucks significantly cheaper to operate per kilometer than diesel trucks.
Reduced fuel excise duty: A temporary reduction in diesel excise duty is in effect until the end of 2025.
Subsidies: Various subsidies are available to support the purchase of electric vehicles and charging infrastructure, partly funded by the revenues from the Truck Levy.
Alternative Fuels Infrastructure Regulation (AFIR): Mandating the deployment of public fast-charging locations for heavy-duty vehicles along the TEN-T core road network every 60 km.
Vehicle registration tax exemption for battery-electric vans: BEV vans are exempt from vehicle registration tax, unlike diesel vans from 2025.
Driving license regulation for heavier electric vans: A temporary legal framework is being introduced to allow B license holders to drive electric vans up to 4,250 kg.

These policies collectively create a framework that incentivizes the adoption of electric logistics vehicles, although their effectiveness and implementation timing are crucial for the pace of the transition.

4 Market developments

Several market developments influence the trajectory of electric logistics, including technological advancements, evolving business models, and infrastructure solutions.

4.1. **Technical developments**

Vehicle manufacturers are continuously innovating. Key advancements for trucks include e-axles, Electric Power Take-Off (ePTO), battery technology improvements (energy density, cost, charging speed, emerging sodium-ion batteries), high system voltage, and increased range. For vans, developments mirror the passenger car market, focusing on range, payload, and towing.

4.2. **Cost developments**

Cost is critical in the low-margin logistics sector. Policy measures like the Truck toll system and ETS2 are expected to make the TCO of BEVs more favorable between 2026 and 2029. However, the higher initial purchase price remains a hurdle, particularly for smaller operators.

4.3. **Charging developments**

Adequate charging infrastructure is paramount. Depot charging is expected to be the priority, often requiring significant grid connection upgrades (75% of logistics companies have small-scale connections). En-route charging requires high-power facilities along highways, as mandated by AFIR. Logistics charging plazas on business parks are gaining traction as a shared infrastructure solution. Urban fast charging is important for vans. Smart charging and energy management (integrating with renewables and storage) are becoming crucial for optimizing grid use and managing congestion. Real estate owners play a role for companies renting premises.

4.4. Electric Road Systems (ERS)

ERS, such as overhead catenary lines, offer potential for dynamic charging. Feasibility is being explored, but high costs, potential high charging costs, and limited manufacturer interest remain uncertainties. ERS could shift charging to daytime, potentially exacerbating peak load issues.

4.5. Hydrogen developments

Hydrogen is considered for specific heavy-duty applications with high energy demand or specialized functions. However, the high current price of hydrogen is a major barrier to widespread adoption, and prices are expected to remain high until at least 2035. The required rollout of hydrogen refueling stations with sufficient capacity is also facing challenges. Truck manufacturers are initially focusing on hydrogen internal combustion engines (H2ICE) as a shorter-term solution, with fuel cell technology expected to become more viable after 2030. Hydrogen is not expected to play a significant role for vans due to the complexity and cost compared to battery-electric technology.

5. Adoption scenarios

Based on the market developments and future expectations, three growth scenarios have been developed to project the number of battery-electric vans and trucks in the Netherlands up to 2050. The medium scenario is considered the most likely outcome based on current expectations.

5.1. Low scenario

Assumes less supportive policies, slower technological development, and hesitant investment.

- **Vans:** Majority of new sales BEVs from 2032, reaching 95% from 2040. 160,000 BEV vans in 2030, 1.15 million in 2050.
- **Trucks:** Adoption gains momentum around 2035. Over 10,000 BEV trucks in 2030, 132,000 in 2050. Hydrogen plays a smaller role than before but is still present. 80% of new sales electric in 2050.

5.2. Medium scenario

Based on continuation of current/planned policies and trends. Favorable TCO drives adoption.

- **Vans:** 100% of new sales electric from 2035. 257,000 BEV vans in 2030, 1.2 million in 2050 (entire fleet electrified).
- **Trucks:** Adoption accelerates before 2030. 24,000 BEV trucks in 2030, 147,000 in 2050. Hydrogen only in niche segments. 90% of new sales electric in 2050.

5.3. High scenario

Assumes more ambitious policies and faster technological development, creating a virtuous cycle.

