LIGHT ELECTRIC FREIGHT VEHICLES – BEYOND THE HYPE?

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Summary

The developments in city logistics are leading to an increasing number of smaller, time-sensitive deliveries. The parcel market has consistently grown over the past decade, with emerging business models such as ship-from-store (both B2C and B2B) and quick commerce. Moreover, companies are increasingly striving to become more sustainable. To address the challenges of faster delivery, clean transportation (low/zero-emission), and limited space in dense cities, the Light Electric Freight Vehicle (LEFV) presents itself as an innovative solution. This study focuses on LEFVs, encompassing all vehicles with a logistics application ranging from pedal-assisted cargo bikes to light electric vans (LEFV-N1). We specifically examine fresh goods delivery, parcel delivery, service logistics, and construction logistics for urban logistics applications. The study concentrates on factors that account for the potential growth of various types of LEFVs in the Netherlands across these applications over the next decade. The research methodology involves desk research, validation through workshops, quantitative analysis, and interviews with users, legislators, manufacturers, and dealers/leasing companies. The findings of the study include identification of trends, developments, vehicle characteristics, legal frameworks, potential growth opportunities for LEFVs, policies governing LEFV deployment, user profiles, reasons for deployment, and an estimated count of LEFVs in 2027. This count distinguishes between cannibalization on N1 and the number of LEFVs entering new (and partly non-existent) markets.

1. Introduction

In the field of city logistics, attention for cargobikes and other types of light electric freight vehicles (LEFVs) has been soaring. Literature on 'cargobikes' accounts for this with almost 2,900 publications of which more than 70% has been published in the past five years (December '23 on Google Scholar). From a business perspective – deploying LEFVs instead of other, often light commercial vehicles – this attention has been driven by various factors as clearly described by Narayanan et al. (2022) and Rudolph & Gruber (2017). LEFVs are seen as a clean delivery option in light of more stringent emission regulations in cities, herewith securing (future) access. This becomes more apparent with the tentative announcements of zero emission zones towards 2030, in some European cities and the somewhat more concrete steps towards 2025 in Dutch cities. Second, in congested and less accessible inner cities and neighbourhoods, smaller vehicles have easier and faster access. Furtheremore, in combination with reducing lead times and vehicle load factors, operational and economic considerations play a role. Softer factors that explain the commercial interest for LEFVs include corporate social responsibility, and company differentiation and specialization.

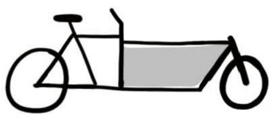
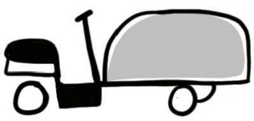
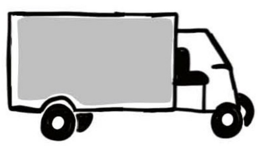
Despite the promise of LEFVs to reduce negative externalities as well as the listed commercial benefits, the assessed uptake of LEFVs that are able to replace vans remains below most forecasts. Narayanan & Antoniou (2022) summarize the substitution potential of cargobikes for commercial trips, with some studies estimating up to two thirds of commercial trips in urban areas. Today we are far from that; we estimate that in the Netherlands for every 100 vans (nationally and not only within cities) there is 1,6 LEFV (see section 4). Both the opportunities and barrieres to the uptake of LEFVs are extensively studied through interviews (Schliwa et al., 2015), surveys (Ploos van Amstel et al., 2018), (real life) experiments (Fitch-Polse et al., 2023), cost calculations (Robichet et al., 2022) and simulations (Llorca & Moeckel, 2020).

So what is there to add to this enormous body of literature on cargobikes? Whereas most studies focus on the cargobike as a specific light electric freight vehicle, this study concentrates on various types designed for diverse logistics applications. With regard to the latter, focus is mostly parcel deliveries in the majority of the studies upon which we extend by including fresh goods delivery, service and construction logistics. The primary aim of this study is to assess the potential deployment of LEFV in urban areas, encompassing both their substitution for light commercial vehicles and their integration into novel business models. The analysis adopts the framework developed by Narayanan & Antoniou (2022) as a comprehensive approach to address the various factors that explain for the potential growth of LEFV. This framework, as explored in the literature study and research approach, goes beyond the commonly examined economic and operational aspects, allowing for an examination of additional factors that can either facilitate or impede the growth of LEFV. To this end, interviews are conducted with users (from the different logistics application areas: fresh, parcel, service and construction), legislators, manufacturers and dealers/leasing companies. Following this qualitative part, the study focuses on projecting the potential growth of various LEFVs in the Netherlands by 2027.

