



URBAN TECHNOLOGY RESEARCH PROGRAMME

CITY LOGISTICS: LIGHT AND ELECTRIC

LEFV-LOGIC: RESEARCH ON LIGHT ELECTRIC FREIGHT VEHICLES



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CITY LOGISTICS: LIGHT AND ELECTRIC

LEFV-LOGIC:
RESEARCH ON LIGHT ELECTRIC FREIGHT VEHICLES

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Summary

This publication presents the results of the LEFV-LOGIC project: a two-year research into the use of light electric freight vehicles for city logistics. In this project Amsterdam University of Applied Sciences, Rotterdam University of Applied Sciences and HAN University of Applied Sciences, together with logistics operators, shippers, vehicle suppliers, network organisations, knowledge institutions and municipalities have developed new knowledge about logistics concepts and business models for the deployment of LEFVs.

A LEFV is a bike, moped or compact vehicle with electric assistance or drive mechanism, designed for the distribution of goods in public space with limited speed. LEFVs are quiet, agile and emission-free and take up less space than conventional vans and trucks. LEFV-LOGIC project partners share an ambition to contribute to regional, national and European objectives to organise urban freight transport in a quieter, cleaner and more efficient way.

LEFV-LOGIC started in 2016 from a question of logistics service from small and medium-sized enterprises (SMEs) which want to use LEFVs, but did not know how to do so profitably. The logistics processes in the chain are particularly suited to the use of vans and trucks. In addition, it was not sufficiently clear which city logistical flows and market propositions LEFVs are suitable for, which technical requirements should be met, and which policy measures influence the use of LEFVs.

LEFV-LOGIC project partners have worked together on:

- Exploring the potential of LEFVs for city logistics flows (Chapter 2)
- The design of new logistics concepts for LEFVs (Chapter 3)
- Technical designs of and modifications to LEFVs (Chapter 4)
- Policy around LEFVs (Chapter 5)
- Research on scalable business models involving LEFVs (Chapter 6)
- Practical experiments with new LEFV concepts

The LEFV-LOGIC project distinguishes between three types of LEFVs:

Electric cargo bike: an agile and active form of transport with a payload of up to 350 kilograms. Suitable for mail and parcel delivery services, food delivery and for services in which small volumes are delivered. However, designing for maximum payload could lead to compromises in the friendly character and manoeuvrability of the electric cargo bike.

Electric cargo moped: a robust form of transport with a payload of up to 500 kilograms. Suitable for heavier loads such as bulky food deliveries and small amounts of construction materials. No effort is required from the driver (unlike the e-cargo bike), who is not protected from the elements (as opposed to drivers of the small electric distribution vehicles).

Small electric distribution vehicle: a mini van with a payload of up to 750 kg. Suitable for catering, street cleaning and waste collection (residential and retail streams). Less manoeuvrable than both the cargo bike and moped, but in comparison with a van, better suited for use in crowded areas and easier to park and manoeuvre.

The main conclusions are:

LEFVs could replace 10–15% of delivery vehicle movements

- LEFVs are used by a variety of professionals, from briefcase-carrying self-employed entrepreneurs to logistics service providers carrying roll container trolleys. The industry sectors with most potential in city logistics are food, construction, services, non-food retail and post and parcel delivery. It is estimated that 10 to 15 percent of the trips with a delivery vehicle in cities are suitable for cost-effective deployment of LEFVs.

LEFVs demand a different logistics concept

- Transportation costs are determined largely by personnel costs. LEFVs can be beneficially deployed if the delivery can be performed faster than with a conventional vehicle. This occurs in areas where vehicle speed or access is limited, where the delivery addresses are close together or where finding a good parking place is important. To utilise this time advantage, a logistics concept is required either solely with inner-city rides or with transfer points in the city where the extra transshipment costs incurred at a hub (personnel, equipment, location) will be recouped in the chain. This requires planning and control systems that match the load capacity and routes of LEFVs, suitable load carriers and suitable staff.

The technology must be developed further

- LEFV vehicle technology is still at an early stage and LEFVs are not yet mass produced. There is currently a very limited offering in cooling capabilities and for standardised load carriers (containerisation). In the case of small electric distribution vehicles, the electric delivery van is increasingly competitive in cost, speed, load capacity, and deployability (for example, by accessing highways).
- With limited use of LEFVs entrepreneurs experience no barriers to charging the vehicles. As LEFVs use far less energy than e-vans, the load on the grid is relatively limited. When electric fleets are expanded, smart charging offers a solution to balancing out peaks and troughs in energy demand.

Policy is still unclear, but can stimulate the adoption of LEFVs

- Urban infrastructure and traffic rules are not yet prepared for an increase in the number of LEFVs. There is uncertainty over which part of the streetscape LEFVs will be allowed to use to drive, load and unload; and furthermore there is a shortage of parking facilities. Further speed limits on the road, the construction of bicycle streets and installation of loading and unloading spaces for LEFVs offer opportunities for better integration of LEFVs in traffic. Purchase subsidies, experiments with LEFVs and realisation of policy objectives (such as emission-free or car-free cities) help to bring about a behavioural change among businesses.

The growth of LEFV use requires a scalable business model

- LEFVs have been successfully deployed in market segments where low weights and volumes are transported, in which operational excellence is key, or where the use of LEFVs contributes to a distinctive social and innovative value proposition. The scalability of a business model involving LEFVs is limited in cases where customers need to be mobilised in the first instance to use the solution; where customers must adapt their processes or systems; or where scaling up depends on a major expansion of investment in vehicles, whilst capital is lacking. Recipients of goods or services themselves feel no urgency to pursue supply by LEFV by vendors and carriers, but do respond positively if it happens.
- A LEFV is a solution which can be used in conjunction with other solutions. A combination of vehicles ensures flexibility and assurance that customer demand can be satisfied. The deployment of a LEFV can ensure that fewer businesses need to use a conventional delivery vehicle.

Colophon

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Foreword

Every day, around the clock, trucks and delivery vans drive past my house in Amsterdam. They deliver parcels from web stores, they arrive with construction materials, deliver fresh fish to restaurants and pick up lots and lots of garbage. It's a wonderful sight if you enjoy transport as much as I do.

My neighbours aren't quite as excited about transport, however. They complain about bad air quality, unsafe roads, the inaccessibility of the neighbourhood and last but not least the public space taken up all of these vehicles.

City logistics is vital for cities. As customer demands evolve, city logistics is becoming more and more intricate and delivered more often just-in-time, leading to more and more trucks and vans. This is not sustainable. Truck technology for city logistics needs to become smarter, cleaner, quieter, smaller and safer; almost invisible, in fact.

With this report, we present our research findings on the question if, and how, light electric vehicles can support sustainable city logistics. This report is based on two years of research with our partners in academia, businesses, and government. With our results, we contribute to more sustainable urban freight for more liveable cities.

Walther Ploos van Amstel.

Professor of City Logistics, Amsterdam University of Applied Sciences



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Photo: Schlijper

1 QUESTIONS FROM THE PROFESSIONAL FIELD

1.1 Background to city logistics

Companies are offering their customers more and more options for the supply of goods and services. Online stores offer “same-day delivery”. Construction materials can be ordered today and delivered tomorrow between 7 and 9am at the building site. Consumers want to be able to pick up their package at a chosen pick-up point and have meals delivered to their homes. Demand for deliveries in cities is increasing and logistics is becoming more intricate and time critical. These factors have led to a growth in the number of delivery vans in towns, cities and neighbourhoods; more than 80% of freight traffic in urban areas is now comprised of delivery vans (Visser et al, 2018). This leaves no space for further growth.

Flows of goods entering the city go to construction sites, restaurants, shops, offices and increasingly to consumers who have bought products online. Waste

also flows out of the city. Without these goods, the city would come to a standstill: no beer on the terraces, no new houses and none of the latest fashions in clothing stores. Businesses would prefer to minimise barriers to supply: deliveries must arrive on time and at the lowest cost. But not everyone is happy with all the traffic movements in the city. Residents want clean air, safe routes to school and a pleasant living environment. Visitors may want to stroll and enjoy sitting on a quiet cafe terrace. Local politicians will listen to all of these often contradictory interests. City logistics is just one of the users of scarce public space in the inner city or residential neighbourhood. (See Figure 1.1)

There is more to city logistics than just clean and emission-free transport. Equally important is smarter transport, less traffic, flexible loading and unloading space, more traffic safety, better traffic flow, a stricter exemption policy, rewards for good city logistics in the form of privileges and a smart supply to residential areas..



Image 1.1: Amsterdam (Source: Schlijper)



Image 1.2: Rotterdam

1.2 Emission-free city logistics in 2025

In city logistics, there is a focus shift happening from air quality to other aspects of 'zero emissions' such as CO₂ and noise. In Dutch cities, 35% of the nitrogen dioxide emissions and 10% of the particulate matter comes from road traffic. Freight traffic accounts for 20 to 25% of all road traffic. 35% of road transport-related CO₂ emissions and 30 to 50% of road transport-related air pollution originate from city logistics (CE Delft, 2016a). 60% of noise pollution comes from traffic (Municipality of Amsterdam, 2016).

Environmental zones in many cities mean that the Euro 5 and Euro 6 freight trucks that drive into the city are now fairly clean. In Utrecht, Rotterdam and Amsterdam, stricter environmental zones for light delivery vehicles have now led to cleaner delivery vans in these cities. The share of electric vehicles in city logistics is still below 1% (ACEA 2017). Some cities, including Utrecht, Rotterdam, Nijmegen and Amsterdam, have decided that the city logistics in 2025 should be completely emission free.

1.3 Challenges for suppliers and transporters

The largest city logistics flows can be found in hospitality, construction, retail and facility products (CE Delft 2016b); these account for more than 50% of the freight vehicles in the city. The parcel sector accounts for 5-10% of freight traffic in cities and is rapidly growing through the digitisation of order methods used by consumers (B2C) and businesses (B2B). Demand for city logistics is growing by 3-4% per year due to, among other things, rising numbers of online purchases, a growing renovation market in the construction sector, and retail hospitality businesses who want to be supplied just-in-time with small volumes and a high frequency (Ploos van Amstel, 2015).

Changes in customer demand (smaller volumes, faster delivery) and changes in mobility policy of municipalities (including the introduction of environmental zones and time slots) bring challenges for companies in the planning and deployment of vehicles. This requires solutions with clean, quiet and space-efficient vehicles used profitably to serve the demands of city logistics.