- **Vans:** TCO lower than diesel from 2025. All new sales electric by 2030, entire fleet electrified well before 2050. 341,000 BEV vans in 2030, 1.2 million in 2050.
- **Trucks:** Rapid growth. Minimal role for hydrogen. 95% of new sales electric in 2050. 29,000 BEV trucks in 2030, 164,000 in 2050.

Total electricity demand from electric logistics vehicles is projected to reach 17 to 20 TWh in 2050, depending on the scenario, representing over 17% of current Dutch annual electricity consumption [7]. The medium scenario projects 18.4 TWh in 2050. Figure 2 and 3 visually represent the projected scenarios of battery-electric vans and trucks.

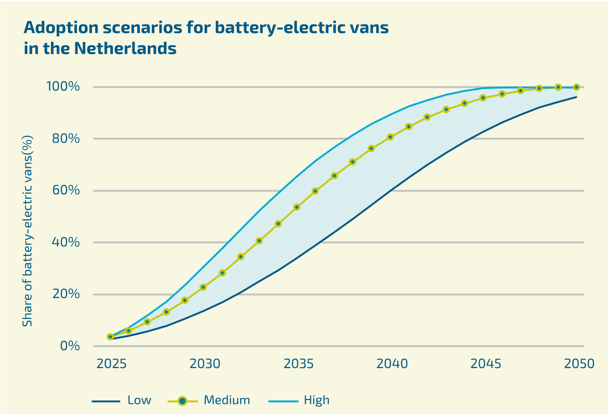


Figure 2: Adoption scenarios for battery-electric vans

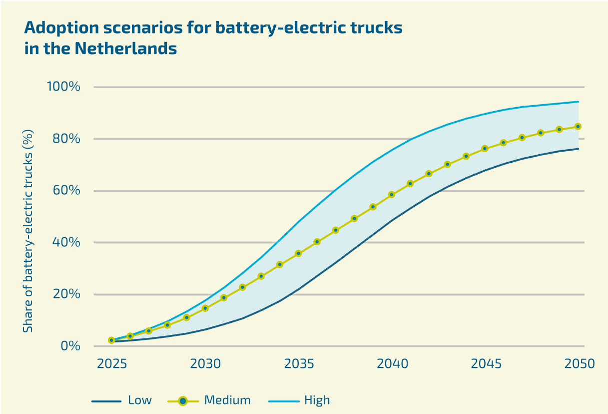


Figure 3: Adoption scenarios for battery-electric trucks in the

6. Regional distribution of battery-electric vans and trucks

Understanding the spatial distribution of electric logistics vehicles is crucial for local infrastructure and grid planning. The distribution model uses recent data on typical vehicle overnight parking locations ("standplaats"), often company depots. About 88% of trucks and 61% of vans are based on business parks. The remainder are outside business parks, including residential areas (especially vans).
The distribution model identifies "BEV hotspots" in neighborhoods with a high expected number of electric vehicles in 2050, coinciding with business parks. Regionally, the province of Noord-Brabant is prominent. Top municipalities for BEV vans include Rotterdam, Westland, Amsterdam, Eindhoven, and Tilburg. For BEV trucks, top municipalities are Rotterdam, Amsterdam, The Hague, Haarlemmermeer, and Breda.