2. LEFVs in city logistics

Cities are growing with more residents, visitors and jobs being concentrated. As a result, demand for goods, services and waste (collection) will increase. Subsequently more delivery vehicles can be expected. At the same time drop sizes are decreasing due to trends such as just-in-time deliveries and quick commerce. This in combination with restrictions on urban deliveries, such as zero emission zones, higher parking fees and decreasing urban space (e.g., densification and the development of car-free neighbourhoods), provides a potential for smaller and light (electric) vehicles (van Duin, Ploos van Amstel, & Quak, 2022).
A LEFV is a bike, a moped, or a compact vehicle with electric support or drive mechanism equipped for delivering goods and goods and people with limited speed. In general, a LEFV is (very) quiet, flexible in usage, emission-free, and requires less space than conventional delivery vehicles (Ploos van Amstel et al., 2021). The LEFV market has emerged along with that of the electric van (BEV-N1). LEFV covers a diverse category of vehicles from mainly small manufacturers. The number of different types of LEFVs on the market has increased, and the performance of the LEFVs in terms of loading capacity, range, and usability has improved. Still, logistics professionals seem to hesitate to make the switch to using LEFVs. Fleet decision-makers and city logistics operators doubt using LEFVs, as many small engineering companies are still optimizing the design of the LEFVS instead of providing an entirely professional service of the LEFVs (Ploos van Amstel, 2021). In this study, three categories of LEFVs are defined (see Table 1).

Table 1. Three class types of LEFVs (based on Ploos van Amstel et al., 2021)

	Electric cargo bike (pedal-assisted)	**Electric cargo moped (full electric)**	**Small electric distribution vehicle (LEFV-N1)**
Loading capacity	50 – 250 kg	100 – 500 kg	500 – 1500 kg
Volume	0,5 – 1 m^3	0,5 – 2 m^3	4 – 6 m^3
Speed	< 25 km/h	< 45 km/h	< 80 km/h
			

City logistics is diverse and consists of different types of (freight) flows with their own delivery characteristics (e.g., volume, vehicles, stop time). As elaborated by Topsector Logistiek (2017), the following flows can be distinguished: conditioned goods (fresh), general cargo, parcels, waste, facility (and services) and construction logistics. When focusing on light commercial vehicles and vans (>80% of urban delivery vehicles), it is estimated that roughly 6% of the vans driving in urban areas carry out parcel deliveries and around 20% conduct trips related to fresh and general cargo deliveries (Topsector Logistiek, 2020). These are the delivery segments that are, according to most studies, eligible for a partial shift to LEFVs. Up to 70% of the vans in urban areas merely provide a service, sometimes including the transport of goods, and are active in the construction and various services sectors (e.g., plumbers, window cleaners). According to Ploos van Amstel et al. (2021) such trips also have characteristis that make it possible to be replaced by a LEFV.

The deployment of LEFVs in city logistics – both by replacing vans in the different segments and in new emerging business models – seem to provide benefits from both a societal and a commercial perspective. Such vehicles take up less road space, are zero emission and less intrusive than largere vehicles, herewith improving (the perceived) traffic safety, and can move more swiftly in less accessible areas (van Duin et al., 2022). Nonetheless, uptake is low. To explain for the adoption of LEFV, a complex interaction of factors must be considered. Narayanan & Antoniou (2022) provide a comprehensive framework with six factors that affect the pentration of cargobikes:

- Operations: the goods type, delivery density and catchment area
- Vehicular, including weather protection, the price and the range.
- Infrastructural: the state of the cycling infrastructure, morphology of the urban area, (overnight) storage facilities and charging infrastructure.
- Workforce: increasing age and income as well as a lower education level negatively influence the willingness to adopt a cargobike.
- Organisational such as an attitude towards sustainability, managerial support, interest in technology in innovation, perceived operational and soft benefits.
- Policy and urban planning: restrictions, parking policy, trail schemes and monetary incentives.