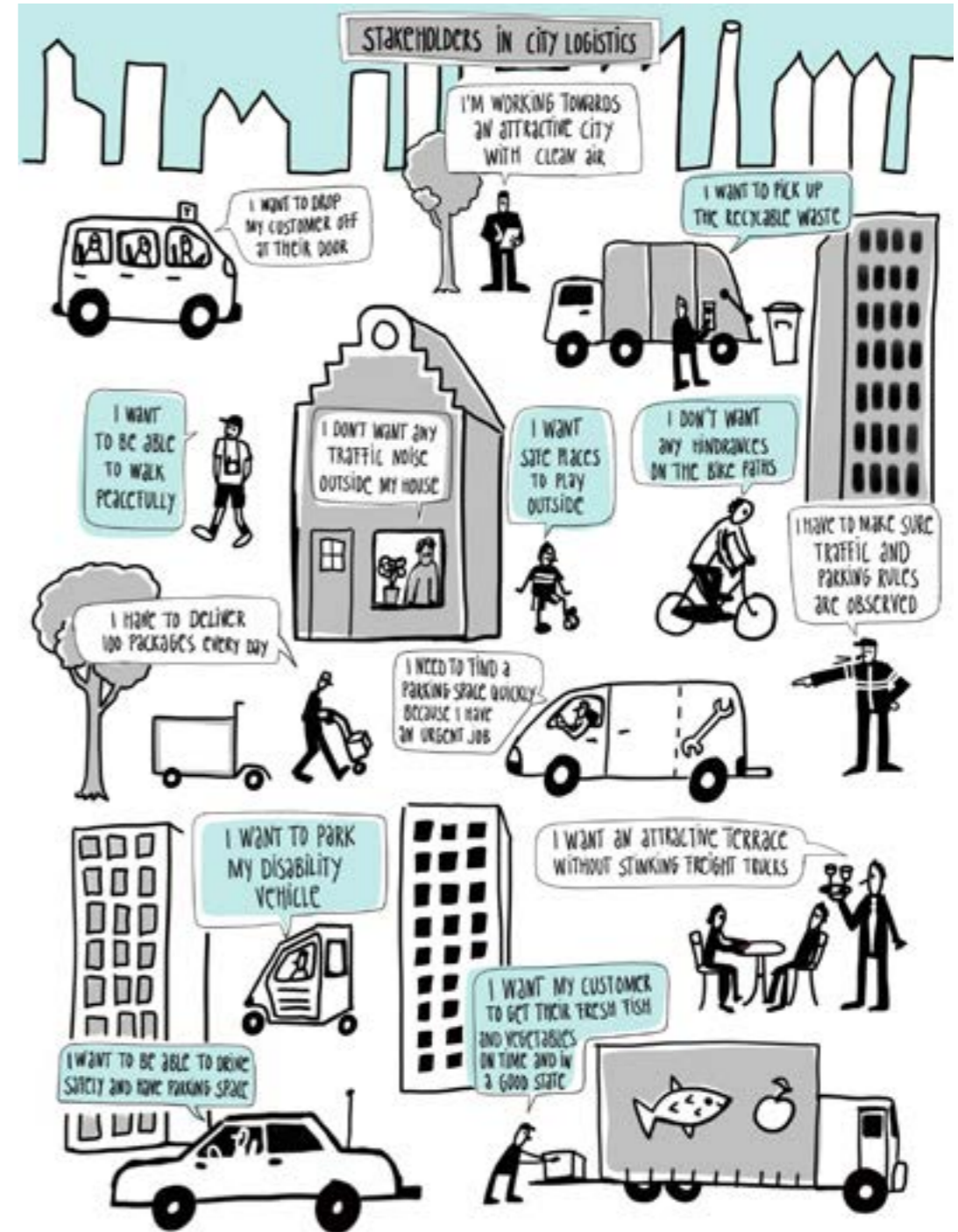


Figure 1.1: Stakeholders in city logistics

1.4 Light electric freight vehicles

A possible solution for city logistics is the use of light electric freight vehicles, or LEFVs. LEFVs occupy the space between bicycles and delivery vans, having electric drive or power assistance, and a limited speed. They are agile, clean and quiet, take up less space than conventional delivery vans and are often faster in the city.

Delivery vans are most commonly used for service logistics, construction logistics and parcel deliveries. Studies show that for commercial vehicles in the Netherlands the average cargo varies between 130 and 420 kilograms per trip, depending on the type of goods (Connekt/Topsector Logistiek, 2017a). The payload of delivery vans is only used to a limited extent. It is possible then that LEFVs are a better option for smart and clean city logistics.

The LEFV-LOGIC research project aims to realise smart and clean city logistics with the use of light electric freight vehicles in order to have a positive impact on the attractiveness, quality of life and economic vitality of cities.

In recent years a number of ambitious startups, either aiming to occupy a position in city logistics with LEFVs or who are offering LEFVs, have entered the market. Examples include Fietskoeriers.nl, City Hub and Stint Urban Mobility. Nevertheless, LEFVs still play a minor role in city logistics, while the number of delivery vans continues to grow (CBS, 2018). How come?



Image 1.3: Fietskoeriers.nl with a Bullitt



Image 1.4: A PostNL Stint



Image 1.5: Flyerman with a Goupil

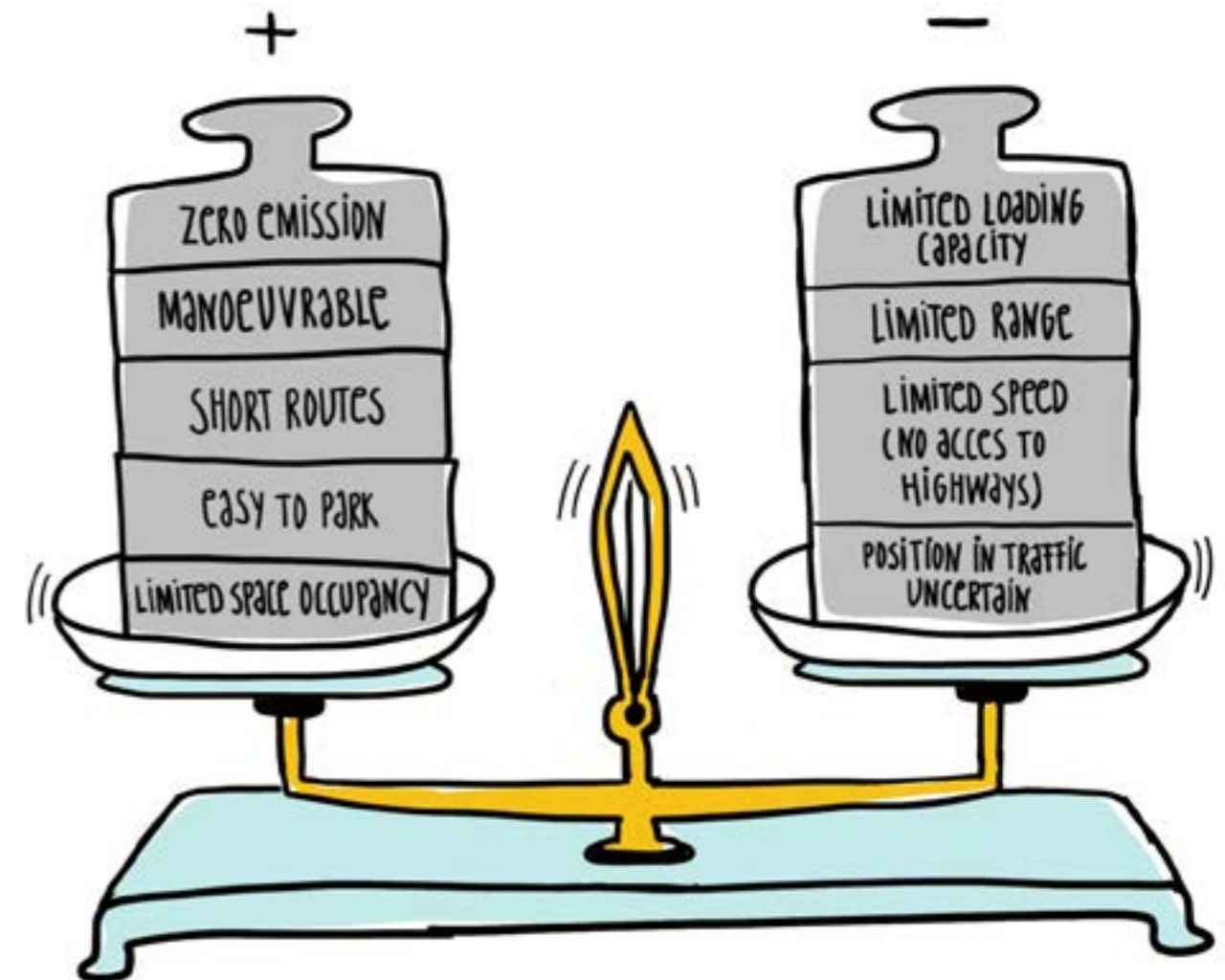


Figure 1.2: Advantages and disadvantages of LEFVs

1.5. Barriers and questions from professionals

Logistics service providers experience of LEFVS is that their use does not adequately match their current processes. The planning, sorting, loading and invoicing of deliveries is currently geared towards the use of delivery vans and trucks. Efficient use of LEFVs requires a different view of logistics operations and customer segments. This is due to the smaller payload and electric drive of LEFVs.

- Henri Hannink, MSG Post & Koeriers, in 2016: *“We recently purchased a cargo bike because it fits nicely into our sustainable business operations, but we are exploring how we efficiently put this form of transport into service.”*
- JJan Deudekom, Deudekom, in 2016: *“Because of declining revenue in removals, our traditional market, we are looking for new markets in which we can generate business with our electric fleet, which has recently been expanded with a LEFV*

Shippers want their products in a fast, reliable manner, transported at low cost. They wonder whether a carrier using LEFVs can guarantee the same service at the same cost.

- Nick Dekker, The Office Service, in 2016: *“We outsource our transport. We want to do this in a sustainable way, but the price offered by a startup with LEFVs is higher than the price of our supplier with a delivery van.”*

Vehicle manufacturers want to develop LEFVs for the logistics market, but can not offer a tailor-made vehicle for every logistics operator. They do not know enough about the specific demand (per market segment) and the desired logistics concepts in order to develop vehicles that can be used on a larger scale and therefore compete with delivery vans.

- Edwin Renzen, Stint Urban Mobility in 2016: *“We want to design our vehicle on the basis of a demand, but for the logistics sector we do not know what that demand is. Which format of vehicle is ideal for package delivery? We also want to be able to tell potential customers what the vehicles have to offer, but for logistics the benefits are not yet quantified.”*

Road managers and policy makers from a traffic engineering perspective also have questions about LEFVs. Questions about vehicle safety if they are to be using the road along with motorised traffic. The fear is that the safety of other road users will be at risk if LEFVs are allowed to make use of bicycle and pedestrian paths, and that soon the sidewalk would be blocked rather than the road.

- Jan-Bert Vroege, councillor in Amsterdam municipality from the D66 party in 2017: *“Urban infrastructure and traffic rules are not prepared for an increase in numbers of LEFVs. Where will these vehicles take their place in traffic? And what measures can municipalities take in order to lead this growth in the right direction?”*

1.6 Aim and methodology of the research

The objective of the two-year LEFV-LOGIC project was to come up with new insights into logistic flows and vehicle specifications to arrive at business models for the large-scale deployment of LEFVs in city logistics concepts.

The central research question is:
With which logistics concepts is there a scalable business model to realise the deployment of Light Electric Freight Vehicles (LEFVs) for city logistics?

This question is answered in the LEFV-LOGIC project with the sub-questions in Table 1.1.