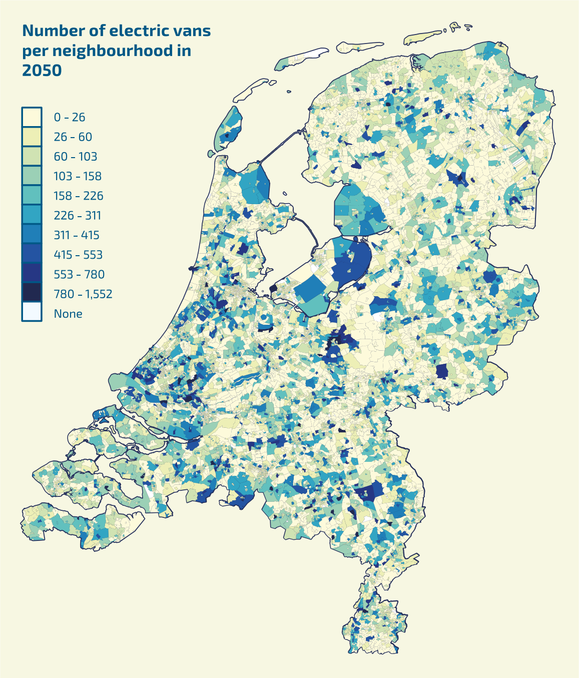


Figure 4: Distribution of battery-electric vans per neighbourhood in 2050

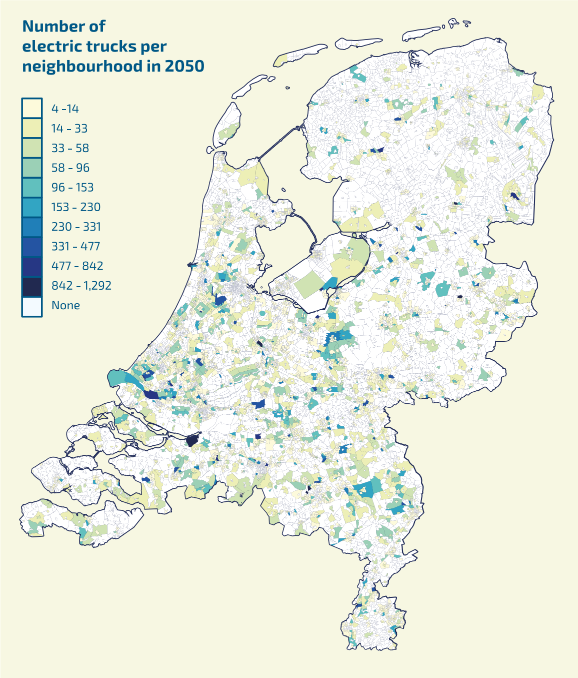


Figure 5: Distribution of battery-electric trucks per neighbourhood in 2050

The pace of electrification and the resulting power demand will vary significantly between neighborhoods, especially in the initial years, depending on the proactiveness of local transport operators and the availability of technical and financial resources. More detailed information on the prognoses per neighborhood can be found via an interactive Outlook dashboard [8].

7. Charging locations

The expected electricity and power demand across different charging locations are analyzed, providing insights into where infrastructure investments are most needed. Figure 6 provides an overview of the different charging locations and their expected share of the total electricity demand.

Charging on business parks

Business parks are expected to be the primary charging location, accounting for 56% of total van charging demand and 88% for trucks. This includes individual depots and shared logistics charging plazas. Total truck charging demand on business parks has increased due to higher projected BEV share.

En-route charging

En route charging is necessary when the distance of a trip exceeds the vehicle's range. This is particularly relevant for trucks undertaking long-haul journeys. The demand for en route charging is projected along major highways (corridors), distributed across nearly 150 different route segments. This analysis is based on traffic and transport models, incorporating insights into traffic intensity and the distances traveled by Dutch trucks and vans. The model estimates the portion of trips that will require en-route charging based on distance and vehicle range. This demand is then distributed among rest areas and truck parking locations along the corridors. In the medium scenario, total corridor charging demand is 1.5 TWh in 2050 (8% of total logistics demand), requiring over 2 GW of power capacity due to fast charging needs. For vans, urban fast-charging locations also contribute to en-route demand.

Charging in residential areas

About 39% of vans are charged in residential areas, as drivers take them home. 9% of these are charged at home (private driveway), and 30% at public charging points, highlighting the need for more public infrastructure in residential areas.

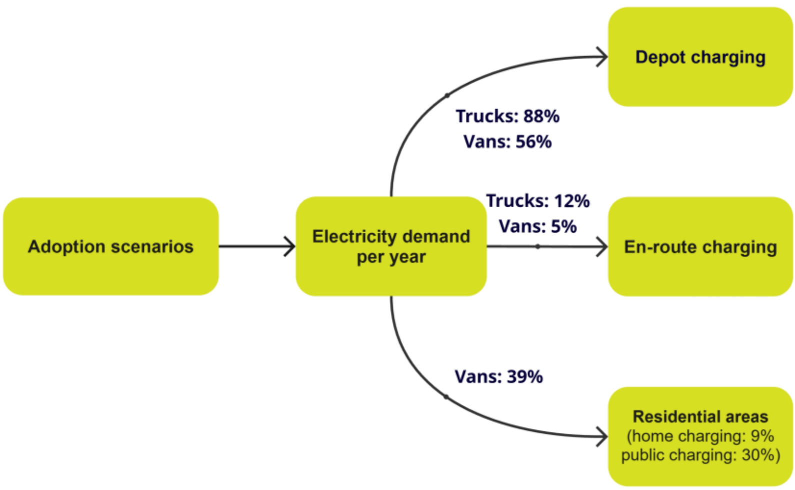


Figure 6: Overview of main charging locations and the corresponding share of electricity demand.