3. Methodology

The goal of this study is to estimate the potential growth in uptake of LEFV in the Dutch vehicle fleet by assessing factors accounting for that. First, the factors that influence penetration of e-cargo bikes as structured by Narayan & Antoniou (2022) (and depicted in Figure 1) is used as a framework for interviews. Interviews have been held with manufacturers of LEFVs, dealers, legislators, lease companies and 13 users from the parcel / fresh / construction / service segments. The framework shows that there is is complex interaction of many variable factors influence vehicle type choice, which makes establishing a well-founded estimation of the uptake of LEFV very challenging. All these factors have their own uncertaintity towards the future, and each factor varies in weight in the decision making for different vehicle owners in different logistic domains. Nonetheless, being aware of the high uncertaintity, we still want to get a grasp on the potential up-take of LEFV. In the interviews, stakeholders were questioned about which of the decision factors play a key role in vehicle decision making, which factors are crucial 'deal-breakers' for the up-take of a certain vehicle type and subsequently also what the users and suppliers expected of the growth of numbers of LEFV. Examples of crucial factors are legislation such as road allowance of the vehicle types or availability of production capacity. The results of the interviews are described in section 4.1.

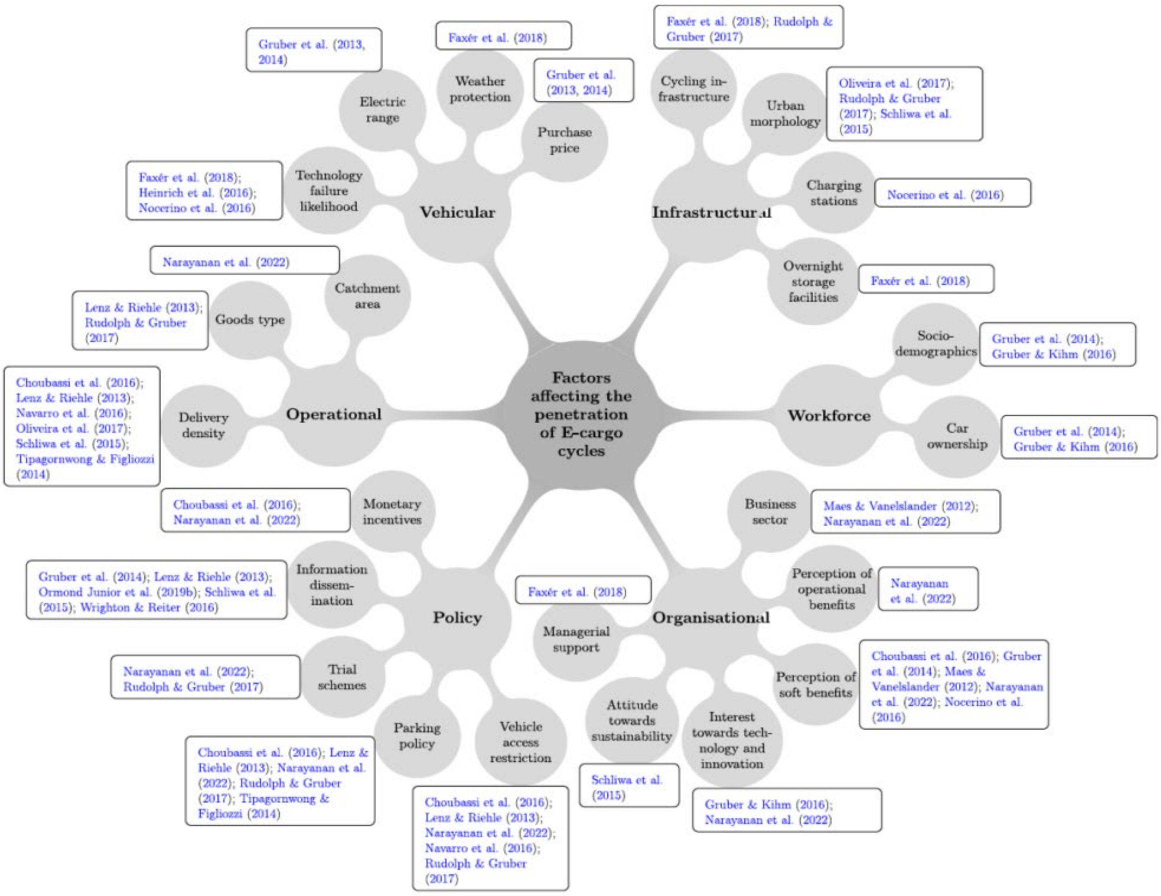


Figure 1 Mapping of factors influencing penetration of E-cargo cycles by Narayan & Antoniou (2022)