Table 1.1: Sub-questions and reading guide

1. What are the most promising logistical flows for LEFVs based on market characteristics and supply profiles?	Chapter 2
2. Which logistics concepts make it possible to deploy LEFVs?	Chapter 3
3. Which functionalities must a LEFV satisfy in terms of vehicle design, drive and supported (loading) infrastructure?	Chapter 4
4. What are attractive alternatives for the design of LEFVs?	
5. What policy and traffic measures affect the deployment of LEFVs? This issue is taken up in collaboration with the SICLEV project (Urban Integration of Cargo Bikes and Light Electric Vehicles).	Chapter 5
6. What does a scalable business model with LEFVs look like?	Chapter 6

Research approach

The research was carried out using different theories, models and practical methods and with input from specialists through workshops, expert sessions and interviews. Five experiments were set up in Amersfoort, Utrecht, Maastricht and Amsterdam (see table 1.2) to test and collect knowledge, on the one hand via evaluations with stakeholders and on the other hand by monitoring vehicles with GPS loggers and cameras. In collaboration with ten businesses, various logistical concepts with LEFVs were mapped out and changes with regard to transport with delivery van analysed. Use was made of the Scalability Model (Stampfl et al., 2013) and the Multi-Actor-Multi-Criteria-Analysis (Macharis et al., 2009) for research into business models with LEFVs. The LEFV Comparison Tool and the EVEC model (Electric Vehicle Expansion Calculator) were developed during the project. The technical research consists of four phases: idea, concept, development and preparation of demonstrators.

1.7 Project partners

The LEFV-LOGIC project was initiated by the Urban Technology Research Programme of the Amsterdam University of Applied Sciences. The consortium is responsible for the implementation and management of the research and consists of seven organisations:

- Three universities: Amsterdam University of Applied Sciences, Rotterdam University of Applied Sciences and HAN University of Applied Sciences
- Two consultancies: Fietsdiensten.nl and Lean Cargo Consultancy;
- Industry association for electric driving DOET;
- Logistics service provider Deudekom.

Around 60 organisations participated in the project, including 32 small businesses. They have contributed to the research through practical experiments with LEFVs, data collection, workshops, expert sessions and dissemination activities for professional practice and education. A summary can be found in Table 1.3. The participants share the ambition to make as many cities as possible emission free by 2025. During the research, practice partners worked together with lecturers, project managers, teacher-researchers and students of the universities of applied sciences (see Table 1.4). More than 100 students from seven educational programmes, together with practice partners, have contributed directly in the research. There is an overview of all involved parties in Appendix B.

Table 1.2: The five experiments

Experiment	Partners	Subject	Sector / Target Audience	Location	Page
1	CycleSpark, Het Lokaal, 2Wielkoerier	CargoBikeXL to replace delivery van	Fresh products	Amersfoort	See page 48
2	City Hub, De Loogman Groep, CB Logistics, Blycolin	Storage, transfer and transport with compact distribution vehicle with trailer	Retail and hospitality	Amsterdam	See page 66
3	Maastricht Bereikbaar, PP Events, Blanche Dael, HairVisit, Jules, eCar-Connect, CycleCenter	Purchase subsidy for cargo bikes	Businesses and entrepreneurs in general	Maastricht	See page 78
4	CityServiceBike, KPN, Douwe Egberts, Coca-Cola, Juizz, Urban Arrow, Mobilock	Pick-up point for delivery vans to transfer to cargo bikes	Service logistics	Utrecht	See page 94
5	Deudekom, Urban Arrow, Stint Urban Mobility, PostNL, RoutiGo, BonoTraffics and others ¹	LEFV-Battle with 3 types of LEFV	Students and Teacher-Researchers	Amsterdam	See page 105

Table 1.3: Partners

Logistics service providers	2Wielkoeriers, Bubble Post, Chris brengt THUIS, City Hub, Deudekom, Fietskoeriers.nl, Leen Menken, MSG Post & Koeriers, MYPUP, Parcls, PostNL
Suppliers of goods and services	APS Glass & Bar Supply, Blanche Dael, Coca-Cola, Douwe Egberts, Energiewacht, HairVisit, Het Lokaal, Jules, KPN, Picnic, PP-Events, The Office Service, The Student Hotel, Vers bij u thuis
Providers of mobility solutions	Cargoroo, CityServiceBike, CycleSpark, Easy Go Electric, JUZZ, Maproloc, MobiLock, RoutiGo, Stint Urban Mobility, Urban Arrow, 4Wieler
Public organisations	City of Amersfoort, City of Amsterdam, City of Delft, City of Rotterdam, RVO.nl, City of Amsterdam Southern District
Consulting and network organisations	DOET, ANWB, BonoTraffics, Clean Mobility Center (CMC) Arnhem, Connekt, Ecorys, European Cycle Logistics Federation, evofenedex, Fietsdiensten.nl, Knowledge Mile, LeanCargo Consultancy, Maastricht Bereikbaar, RAI Vereniging, TNO, Transport en Logistiek Nederland, Turn2Improve
Universities of Applied Sciences	Amsterdam University of Applied Sciences, Rotterdam University of Applied Sciences, HAN University of Applied Sciences (in Arnhem and Nijmegen)

1. The following parties participated in the LEFV Battle by making goods available to accept or by publishing the event: Fruitful Office, Praxis, Canon, Maas, CWS, BalkonBar, Het Werkmanspaleis, BedAffair, RGtects, Café Goos, Het Amstelhuis, Parcls, The Studenthotel, Bas met Dubbel A, Eevofenedex, Amsterdam Logistics

Table 1.4: Education

Programmes	Modules	
Logistics Engineering	Urban Logistics Minor (Amsterdam University of Applied Sciences) Distribution in and around Rotterdam Minor (Rotterdam University of Applied Sciences)	Internship and graduation
Logistics Management		
Automotive	Automotive Management Minor (Rotterdam University of Applied Sciences) Drivetrain Minor (HAN University of Applied Sciences) Mobility Innovation Centre (HAN University of Applied Sciences)	
Engineering	Innovatielab (Amsterdam University of Applied Sciences)	
Technical Business Administration	Business Development (Amsterdam University of Applied Sciences)	
Built environment traffic engineering	Minor Infrastructuur en Mobiliteit (Rotterdam University of Applied Sciences)	

Urban Technology Research Programme – Amsterdam University of Applied Sciences

The world faces a period of increasing urbanisation. In 2050, 80% of the world’s population will live in cities. This brings with it many challenges, after all, how do you remain accessible as a city when space is becoming scarcer? How do you set up the city so that functions are retained? How do you come up with smart solutions to tackle challenges such as climate change and decreasing availability of fossil energy, raw materials and water? The Urban Technology program is a partner for professional practice and knowledge institutions in the Amsterdam Metropolitan Area, and focuses on these challenges. Urban Technology works on the design and realisation of smart, technological solutions that can be applied locally. Within Urban Technology seven lecturers work with senior lecturers, lecturer-researchers, PhD students, alumni and students from the AUAS on practical research.



Photo: Albert Heijn

2 OPPORTUNITIES FOR LEFVS

This chapter sketches an outline of the abilities, history and potential of LEFVs. With practical examples we have illustrated the diversity and development seen in recent years (2.2). LEFVs come in many forms and applications: from package distribution to food transport and from service to waste collection. In this chapter, we answer the sub-question: What are the most promising logistical flows for LEFVs, based on market characteristics and supply profiles (2.3)? But first of all, we will take an in depth look at the various types of LEFV (2.1).

2.1 The different types of LEFVs

A light electric freight vehicle (LEFV) is a bicycle or compact vehicle with a electric pedal assistance or electric drive designed for the distribution of goods

on public roads with a limited speed (max 45 km/h). There are no generally accepted conditions for the term 'light', which makes the formulation of a definition complicated. The LEFV-LOGIC project researched vehicles that are smaller than a delivery van and can transport up to 750 kilograms. Based on external characteristics, we distinguish between the following types of LEFVs:

- Cargo bike with electric pedal assistance;
- Electric moped without pedals and no covered cab;
- Compact distribution vehicle with electric drive

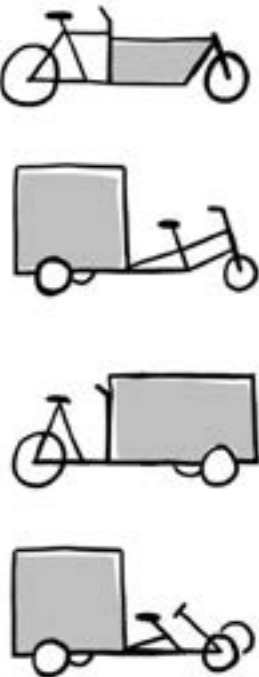
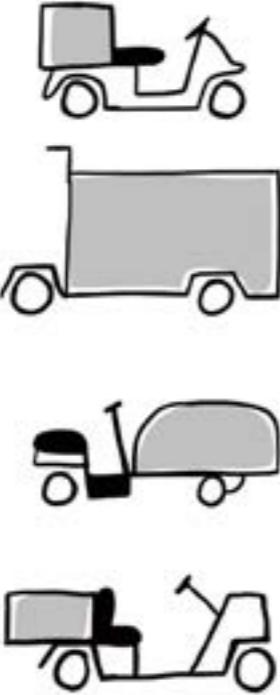

ELECTRIC CARGO BIKE	ELECTRIC CARGO MOPED	SMALL ELECTRIC DISTRIBUTION VEHICLE
		
<p>EXAMPLE SUPPLIERS CENTAUR CARGO, CYCLES PARK, EBIKE4DELIVERY, LARRY VS HARRY, URBAN ARROW, VELOVE</p>	<p>EXAMPLE SUPPLIERS CARGO BEE, EBRETTI, ELVECO, GOVECS, STINT, TRIPL</p>	<p>EXAMPLE SUPPLIERS EASYGOELECTRIC ELECTROCAR, FACTORY, TUKTUK, VAN BITTERSWIJK ECO-MOBILITEIT</p>
<p>LOADING CAPACITY 50 - 350 KG</p>	<p>LOADING CAPACITY 100 - 500 KG</p>	<p>LOADING CAPACITY 200 - 750 KG</p>
<p>VEHICLE WEIGHT 20 - 170 KG</p>	<p>VEHICLE WEIGHT 50 - 600 KG</p>	<p>VEHICLE WEIGHT 300 - 1000 KG</p>

Figure 2.1: Three types of LEFVs

LEFVs fall into the following legal vehicle categories:

- Cargo bikes for which national testing procedures and registration are not obligatory, for which the power of the electric motor is up to 0.25kW and the maximum speed 25 km/h;
- Vehicles for which a national testing procedures (special moped) or approval by the Ministry of I&W (motor vehicle with limited speed) is required. Registration is not (yet) obligatory. The maximum speed of these vehicles is 25 km/h;
- L-category vehicles (see Appendix C): Light vehicles ranging from bicycles with an auxiliary engine to mini-delivery-vans, for which a European type approval and registration are required. *Note: the maximum speed in the L-category is up to 90km/h. The LEFV-LOGIC research project limited itself to vehicles with a maximum speed of 45km/h.*

A LEFV differs from a delivery van in a number of ways, including smaller capacity, lower speed, ability to use different infrastructure and the requirements imposed on the driver. This has consequences for city logistics flows that lend themselves to LEFVs, which we will elaborate upon in this chapter.

2.2. History

Manufacturer Spijkstaal was making electric milk and bread delivery vans in the 1950s. Due to the emergence of supermarkets, they subsequently disappeared from the streets. Since 2011 there has been a growth in the supply and use of light electric vehicles (LEVV-NL, 2017). Increases are evident not only in the numbers, but also in the diversity of types of LEFVs. Several Dutch companies, including Urban Arrow, Easy Go Electric and Stint Urban Mobility, started developing light electric solutions for passenger transport before 2010, after which they also began to see market potential in freight transport. Growing levels of attention for electric city distribution from the Dutch government also contributed to this.