Regional distribution of charging infrastructure

The regional distribution of charging demand, particularly along major transportation corridors, is a key consideration for infrastructure planning. Figure 7 visualizes the projected electricity demand along corridors in 2050 under the medium scenario.

The analysis includes nearly 150 route segments across the corridors. Trucks account for almost 90% of the charging demand along these corridors, with vans contributing the remainder. The analysis considers both traffic intensity and distance traveled. The largest charging demand is projected in the southern part of the Netherlands. On average, approximately 26 charging points for trucks and 8 for vans are needed per corridor in 2050 in the medium scenario, with some segments requiring over 70 charging points for trucks alone. The total charging demand along corridors is projected to reach 1.5 TWh, representing about 8% of the total logistics electricity demand. Given the need for fast charging, the required power capacity along these corridors is substantial, exceeding 2 GW in 2050.

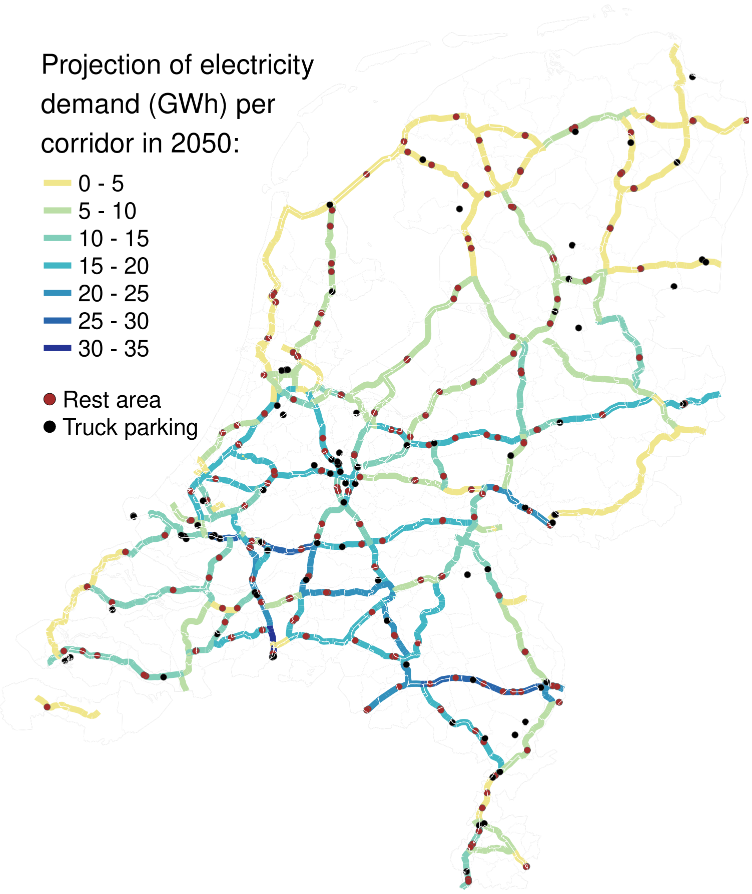


Figure 7: Projected electricity demand along the corridors in 2050 (medium scenario)

8. Charging profiles

Charging profiles are essential for understanding the temporal characteristics of electricity demand from electric vehicles and assessing their impact on the grid. They represent the power demand over time for a given number of BEVs or charging points. For the purpose of this study, a synthetic charging profile generator was developed using profiles derived from real-world charging data. This advanced and openly accessible tool is available through the ElaadNL data platform.

8.1 Charging behavior of vans and trucks

The charging profiles are based on insights into the annual mileage of vans and trucks to calculate energy demand, and on actual charging sessions collected from various charging locations. These sessions include both regular and fast charging events, with the mix varying by location type.

Figure 8 illustrates a charging profile for a hypothetical business park with 40 electric trucks and 125 electric vans, without considering smart charging. This profile shows a clear peak in power demand between 16:00 and 21:00, corresponding to the end of the operational day and the return of vehicles to the depot.