A two-sided approach has been applied to estimate the number of vehicles in the different LEFV segments:

1. A *top-down approach*: from the national vehicle fleet numbers provides an overall view on the numbers of LEFV and conventional cargo bikes and vans currently in the fleet. With a potential shift in vehicle choice this combines to a gross estimate on the number of LEFV there could be in the fleet. The top-down approach requires national vehicle fleet numbers on the number of cargo bikes and vans, with both conventional and electric powertrains. For vehicle types with license plate registrations these numbers are quite accurately available. However, for motorized

cargo scooters and cargo bikes there is a license plate registration, but the numbers are hard to retrieve from the total registrations as not all freight related vehicles are identifiable within all mopeds and scooters registrations. As the majority oft he mopeds are mainly used for personal mobility. For van registrations, which have there own license category (N1), the number of vehicles and the type of power train are retrievable and can be categorized in weight classes.

2. A *bottom-up approach* where for logistic domains in which LEFV are expected to be used in an increasing rate a more detailed approximation of the number of LEFV is made.

Combining the bottom-up and top-down approach results, provides a band width for the uptake of LEFV into the Dutch (city logistics) vehicle fleet. The more detailed bottom-up approach requires detailed insight in operational requirements and conditions for the choice of vehicle in each domain. These insights are attained through the interviews. The results are presented in section 4.2.

4. Results

4.1. Factors affecting the growth of LEFV

Policies and regulations from local, national, and European governments determine the type of vehicle allowed. New legislation for the pedal-assisted cargo bike segment is under development; the upcoming LEFV framework sets new rules. The current bill has no significant impact on recent vehicle models and deployment of pedal-assisted LEFVs. Fully electric LEFVs fall under existing moped legislation, and LEFV-N1 under existing car legislation. Comprehensive type approval requirements make it challenging for new vehicle manufacturers to bring new vehicles into compliance with regulatory requirements. This currently limits the influx of (affordable) LEFVs. Locally, there is much ambiguity about location on the road; each city can use general local ordinances (APV) to influence location on the road, access restrictions, and exceptions. The deployability of LEFVs varies by municipality as a result. Zero emission zones do not seem to determine LEFV deployment.

Companies deploy LEFVs for three reasons: 1) Small-scale testing to anticipate on regulations, including zero-emission zones and reduced access to innercities and car-free commuting areas; 2) Image; and 3) Companies that built their business model and distribution network (from scratch) around LEFV (e.g., Bicycle Couriers, Picnic). New delivery concepts are also emerging from companies where LEFV provides opportunities for quick service-driven local deliveries such as ship-from-store and just-in-time deliveries from construction wholesalers. Some players are reducing LEFV deployment and opting for vans again. LEFV deployment is particularly interesting in (old and) dense city centers and car-free areas. A LEFV is more manouevrable due to a less wide design, can use alternative routes, has more access (versus a van), and has fewer parking problems. Furthermore, LEFVs are used for flexible capacity. Some companies have temporary jobs in inner cities, such as replacing smart meters or installing fiber optics. Here, flexible capacity in vehicles allows for the choice of using LEFV for those jobs.

On an *operational level* the use of LEFVs seems particularly interesting for parcel and fresh deliveries. In the service and construction sectors, this is more challenging due to longer distances and the fact that a van often serves as both a commuting vehicle and as a large mobile toolbox. Despite LEFVs suffice with regard to load capacity, these generally offer insufficient operational flexibility, especially concerning distances, as they can be deployed exceptionally within one city. The companies that have started using LEFVs on a larger scale, developed their distribution networks around cities from scratch. Interviewees indicate that deployment of LEFVs in car-restricted and narrow areas is interesting, but the scale is limited. A major barrier to the deployment of LEFV is the additional cost for space for (micro)hubs close to urban cores. Finding suitable and affordable space for hubs is a challenge.