The Dutch government uses subsidy schemes to stimulate experimentation, such as the "Proeftuin Hybrid and Elektrisch Rijden" in 2010-2011 (Hybrid and Electric

Driving Test Garden)(RVO.nl, 2012). In addition, the government has an influential regulatory role. For example, the 'special moped' was approved for use on public roads in 2010 by the Ministry of Infrastructure and the Environment. No European type approval, driver's licence or helmet is required for this category. With a maximum speed of 25 km/h, the vehicle can be driven on bike paths; an important decision for the further development of LEFVs. An example of the special moped is the Stint, an electric vehicle designed for the transport of children, which was approved for use on public roads in 2011.

Following this, there was an advance in light electric transport for logistics activities. In 2012, Urban Arrow's customer Marleen Kooft was the first to deploy electric cargo bikes for distribution in Amsterdam. Bubble Post, a Belgian company founded in 2013 (and acquired by BPost in 2017), was one of the first logistics service providers to focus on the deployment and (social) benefits of LEFVs in their operations and marketing with the designation 'ecological city distribution'.

2014 was an important year with the signing by 54 parties in the Netherlands of the Green Deal Zero Emission City Logistics, the establishment of the European Cycle Logistics Federation and the acquisition of Streetscooter by DHL. From 2015, the potential of LEFVs for the delivery of messages was made visible by parties such as Hoogvliet, Albert Heijn, Picnic and Leen Menken. In 2016 and 2017, during the term of the LEFV-LOGIC project, many pilot projects with LEFVs took place and various municipalities developed purchase subsidies for cargo bikes. Dutch cycling advocacy group Fietsersbond also started promoting LEFVs in this period. Large and well-known online stores, including Wehkamp (in cooperation with DHL and Fietskoeriers.nl) and Coolblue, also began their own delivery services, a development which resulted in more attention for LEFVs.

With the increase in numbers and diversity of LEFVs, discussions about approval rules, their position in relation to infrastructure and loading standards grow correspondingly. These discussions are all necessary in order to facilitate growth. LEFVs for both personal and freight transport appear increasingly prominently on political agendas (see also chapter 5) and in the research programmes of municipalities, provinces and the European Commission.

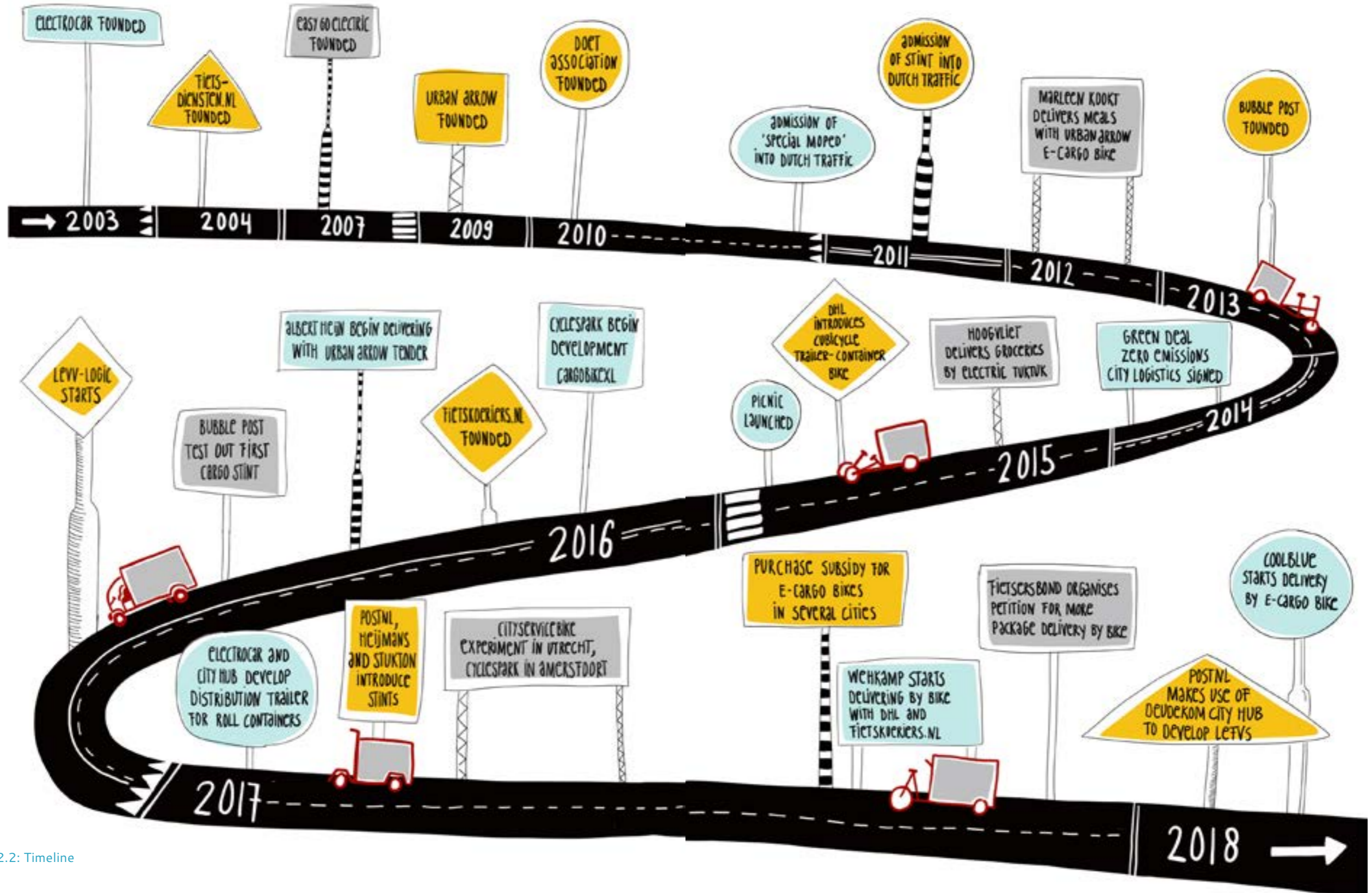


Figure 2.2: Timeline

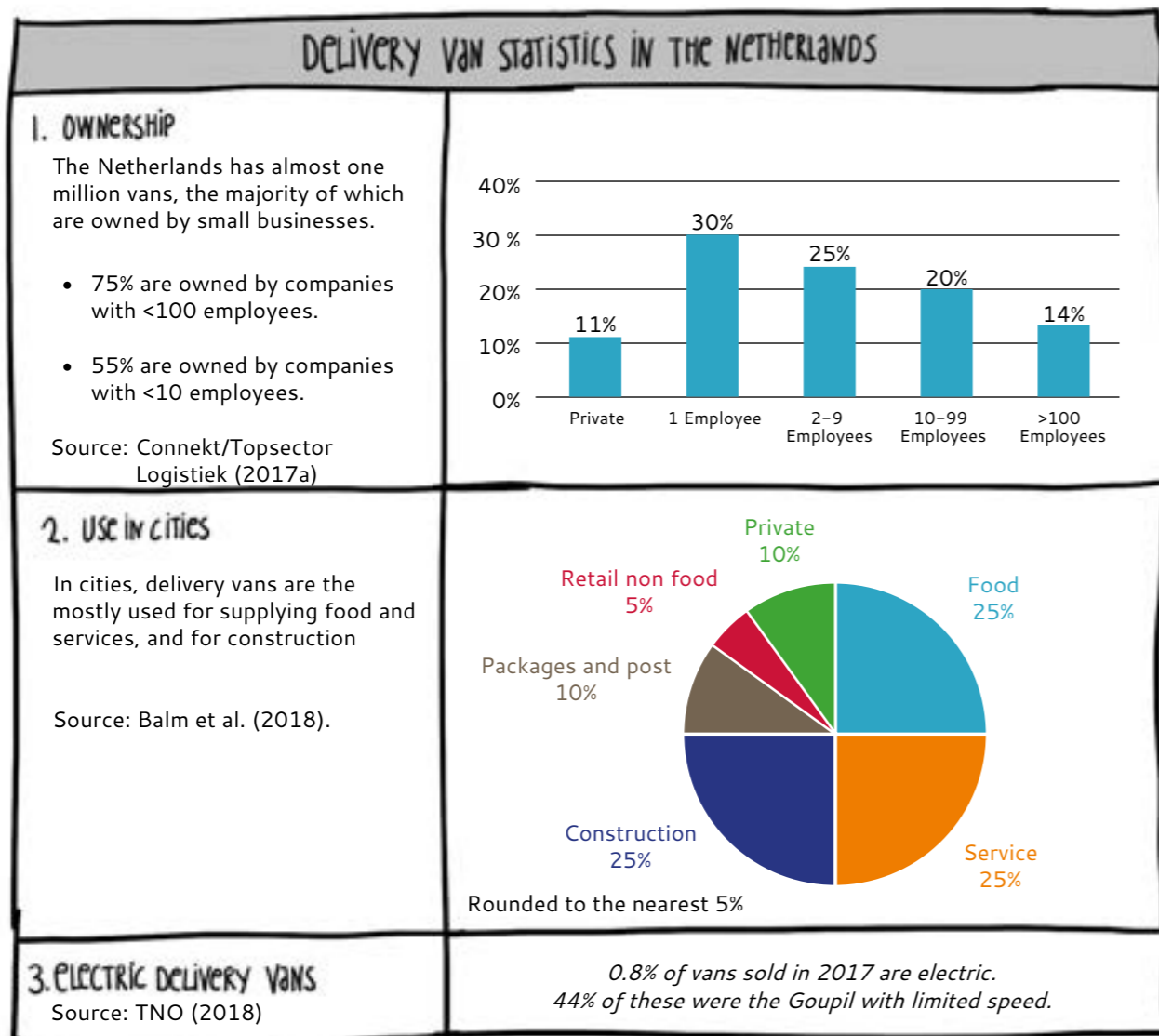


Figure 2.3: Delivery van statistics in the Netherlands

2.3 Market opportunities for LEFVs

LEFV-LOGIC researchers have investigated the potential of LEFVs for different cargo flows within city logistics (Balm et al, 2018). They arrived at four criteria that influence the potential of LEFVs: small and light shipments, high network density, time-critical shipments and sufficient

opportunities for growth and innovation (See table 2.1). The most important conclusion from the research is that the bulk of large city logistic flows can, to a greater or lesser extent, be carried out with LEFVs. The various flows in city logistics for which LEFVs can be used are briefly discussed below with practical examples.