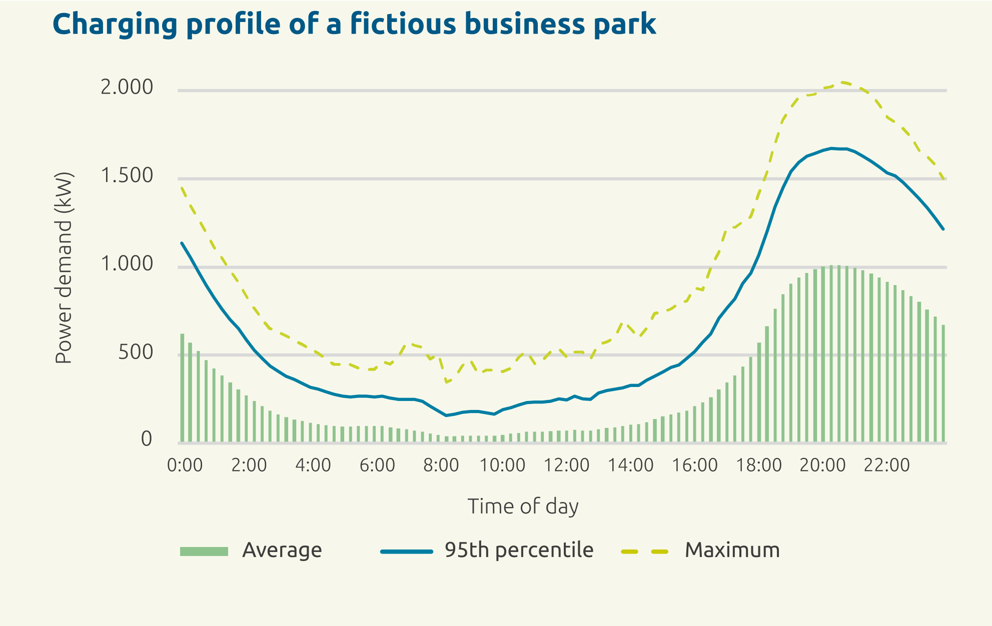


Figure 8: Charging demand of a hypothetical business park with 40 e-trucks and 125 battery-electric vans.

8.2 Smart/Grid-aware charging

Similar to passenger cars, there is a strong incentive to shift the charging demand of logistics BEVs away from peak hours (late afternoon and early evening) to other times of the day. This is known as "smart charging" and can be driven by factors such as lower electricity prices during off-peak hours, the desire to utilize locally generated renewable energy, or the need to manage charging within the limits of a constrained grid connection. "Grid-aware charging" specifically refers to shifting charging based on available grid capacity. While a standardized approach for grid-aware charging in the logistics sector is still under development, tools like the ElaadNL charging profile generator allow for modeling the effects of different smart and grid-aware charging strategies.

8.3 Utilizing charging profiles

The charging profiles for logistics vehicles, along with the underlying data and the charging profile generator tool, are made publicly available by ElaadNL. This allows grid operators, government authorities, and market parties to calculate the expected electricity and power demand at local and regional levels based on the distribution model's prognoses for the number of BEVs per neighborhood.

9. Points of attention

Achieving the projected electrification rates and managing the resulting electricity demand requires addressing several critical points of attention. In this section we describe key challenges and areas where concerted effort and supportive policies are needed.

Optimal grid utilization with time-based contracts

Overnight charging offers an opportunity to utilize off-peak grid capacity. Time-based contracts, providing access to additional capacity during specified off-peak hours (e.g., 23:00-05:00), can be valuable for logistics companies. This form of grid-aware charging helps manage demand within capacity limits and potentially benefits from lower tariffs. A 6-hour block is often sufficient. Clear communication and rapid availability of these contracts are crucial.

Impact of upgrading grid connections

A significant challenge is the need for many logistics companies to upgrade their grid connections from small-scale to large-scale to accommodate charging power demand. 75% of operators have small-scale connections, and two-thirds will likely need upgrades. Even existing large-scale connections may need capacity increases. This process involves significant costs and can face delays due to grid congestion and grid operators workload. Proactive sharing of growth plans by logistics companies with grid operators is essential to enable timely infrastructure planning and implementation.

Safe deployment of stationary batteries

Stationary battery storage can buffer electricity, allowing companies to manage charging with smaller grid connections or optimize renewable energy use. Substantial growth in battery system capacity on business parks and en-route locations is projected. However, further research is needed on their potential impact on local grid congestion if not managed effectively. Incentives need to discourage grid-congesting behavior from batteries. Standardized control and integration are necessary for grid reliability, safety, and stability.