When it comes to the *vehicle*, several hindrances are indicated. Due to the relatively low production per manufacturer, prices are high. Comfort, safety and use in bad weather conditions are currently seen as limitations. In order to improve the acceptance of LEFV, customer service must be improved with more professional supply chains.

With regard to the *workforce* a twofold image emerges. On the one hand, there is personnel that is accustomed to a van. This van is perceived as comfortable and mostly functions as an 'office' (to eat lunch or do some administration in between tasks). On the other hand, there are specific companies that attract personnel that wants to join the company because of the image or due to more practical reasons (no need for a drivers license).

Infrastructure applies to the road network as well as the distribution network of companies. The road network in cities is suitable for both light and heavy LEFVs, and it becomes more interesting when a maximum speed of 30 km/h will be introduced. It is crucial that cargo bikes maintain ongoing access to bike paths. However, challenges may arise when bikes become larger and heavier, and when they have a trailer—too small and vulnerable for the roadway, yet too large for the bike path. LEFVs cause less traffic obstruction and therefore have less issues finding unloading spots. The morphology of a city is crucial for the deployment of LEFVs: their use in the city centers of The Hague, Delft, or Amsterdam is more appealing than in a city like Rotterdam or Tilburg.

4.2. Quantitative assessment

The estimation of the number of LEFVs in current and future fleets is done in 3 categories: pedal-assisted bikes, full-electric (e.g., Carver, Stint) and LEFV-N1 (e.g., Goupil). This latter category contains vehicles which are observed as a LEFV, but fall in the same vehicle category as general vans (N1) due to the type approval and vehicle weight. Therefore this last category implicitly has a lot of overlap in properties with a full electric van, which makes it hard to differentiate when vehicle owners will choose for a LEFV-N1 or regular electric van. First, the total number of vehicles per category is presented, subsequently the number of vehicles are categorized per domain to be able to apply a growth estimate per domain. This growth in vehicles per domain provides an estimate for the total uptake over LEFV over the 3 categories.

As mentioned before, for the pedal-assisted bikes, the statistic sources are limited due to lack of license plate registration. Therefore, the logistics vehicles, the cargo bikes, are based on sales counts, years of operation and the market share of one of the major suppliers of cargo bikes. These are put in perspective with the estimation of total number of these bikes in the Netherlands. It is estimated that in 2021 around 125,000 pedal assisted electric bikes are owned and in use in the Netherlands (Knoope and Kansen, 2021), of which around 10% (12,500) are cargo bikes in private and commercial ownership (hence considered as city logistics applications). There are around 1500 full-electric LEFVs in the Netherlands in 2022, based upon the share of electric power trains in mopeds and share of cargo related vehicles in the moped categegory (CBS statline, 2022). In the category van, N1, there were just over 1 million active registrated vans in the Dutch fleet on January 1 2021 (RDW, 2021), of which 2,000 have a full battery-electric power train. Table 2 show the estimated number of vehicles in 2022 per category of both the bottom-up and top-down approaches.

Table 2. Combining bottom-up and top-down numbers to an estimated total number per vehicle catogery.

	2022 - bottom-up	*2022 - top-down*	*Estimated total*
Electric bike pedal-assisted	12,775	12,500	**12,650**
Full electric bike	700	1,500	**1,100**
LEFV - N1	2,415	2,000	**2,200**

The total number of vehicles per category in the fleet is broken down into different applications in table 3, showing the total number of LEFV per domain and the expected growth towards 2027 in two scenarios with high and low economic growth and growth of the segment.

Table 3. Total LEFV per domain in 2022 and in 2027 with a low and high uptake scenario.

Domain	*2022*	*2027 – low*	*2027 high*
Groceries(regular; consumer)	1,700	1,600	3,200
Groceries(flash-delivery; consumer)	1,300	1,300	3,000
Groceries(catering)		100	200
Parcel	500	1,100	2,100
Services (mechanics, maintaince, care, …)	100	1,300	3,500
Other (e.g. private, construction, municipalities, …)	12,300	17,300	19,700
Total	**15,900**	**22,700**	**31,700**

The growth per category resulting from the bottom-up forecast is shown in Figure 2. For pedal-assisted and full electric a significant growth is expected. Especially the growth of full electric bikes is high, due to the current fleet size being very small. It is expected that the share of full electric compared to pedal-assisted bike increases due to the cheaper producible and maintainable powertrain. However, it's important to acknowledge that the adoption is closely tied to rules and regulations. For LEFV-N1 a relative minor growth is prognosed. This due to the competition with the regular electric van (N1) and major LEFV-N1 users, grocery delivery to consumers, still operate with higher costs than turn-over.