Table 2.1: Criteria for deploying LEFVs

Criteria	Motivation
1. Small and light shipments	LEFVs have a limited loading capacity
2. High density network: many stops a short distance from each other	LEFVs have a limited range but can be parked easily
3. Time-critical shipments	LEFVs manoeuvre quickly through the inner city and are reliable because they are hardly affected by congestion
4. Possibilities for innovation and growth	Customer demand and degree of competition affecting the transition to new concepts such as LEFVs

Post and parcel logistics

Connekt and Topsector Logistiek (2017b) expects the number of shipments in postal and parcel logistics to double in the next ten years. Package shipments are generally small and have a high network density; which offers a lot of potential for LEFVs. This is confirmed by package services that already use LEFVs, including DHL, UPS, PostNL and Fietskoeriers.nl. One development is that postal companies want to access a larger share of the package market. Dutch postal service providers Sandd and PostNL will both deliver more parcels with declining mail volumes. Another development is cooperation between postal and parcel deliverers. In Berlin, for example, DHL, GLS, DPD, UPS and Hermes all work together under the name KoMoDo at a shared

inner-city hub for cargo bikes (RIPPL, 2018). In the Netherlands, the amendment of laws relating to postal services has offered more scope for cooperation between postal and parcel carriers (Rijksoverheid, 2018). However, not all package volumes are suitable for LEFVs; for some delivery rounds, 150 to 200 packages need to be delivered. In these cases a delivery van is a better alternative because of the loading space available. Successful deployments of LEFVs for parcel and mail services can be seen mostly in busy, old inner cities with space restrictions and in specific flows such as evening delivery at UPS. For postal routes, regular bicycles and LEFVs are often used by PostNL, DHL Express, UPS, Deutsche Post and Bpost.

Food Logistics

Circa 30% of delivery vans in cities transport foodstuffs to hospitality businesses, shops, offices, institutions or consumers in their homes. The share of delivery vans, the proportion of time-critical shipments and the network density within this flow ensure that there is high potential in this sector for the use of LEFVs. Back orders, orders for additional items or order corrections in which the deliver must return following a first delivery to companies and institutions are suitable because of their smaller volume and greater time pressure. The same applies to food products for consumers at home: these are often small and time-critical. The number of shipments to consumers is expected to increase further in the coming years, meaning network density will rise correspondingly. Many electric bikes are already being used for the delivery of meals by suppliers such as Marleen Kooft, New York Pizza, Domino's Pizza, Foodora and Deliveroo. In many of these cases, the e-bike replaces a scooter.



Image 2.1: Mail and parcel logistics with Fietskoeriers.nl

Construction Logistics

Large, heavy construction shipments are not suitable for transport by LEFV. However, potential for LEFVs does exist in the completion maintenance phases of construction projects, in which shipments are small and time-critical. There are also opportunities for the use of LEFVs for the transport of materials from a wholesaler, hub or on the construction site itself. For example, construction wholesaler Stiho uses an electric cargo trike to transport materials such as paint, nails and insulation materials to building sites in Utrecht (Duic, 2018).

Service Logistics

Service logistics consists of activities in the area of maintenance, cleaning, installation and repair. Delivering a service is key, but materials or tools are also required. The question is whether using LEFVs provides enough of a benefit given the small number of stops that vehicles tend to make per day (low network density) and the unpredictability of possible routes in a wide geographic area. One advantage is that LEFVs are easier to park, which is especially important if a parking place is required for a long time. LEFVs are also particularly suited to municipal street cleaning, in which network density is a key characteristic.

Retail Logistics (non-food)

The number of delivery vehicles involved in delivering to larger non-food retail and fashion stores is small (<5%). One reason for this is that it is more common for larger retail chains to resupply with full trucks coming from long distance. This limits the potential of LEFVs unless working with transshipment points and trailers. The options for innovation and growth are also limited. Smaller shipments to retailers go through courier networks. An interesting opportunity is there for retailers to deliver to local consumers from their store inventory. Examples of this are Cool Blue (2018) and Hive (see image 2.8). This is still a small segment, but one in which growth opportunities for the deployment of LEFVs exist.

2.4 Conclusion

There is a renewed level of interest in LEFVs. After decades of absence, LEFVs are returning to our streets. Both large and small shippers and logistics service providers see opportunities for efficient use of these vehicles. This is evident from the many examples in this chapter. Promising sectors for the use of LEFVs include mail, parcel and local retail deliveries, and smaller shipments in food, construction and service logistics. This begs the question: with which logistics concepts can logistics service providers and shippers successfully and profitably make use of LEFVs? And what adaptations are therefore necessary to business operations?



Image 2.2: Food Logistics with Easy Go Electric / Addax



Image 2.3: Food Logistics with Urban Arrow Tender (Photo: Albert Heijn)



Image 2.6: Service Logistics with a City of Gouda Municipality Stint



Image 2.4: Construction Logistics with Heijmans Stint (Photo: Heijmans)



Image 2.5: Construction Logistics with CycleSpark CargoBikeXL at construction wholesaler Stiho



Image 2.7: Service Logistics with CityServiceBike for mechanics



Image 2.8: Retail logistics with a TRIPL by Byondo for De Bijenkorf



Photo: Gerard Wagemakers

3 LOGISTICS OPERATIONS

3.1 Logistics concept

Chapter two discussed the types of LEFVs that are available, the possibilities for the use of LEFVs for delivery and for which other activities potential for their use exists. In this chapter we will discuss the circumstances under which LEFVs are a suitable alternative to the delivery van based on business case studies and practical experiments. LEFVs are used by shippers themselves, logistics service providers who work on behalf of shippers and logistics service providers who work on behalf of other logistics service providers.

Practical research has shown that city logistics with LEFVs requires good locations for hubs in the distribution network, robust processes, cooperation between customers, logistics service providers and suppliers, good insight into the costs involved, modern ICT and good organisation.

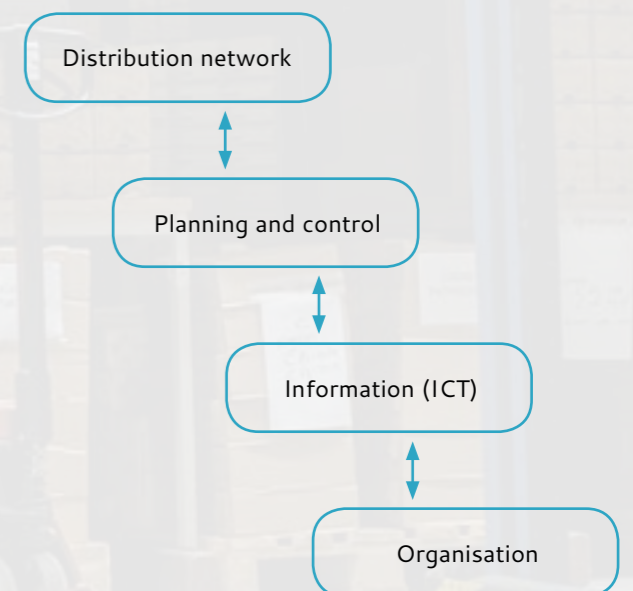


Figure 3.1: Logistics concept

3.2 LEFV Case Studies

APS Glass & Bar Supply

APS Glass & Bar Supply is a supplier of bar goods to the hospitality industry. In the centre of Amsterdam, APS increasingly experiences delays to deliveries carried out by traditional delivery vans. APS has already had good experiences with deliveries by logistics service providers using LEFVs and wants to

know if extending their use is worthwhile. In the study, several alternatives were assessed. For consignments within central Amsterdam, the use of LEFVs resulted in transport costs savings (personnel and vehicles) of 50 to 60%; for both internal transport and for outsourcing. The disadvantage of outsourcing is that consignments must be properly arranged internally: the items must be ready when the logistics service provider comes to collect them.

Vers bij u thuis

Vers bij u thuis (Fresh at home) was a provider of ready-to-eat meal boxes for the elderly and nursing homes. These were sent to customers with a delivery van. For this study a cost-benefit analysis was carried out comparing the van with LEFVs and electric vans. Using a LEFV on one of the three routes and an electric van on the other two could allow them to save up to 37% of transport costs. Research undertaken by a student showed that in the

event of further growth of the company (particularly outside the current region) the deployment of LEFVs, in addition to electric delivery vans, could allow 15 to 25% savings on their transport costs. In this scenario, the LEFV was used in dense urban areas close to the head office, where many deliveries are on a route and the distance between deliveries is short. Meanwhile, the electric delivery van would take care of the longer routes, further from the headquarters. As of 2018 the company ceased operations.

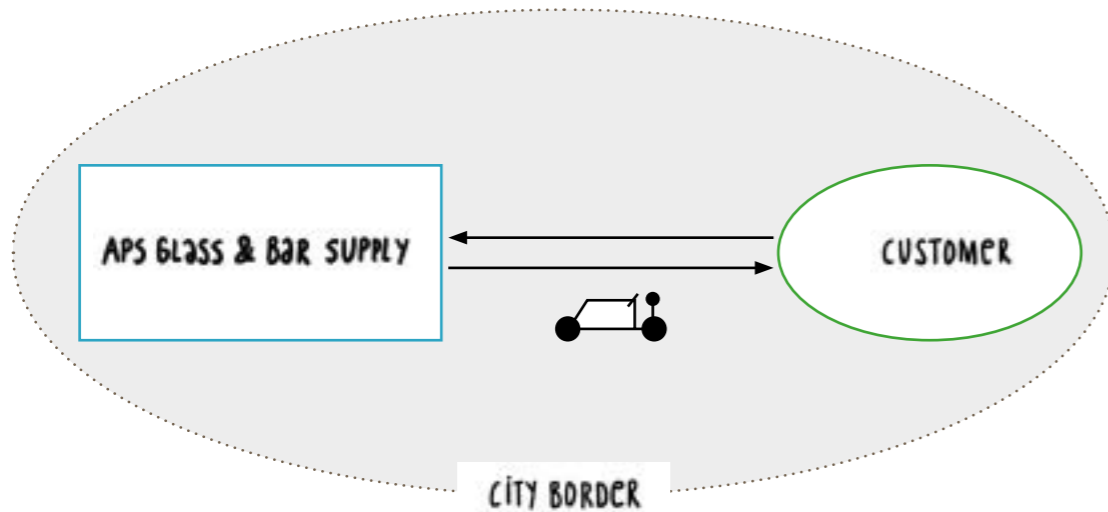


Figure 3.2: APS Glass & Bar Supply distribution network

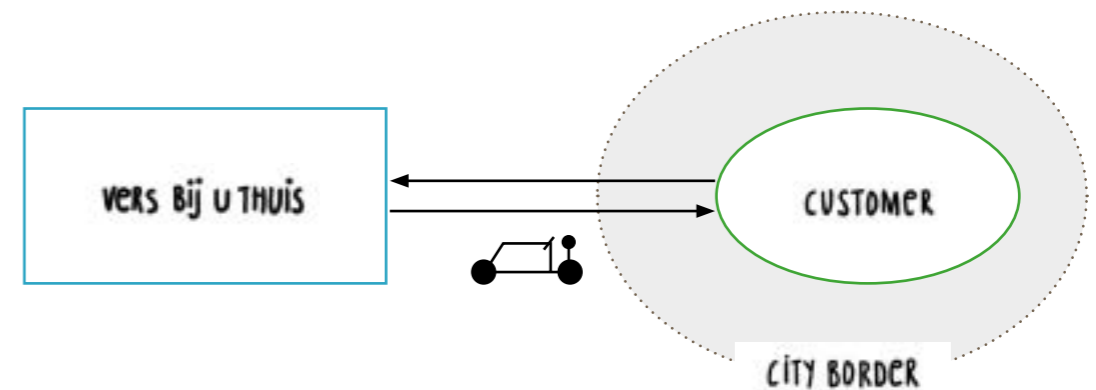


Figure 3.3: Vers bij u thuis distribution network

Deudekom

Deudekom has been a removals company since 1874. The company has a warehouse in the Duivendrecht area of Amsterdam in which goods are stored for customers. Deudekom is developing into a logistics service in the Amsterdam region. The company uses its warehouse as a hub for the bundling of goods going in Amsterdam, including the University of Amsterdam (UvA), AUAS and the City of Amsterdam. UvA and AUAS want their suppliers to use bundling to reduce mileage, CO₂ emissions and overall number of deliveries. Scenarios were been

drawn up in which different types of logistic facilities were used in combination with LEFVs. Student research revealed that logistics facilities in the city, such as a micro hub, can contribute to the cost-effective deployment of LEFVs, because the distance to the customer is shortened. The condition is that there is sufficient scale: these facilities must be used daily to cover the costs. The extra costs of these facilities are compensated for by the reductions in cost compared to transport by delivery vans. As a result, LEFVs can be used profitably in city logistics. The amount of savings made depends upon the volume that goes to customers via the hub.