Policy consistency and clarity

Clear, stable, and consistent policy is essential. Uncertainty and conflicting signals (e.g., regarding zero-emission zones, driving license requirements for heavier vans, and the use of rest areas for truck charging) create hesitation and delays. Lack of clarity on whether longer parking for charging will be permitted at rest areas impacts investment and planning for en-route infrastructure. Clear policy decisions are crucial for a predictable and achievable transition.

10. Conclusion

The transition to battery-electric logistics vehicles in the Netherlands is progressing, driven by technology, market dynamics, and policy. While initial growth, particularly for trucks, has been somewhat slower than anticipated, market confidence in a battery-electric future is increasing due to prospects of lower long-term operating costs. Hydrogen is expected to play a limited role in specific niche segments.

The medium scenario projects that by 2050, 100% of vans and 85% of trucks will be battery-electric, totaling nearly 1.2 million vans and 150 thousand trucks. This widespread adoption will lead to a significant increase in electricity demand, reaching 18.4 TWh in 2050 in the medium scenario.

The majority of this demand is expected on business parks (56% for vans, 88% for trucks), primarily at depots and increasingly at shared logistics charging plazas. This necessitates significant grid capacity expansion and upgrades for many logistics businesses. Optimizing grid utilization through smart and grid-aware charging, including time-based contracts, is vital for managing demand and mitigating congestion.

Although en-route charging is a smaller portion of total demand (around 8%), challenges are significant due to the need for high-power charging and uncertainties regarding optimal locations (rest areas, truck parking) and regulations. Clear policy decisions on the use of these locations are needed to facilitate investment and planning.

Furthermore, the safe and effective integration of stationary battery storage systems requires further investigation and standardized control mechanisms for grid stability. The success of the energy transition in logistics depends on integrated planning, timely infrastructure development, proactive grid reinforcement, and consistent, clear policy signals that support necessary business investments. Insights from outlooks like this are crucial for guiding these efforts towards a smooth and efficient transition.

References

[1] International Energy Agency (2023), *CO_2 Emissions in 2022*. https://www.iea.org/reports/co2-emissions-in-2022, accessed on 2025-03-22.

[2] European Commission (2021), *Fit for 55: delivering the EU's 2030 Climate Target on the way to climate neutrality*, https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541, accessed on 2025-03-22.

[3] European Environment Agency (2023), *Greenhouse gas emissions from transport*, https://www.eea.europa.eu/en/analysis/indicators/greenhouse-gas-emissions-from-transport, accessed on 2025-03-22

[4] Government of the Netherlands (2025), *Zero-emission zones in the Netherlands,* https://business.gov.nl/sustainable-business/sustainable-business-operations/zero-emission-zones-to-be-introduced-in-many-cities-from-2025/, accessed on 2025-03-22.

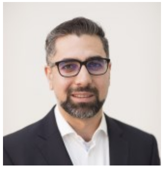
[5] ElaadNL (2025), *Outlook Logistiek 2025, https://elaad.nl/verwachting-onderzoekers-elaadnl-bijna-alle-trucks-en-bestelwagens-elektrisch-in-2050/,* accessed on 2025-04-10.

[6] RVO.nl (2025), Dashboard Electric Vehicles, https://duurzamemobiliteit.databank.nl/homeelektrischvervoer.aspx, accessed on 2025-04-10.

[7] CBS (2025), *Elektriciteitsbalans; aanbod en verbruik, https://opendata.cbs.nl/#/CBS/nl/dataset/84575NED/table,* accessed on 2025-04-10.

[8] ElaadNL (2025), *Interactieve Outlook Dashboard,* https://data.elaad.nl, accessed on 2025-04-10.

Presenter Biography



Nazir Refa (MSc) is a leading data researcher with expertise at the intersection of electric mobility and energy systems. He collaborates with grid operators, policymakers, and research institutions to develop scenarios and predictive models for electric vehicles (EV), charging infrastructure, and the grid impact of e-mobility. He has contributed to numerous scientific publications and both national and international studies—including the ElaadNL Outlooks—helping shape electric mobility policy and infrastructure planning in the Netherlands. Driven by a strong commitment to decarbonization, he leverages data-driven insights and innovative research to support the transition to sustainable mobility and energy systems.