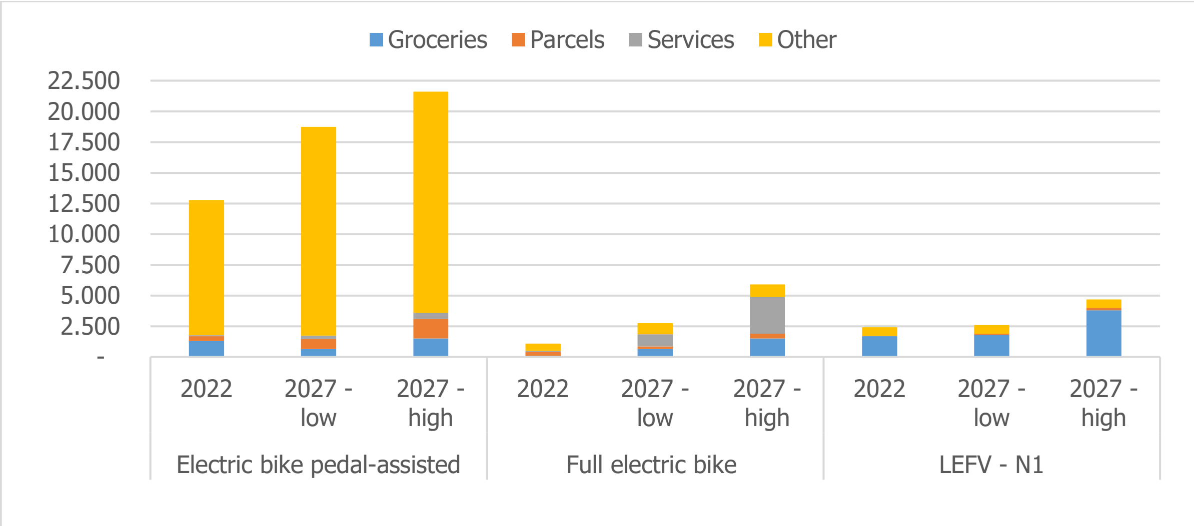


Figure 2 Estimation of uptake of LEFV from 2022 to 2027 in two uptake scenarios for the 3 different vehicle types.

5. Conclusions and recommendations

It is estimated that, in the high projection, slightly more than 30,000 LEFVs will be operational in the Netherlands by 2027. This can be considered a small market if compared to almost one million vans in the Netherlands (currently). The use of LEFVs is expected to be concentrated in specific logistics segments and dense urban areas. Several large carriers have already started experimenting with diversifying their vehicle fleets in city logistics, including LEFVs. LEFVs provide a fast transition option to clean electric-powered vehicles as well as flexibility and suitability for crowded and car-free areas. A drawback is that the currently used vehicle types are manufactured in small production batches, making them relatively more expensive than vehicles produced on a larger scale.

Safety, comfort, flexibility, and cost will continue to be important factors in choice of vehicle type. On many of these factors, the conventional van, also available with a full electric powertrain, holds a strong position compared to LEFVs. For pedal-assisted and full electric vehicles, there is a small, but growing market, especially for users who have specifically designed their distribution networks to accommodate distances and cargo volumes. These vehicles are small, flexible, energy-efficient, and have lower driver's license requirements. However, suppliers face the challenge of providing low-cost yet reliable vehicles, as the current wide variety of suppliers and LEFVs is accompanied by a high number of breakdowns and high repair costs, negatively impacting the total cost of ownership. For all LEFVs, alignment with legislation is crucial. It is important for legislation to align with LEFVs to support maintaining clean, accessible, and livable city centers and car-free neighborhoods. Suppliers need harmonization, for example, on the EU level, and users require clear municipal rules for road access and parking, which are crucial for successful integration.

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