MSG Post

MSG provides postal and courier services in the eastern Netherlands. They wanted to know if there was a logistics concept which would make it possible to use LEFVs for the collection and delivery of mail for the business post market in the region. An analysis of the routes by a student showed large differences in their characteristics. For example, the shortest route had a distance of 15 kilometres, whilst the longest

was more than 60 kilometres. Only a small amount of the capacity of the delivery vans was used. Two scenarios were developed: one in which only LEFVs were used and another with a combination of LEFVs and delivery vans. These scenarios resulted in savings in the transportation costs of 7 and 10%, respectively. The second scenario would allow MSG to better fulfill agreements with their customers.

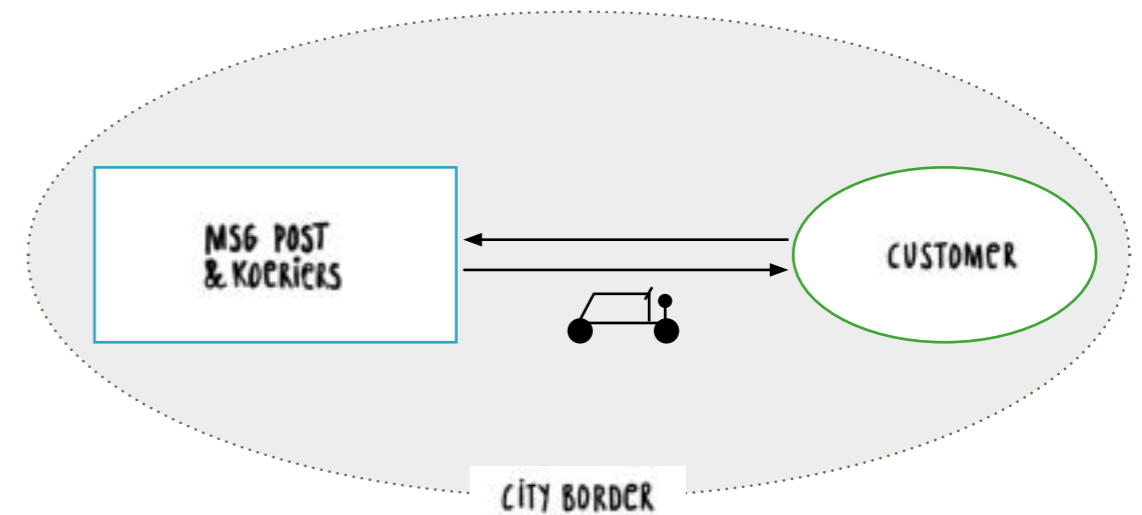
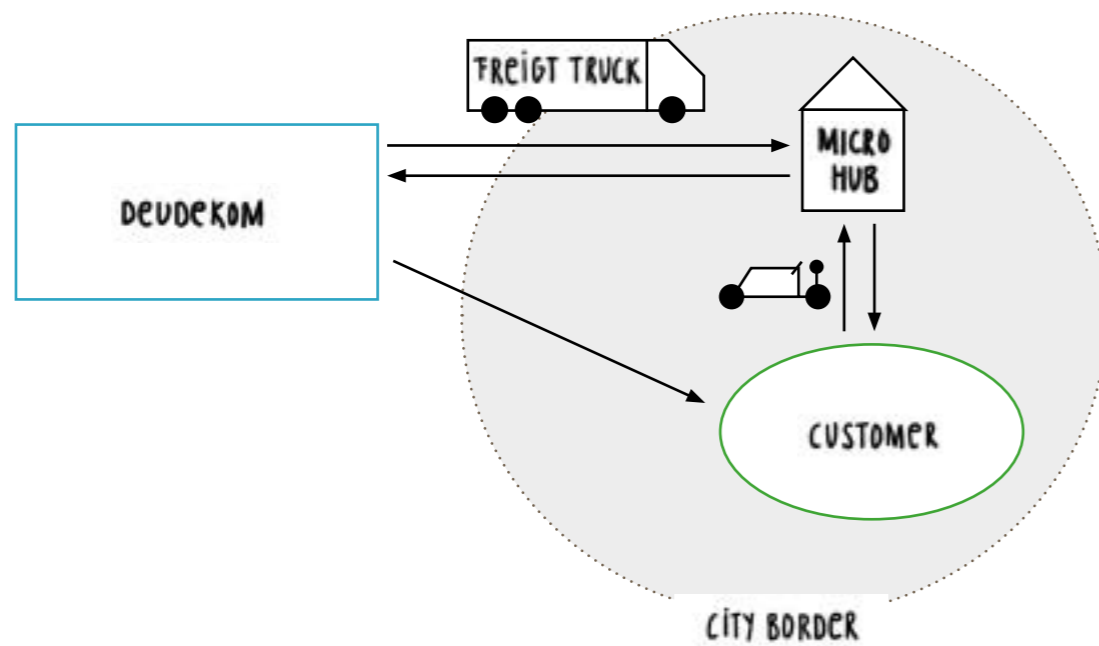


Figure 3.4: Deudekom distribution network

Figure 3.5: MSG Post & Courier distribution network

Energiewacht

Energiewacht in Heemstede carries out the installation of smart energy meters in the Amsterdam region. Parking spaces in Amsterdam are scarce and traffic in the city is very busy. This leads to Energiewacht mechanics spending a lot of time travelling and parking. Student research at Energiewacht focussed on the design of a logistics process that would make it possible for mechanics to get to the right place, with the right equipment, at the right time for the lowest possible cost and with minimal CO₂ emissions. A LEFV proved to be the most suitable vehicle for the city. The solution was achieved by placing a hub

outside the city centre for the supply and preparation of orders, together with a logistics service provider. At the hub, mechanics transfer from their own vehicle to a LEFV. The LEFV itself does not have enough space for the necessary materials for all of the customers a mechanic visits in a day. Therefore, a choice was made to use a mobile hub, which is centrally parked in the work area of the mechanics throughout the day. Here the mechanics can collect new meters and installation materials. This system has the potential to save 30% on transportation costs and achieve an 80% reduction in CO₂ emissions.

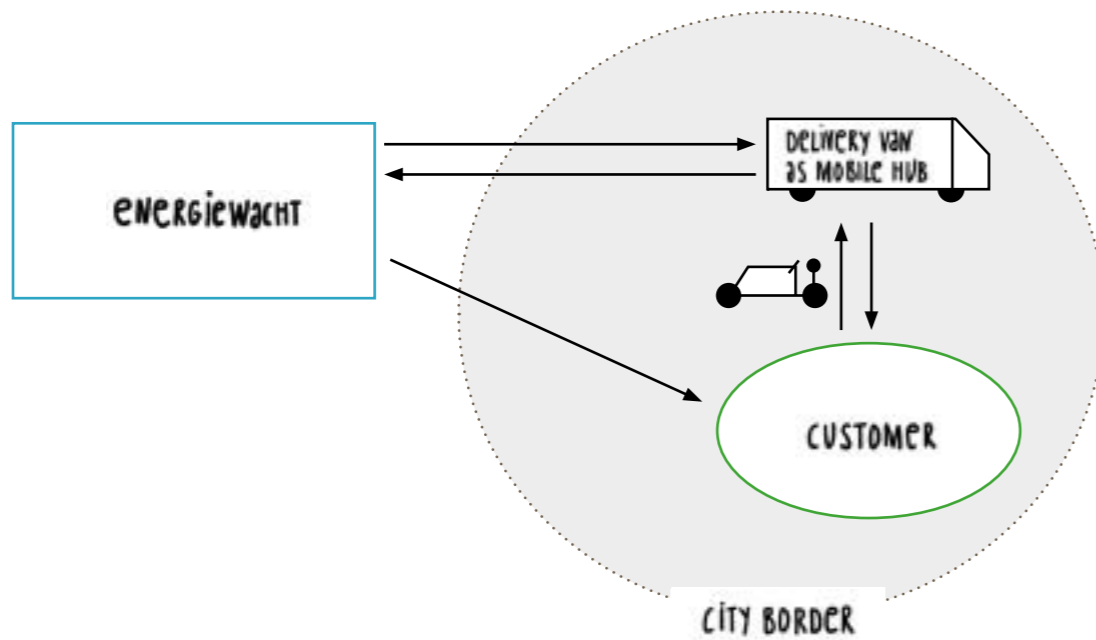


Figure 3.6: Energiewacht distribution network

Parcls

Parcls is a local parcel service where parcels are delivered to a neighbourhood collection point, so that the recipient does not have to be present when packages are delivered by the courier. The recipient can pick up the package themselves, or if they are at the delivery address, it can be delivered there within a specified 15 minute time slot. A survey in the Oude Pijp area of Amsterdam (AUAS, 2016) among 86 entrepreneurs (shops, catering establishments and

companies) showed that 13% were directly positive about such a collection point and 8% set certain conditions for the costs (5%) and opening hours (3%). Nearly a quarter (24%) thought that goods should only be delivered to their door, the main reason being that there are not sufficient staff to collect the packages elsewhere. In Oude Pijp, UPS outsources delivery of packages for consumers to Parcls. Parcls also offers its services to entrepreneurs in the neighborhood and to other parcel delivery companies.

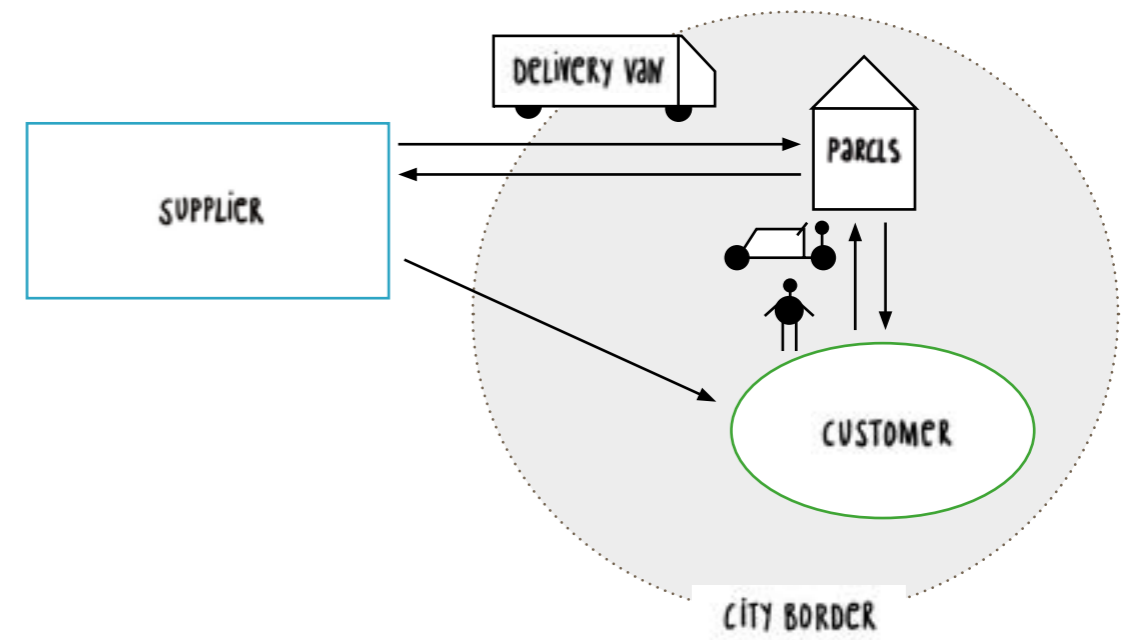


Figure 3.7: Parcls distribution network

Table 3.1: Characteristics of the business case studies

	APS	Vers bij u thuis	Deudekom	MSG Post & Koeriers	Energie-wacht	Parcls
Market	Hospitality non-food	Food service	Facility services	Post	Service logistics	Packages
Goods	Not conditioned and packed	Fresh food	Not conditioned and packed	Crates of post	Not conditioned and packed	Not conditioned and packed
LEFV user	Partly	Partly	Partly	Possible	Possible	Possible
Which shipments go with LEFVs?	10-20% of shipments for customers in the inner city are delivered with LEFVs. These are the smaller shipments.	A third of shipments are delivered by LEFVs, mostly within Amersfoort.	There is at this moment no deployment of LEFVs. The research was aimed at potential use.	There is at this moment no deployment of LEFVs. The research was aimed at potential use.	There is at this moment no deployment of LEFVs. The research was aimed at potential use.	Parcls delivers all shipments within Oude Pijp (Amsterdam) with LEFVs.
Motivation	High costs of using delivery vans in heavy traffic (drivers are on the road for a long time).	Can it be done cheaper?	Wish to deliver bundled goods with zero emission deliveries to customers.	Can it be done cheaper?	More demands upon delivery vans in the city centre. It is becoming increasingly difficult to park. Can it be done cheaper?	Better service for consumers (who are not at home) and more efficient for delivery personnel
Operation	Outsourced (to Bubble Post and Fiets-koeriers)	In-house	In-house	In-house	In-house	In-house
Delivery	From stock	From stock	From stock and cross dock	From own hub	From stock via hub	From own hub
LEFV	E-cargo bike	E-cargo bike	Goupil	E-cargo bike	E-cargo bike	Bike
Shipments	1-20 kg	Maximum 50 kg	Larger volumes	10-50 kg	10-50 kg	2-10 kg
Addresses on route	1 to 5 addresses	5 to 30 addresses	3 to 4 addresses	5 to 15 addresses	Mechanic takes multiple shipments to work area	A few dozen shipments per day
Length of LEFV route	10-20 km	50 km	10-40 km	30-40 km	20-25 km	Less than 10 km
How to develop further?	With one cargo bike of their own and partly outsources to cycle couriers.	The business is no longer operational	Deployment of electric freight trucks due to the large volume	Financial feasibility and LEFV range are still barriers	Case is being developed for central Amsterdam.	The case is in the process of being developed for consumers

3.3 City Logistics with LEFVs

The business cases and experiments show that a company must first to make an analysis of the distribution network; what are the characteristics of the shipments (see table 3.2) and which shipments are suitable for a LEFV? The chosen solution is often a combination of LEFVs and delivery vans. CB Logistics and Blycolin outsource selectively to City Hub.. APS outsources smaller consignments in Amsterdam city centre to a logistics service provider with electric freight bicycles. UPS outsources deliveries to

consumers in the Oude Pijp to Parcls. Het Lokaal and MSG make a distinction between orders that lend themselves to LEFVs and orders that are more suitable for a delivery van. CityServiceBike only focuses on maintenance at addresses in Utrecht city centre.

Research shows that for smaller, often time-critical shipments in busy neighbourhoods, LEFVs are often faster than delivery vans. Moreover, LEFVs are suitable for the transport of goods with limited volume and mass over a limited distance.

Table 3.2 Criteria for determining whether goods flows are suitable for LEFV deployment

Temperature	+ Non-refrigerated products, or products that are cooled via the load carrier are suitable for LEFVs + For temperature controlled products (hot or cold) fast transport is important; LEFVs can offer an advantage → See Access and speed of cars - There are not currently any (or many) LEFVs for transporting frozen goods
Weight	+ Limited weight transported per trip (see Chapter 2) - Excess weight does not fit into a LEFV
Volume	+ Limited transport volume per trip (see Chapter 2) - Too much volume does not fit into a LEFV
Access and speed of cars	+ Where the speed of access of motorised traffic is limited, the benefit of using LEFVs increases (for example in congested areas) - In areas where motorised traffic is allowed to drive at high speed, LEFVs lose their advantage
Number of stops	+ LEFVs are easier to park. The more stops, the more benefit LEFVs offer during parking and loading / unloading - The more stops on a route, the greater the volume → See volume / For routes with many stops, a LEFV may need to shorten its routes by using a hub → See Costs of a hub
Distance and stops	- For long distances between stops (or from starting location), in areas where vehicle speed is high, LEFVs lose their advantage → See Access and speed of cars
Costs of a hub	+ If a hub is affordable, it is possible to split routes and load goods so that the volume per route decreases - The more shipments that are bundled together at a hub, the greater the volume → See Volume"
Parking space / time	+ When a good parking place is important (nearby location), using a LEFV is beneficial - The longer you are parked at a customer's premises, the less stops are possible per trip → See Number of stops

3.4 Cost comparison of LEFVs with delivery vans

In this section, various costs are discussed and compared with those of delivery vans. There are advantages in both investments and operational costs of LEFVs. Disadvantages can arise from longer driving times due to the lower speed and limited payload of LEFVs as well as from the costs of hubs.

Vehicle costs

A LEFV costs about 3,000 euros less each year than a delivery van (see Table 3.3). That difference alone may be enough reason to replace a delivery van with a LEFV at shorter distances and appropriate volumes.

However, there are differences in speed, range and payload, which in practice may mean more LEFVs are required than delivery vans. Moreover, any additional costs for hubs in the distribution network need to be taken into account.

Costs associated with deployment of a Goupil total are similar to those of an electric delivery van. The larger Goupil, as used by Picnic, costs about the same as a small delivery van. The monthly costs (such as insurance) are also similar to a small delivery van. The operational lease of Goupil is about 750 to 900 euros per month.

Table 3.3. – Vehicle costs of a diesel delivery van vs a LEFV on the basis of an operational lease arrangement

Amounts in Euros	Small diesel delivery van	Electric cargo bike / moped	Small electric delivery van
Investment	€15,000–€25,000	€3,000–€13,000	€20,000–€35,000
Annual Costs			
Operational lease per year	€3,500–€4,000	€1,800–€3,500	€5,000–€7,500
Fuel for 10,000–15,000 km per year	€1,500–€2,000	€400–€1,000	€1,000
Insurance	€1,000–€2,000	€200–€400	€1,000
Road tax	€200–€400	€0	
Parking and charging infrastructure	€0	€1,000	€1,000
TOTAL	€6,200–€8400	€3,400–€5,900	€8,000–10,500

Personnel: labour costs are lower

The Dutch government uses subsidy schemes to stimulate experimentation, such as in 2010–2011 the Proeftuin Hybrid and Elektrisch Rijden (Hybrid and Electric Driving Test Garden)(RVO.nl, 2012). In addition, the government has an influential regulatory role. For example, the 'special moped' was approved for use on public roads in 2010 by the Ministry of Infrastructure and the Environment. No European type approval, driver's licence or helmet is required for this category. With a maximum speed of 25 km/h, the vehicle can be driven on bike paths; an important decision for the further development of LEFVs. An example of the special moped is the Stint, an electric vehicle designed for the transport of children, which was approved for use on public roads in 2011.

Alongside salary costs, company specific issues are also in play. For example, Energiewacht and CityServiceBike use more expensive technicians who carry out smart meter installations. MSG employs people with poor job prospects. Vers bij u thuis hired temporary workers to deliver meals. When hiring staff externally, it is simpler to choose those without a driving licence.

Personnel: route costs are sometimes lower

The average speed of LEFVs in cities is comparable to delivery vans, but because the routes LEFVs take are shorter, a LEFV in the city is ultimately faster than a delivery van. Delivery van routes are longer because they have no (or limited) access to one-way roads, cycle paths, squares, parks and bicycle bridges and because of window times that do not apply to the LEFV. Particularly in inner cities, the difference between delivery van and LEFV can be considerable in terms of both distance and in time. For example, for Energiewacht, the use of LEFVs in the city saves an average of 20% in distance (the difference varies from 0% to 70%, depending on the route taken). For MSG, routes are on average 14% shorter (the difference varies from 8% to 19%). At Vers bij u thuis the route in the city was 15% shorter and two routes outside the city are 8% and 10% shorter in distance. Although LEFVs can complete these two routes outside the city in fewer kilometres, they take twice as long as the delivery van to complete it. This is because delivery vans can drive faster than LEFVs outside cities.

Within the city, delivery vans drive at low average speeds because of traffic lights and congestion. For example, at Energiewacht the speed of engineers in a delivery van was on average 18km/h. During the LEFV Battle routes were travelled to deliver shipments across Amsterdam with an electric cargo bike from Urban Arrow, a Stint and a Goupil. The average speed was 17.5km/h for the e-cargo bike, 12.5km/h for the Stint and 16.5km/h for the Goupil.

Personnel: loading and unloading

LEFVs are smaller than delivery vans. This makes them easier to manoeuvre through traffic, it is easier to find a place to load and unload, they fit into smaller parking places and can also park in areas where a delivery van cannot, for example, on the sidewalk. This allows for faster loading and unloading with a LEFV. Mechanics from CityServiceBike previously spent 15 to 20 minutes searching for a parking space. According to research by the municipality of Amsterdam, the average loading and unloading time for delivery vans and lorries is 12 minutes (Dufec, 2016). The average loading and unloading time measured during the LEFV Battle was between 3 and 6 minutes. LEFVs enable enhanced levels of productivity; more customers can be delivered to in one route, or routes are completed faster.

3.5 Costs of the distribution network: hubs

Amongst the business cases and experiments are several companies whose deliveries already originate within the city or on the outskirts of the city, such as Het Lokaal, APS, Parcls and CityServiceBike. For these companies, the limited range of a LEFV presents no obstacle to reaching their customers. Het Lokaal also collects shipments from farmers in the vicinity of Amersfoort.

For companies that come from outside the city a transshipment point at a short distance from the city is necessary because of the range of the vehicles. The most well-known is a hub on the outskirts of the city (also known as the Urban Consolidation Centre) where goods are transferred from large-scale transport to small and fast local transport.

There are also companies that offer the hub as a service (CityServiceBike, Deudekom) that thereby also create the possibility of bundling together goods for the same recipient. The costs of the hub, especially those of space and personnel, must ultimately be recouped with savings in the supply to the hub with, for example, more fully loaded trucks or barges, or with savings in the costs of local transport from the hub.

A hub on the outskirts of the city is not the only option. For example, a city centre micro hub can bring the transshipment point to a dense urban location, or to the edge of the city centre (Parcls is one example). Meanwhile, mobile hubs in the form of a truck upon which, once parked in a certain location, shipments can be transferred to LEFVs have been deployed by DHL and UPS. Energiewacht use a delivery van as a mobile hub to supply electric cargo bicycles and to receive return shipments.

An important trend in city logistics is the introduction of containerisation to prevent unnecessary operations

in the supply chain. It is made possible by a electric cargo bike (sometimes in combination with a trailer) from DHL; the Cubicycle is a four-wheeled pedal-powered vehicle with a detachable container of a cubic meter with a capacity of around 125 kilos. The containers are pre-loaded in a DHL sorting centre, transported by trailer to the city centre and placed there on the Cubicycle. The containers are equipped with smart locks which ensure that shipments are safe and secure. In addition, the trailer and containers are equipped with GPS technology that allows all movements to be remotely and accurately registered, and that immediately raises the alarm when containers or trailers are unlawfully moved. The GPS technology provides real-time status information for the packages therein and gives instructions to the the bicycle courier to use the most efficient route. If containerisation in the supply chain were to become standard, this could have a positive impact on LEFVs, because transshipments taking place in cities could be quicker and have lower costs.

How much does a hub cost?

A fixed hub in the city costs at least 150,000 to 250,000 euros per year in terms of space and staff (without taking into account the transport to the hub), based on an area of 250 to 1000 m². This means that the volume that passes through the hub is an important factor for the cost per shipment.

High real estate prices can make it difficult to find an affordable hub location, but companies find all sorts of solutions for this. For instance, using existing locations, a customer's space or mobile hubs for transshipment. But in addition they can also:

- offer storage space to customers;
- offer a pick up point where customers can pick up their packages, like Parcls;
- share a location with other companies;
- share LEFVs, for example by using them during the day to deliver goods and in the evening to deliver meals.

3.6 Do it yourself or outsource?

The business cases show a combination of outsourcing and doing it yourself. Points to consider when outsourcing transportation and warehouses include:

- Concentration on your core activity: When you allow the logistics of your company be taken care of by an expert and experienced third party, you can more easily concentrate on what your company is good at. Logistics service providers can introduce new concepts that increase sales or improve your service and thus provide you with new customers.
- Reduced worries and risks: the logistics service provider takes care of the hiring of personnel. The company must, however, spend time on contract management to ensure the service provider is meeting their obligations.
- Financial advantage: outsourcing means no need to invest in transport and logistics assets and facilities. This money can now be put to use elsewhere. You also don't need to take over-capacity into account because the service provider often works for more companies. Equally, a peak is easier to absorb.
- Oversight of logistics costs: when you organise logistics yourself, the costs are often hidden. When outsourcing you only pay for the logistical capacity that you need and it is clear how much you have spent.

3.7 Planning and control, ICT and organisation

LEFV-based city logistics distribution networks with are complex with, among other things, hubs that must seamlessly connect to a network of LEFVs in the city. Using LEFVs requires a different approach to planning and control of the network and supporting ICT.

Points of consideration for city logistics networks with LEFVs include:

1. The journeys are different than with delivery vans. With LEFVs, the driver can often use the footpath, go against traffic, down narrower streets and use bridges and streets with weight restrictions. They are more flexible in their routes and in where they are able to load and unload. However, they are not permitted to use highways.
2. The connection of incoming flows via (micro) hubs to delivery staff sometimes results in more links (for example, for deliveries within a city which would otherwise be sorted outside the city), further minimising the costs of the hub.
3. With a dense distribution network, time spent driving becomes relatively less important, while the time that delivery staff spend outside the vehicle becomes more important.
4. The capacity of a LEFV is different in volume and weight than that of a delivery van.

Based on the business cases, the following points of consideration for business operations with LEFVs emerged:

Distribution network:

- Which goods, services and routes are suitable for LEFVs? (see Table 3.2)
- Is a hub needed in the city, or nearby?
- Which routes should you do yourself and which should you outsource?

Planning and control:

- Splitting different goods flows to different modalities (on the basis of cost information);
- Adapt trip and route planning for LEFVs: different routes are possible than compared to a delivery van;
- Taking into account the range and speed of LEFVs during route planning;
- Planning transfer processes in the hub.

ICT:

- Support LEFV operated routes with transport management systems;
- Supporting the deployment of other modalities;
- Ensuring a good connection between the administrative and financial processes in the chain, preferably paperless.

Organisation:

- Planning differently: skills of planners to select modalities (tactical and operational) and to carry out trip and route planning;
- Communication with possible service providers in outsourcing (purchasing, planning and execution);
- The human factor: What do drivers/riders think about the deployment of LEFVs?

PostNL has thirty electric cargo bikes and Stints in use in Amsterdam. Lodewijk Aandewiel PostNL explains: *“One of the biggest challenges was the route planning. Existing software for vehicles was not suitable for planning cycling routes. A bike is much faster in the city, you are not always tied to one-way traffic. You can also cycle through a park. Furthermore: you can park a bike on the sidewalk without blocking the road. With simulation software we adjusted our schedules, including different speed profiles. If necessary, we can adjust the plans manually, but this doesn’t happen frequently. When planning our journeys, the quantity of routes and the number of delivery staff required are the leading factors. These are the critical elements in our process.”* (Transport & Logistiek, 2018)



Image 3.1: PostNL

Monitoring systems: requirements and possibilities

A team of students from AUAS examined the needs of stakeholders with regard to vehicle monitoring. The main requirements were: real-time location, speed, route optimisation, battery status (for example consumption rate and range) and battery temperature. The team then searched for monitoring systems that could fulfil these needs. Software company ViriCiti offers a system that continuously collects data via GPS, filters it and sends it to secure servers where it can be monitored in real time. However, the system was developed for city buses and trucks and is therefore too comprehensive for LEFVs in terms of price and data storage. Another system looked at by the team was derived from a system called RoutiGo. This system allows vehicle and cycling routes to be optimised and interpreted in real time. During the LEFV-Battle the RoutiGo system was used.

Melle Sprenger of RoutiGo: *“Planning is still a job for people, even though the system shows the optimal route for each LEFV. If one of the addresses do not appear correctly, for example, the same street name in the wrong city, the system just calculates a route, whilst a planner can see at a glance that something is not right. And when a puncture happens, the software can only indicate that the delivery time hasn’t been met. In such cases, the planner should decide how the rest of the shipment is delivered.”* According to Sprenger 25 to 50% of attempted deliveries to consumers occur when nobody is home. *“That also requires some planning. The back office determines whether delivery personnel try again that day, or whether they go back the next day. These instructions can be passed on to delivery personnel via the software.”*



Online dashboard ViriCiti (left) and RoutiGo (right)

3.8 Conclusion

Large multinational delivery companies such as TNT, UPS, DPD and DHL have already discovered that LEFVs are a good alternative to delivery vans. These organisations have the capacity to invest in the deployment of LEFVs and test them in multiple cities and their experiences of LEFV deployment are generally positive with, for example, less costs. Moreover, they know that by using smart processes, such as containerisation, standardisation and automation, extra handling costs in local hubs can be minimised. Retailers have discovered LEFVs; these include supermarkets Albert Heijn, Ocado and Picnic (online), and Dutch electronics online retailer Cool Blue. Deutsche Post, Ocado and JD are even testing ultracompact LEFVs that autonomously follow delivery personnel (see image see 3.2).

The research shows that there are many issues associated with using LEFVs for city logistics. When using LEFVs, business operations demand good hub locations, robust processes, supported IT, enthusiastic and sympathetic staff and good organisation. Each

goods supply chain is subject to different requirements, such as return flows or refrigeration, meaning that the optimal transshipment moments and locations may be different. Besides a well thought out logistics concept, a good vehicle is also needed; sometimes this is a LEFV, sometimes it is a delivery van. In the next chapter we will look at vehicle technology.



Image 3.2: Autonomous LEFV. (Photo: Deutsche Post)

The project with Stints at PostNL was challenging, but according to Project Leader Aandewiel the results have been positive: *“We really had to convince drivers who were accustomed to driving in their heated delivery vans. But after a few weeks, most drivers seemed to really like working in the fresh air. When they returned from their routes we saw that they were physically revived and had smiles on their faces. Another side benefit that the delivery staff appreciate is that they now have many more positive interactions with residents in the city.”* (Transport & Logistiek, 2018)

Mechanic Danny from central heating maintenance company Feenstra drives 20,000 kilometres with his van, mostly visiting customers in and around Utrecht. *“With the van, I’m sometimes working for three times as long as I am with the bike. And to reach customers in the pedestrianised shopping area, I have to park the van five to ten minutes away. Awkward! Even collecting a small part from the van takes a lot of time. The cargo bike solves all of these problems.”* (Feenstra, 2017)



Experiment – CycleSpark, Het Lokaal and 2Wielkoerier: fresh products in Amersfoort

Greenolution, founded by Christian Suurmeijer, developed the CycleSpark CargoBikeXL. This cargo trike has electric assistance and, together with a trailer, can carry up to 500 kg. In the second quarter of 2017 the CargoBikeXL was tested weekly by 2Wielkoeriers (an Amersfoort-based cycle courier company) for the supply of goods from Het Lokaal (The Local), a sustainable 'regional supermarket', also in Amersfoort. The purpose of the experiment was to gain insight into the how appropriate the cargo trike was for the job and to identify the benefits and opportunities for improvement.



Het lokaal and 2Wielkoeriers



CycleSpark CargoBikeXL

Plan

The evaluation consisted of a research project carried out by an AUAS student, a workshop in which logistics concepts were visualised, a workshop in which business models were analysed and a discussion with stakeholders on site at Het Lokaal.

Martin from 2Wielkoeriers *"The CargoBikeXL is ultimately for the inner city, you can carry an awful lot."* Martin is an experienced bicycle courier for package delivery. He does this with a Bullitt cargo bike without electrical assistance. Delivering food with the CargoBikeXL is a different way of working. *"It takes less effort and stopping time is often longer because the products are heavier and sometimes need to be taken into the kitchen."* This means that Martin must charge different rates than he normally does.

Results

The experiment showed that the CargoBikeXL is suitable for the transport of heavy goods such as milk crates and food. The vehicle has lower costs than a delivery van and matches the sustainability principles Het Lokaal strives towards. In practice, however, other factors are involved which prevent the delivery van from being completely replaced. The van is used for commuting, is shared with another entrepreneur and provides flexibility for early pick-ups from producers outside the city. Out of town, delivery vans are able to move faster than bikes, so for time-sensitive deliveries, preference is given to the delivery van. In the inner-city, the cargo bike is advantageous because for example it is able to use contraflows on one-way streets. However, the situation in Amersfoort does not apply to all cities. The acceptance of the cargo bike by other road users can be lower than was the case in Amersfoort in busier cities or in cities with different cycling infrastructure.

Ways in which the CargoBikeXL could be improved are:

- Reliability of electric assistance (such as water resistance when it rains);
- Cooling options, including sensors to monitor the temperature of the goods;
- Power steering;
- A higher peak power (750 W) to increase flexibility with heavy loads, riding up hills or onto sidewalks.

Additional items that could improve the deployment of the CargoBikeXL are:

- Use of standard crates for quick loading and unloading;
- Training for users in handling cargo bikes;
- An efficient, user friendly and dynamic routing planning system including cycling routes;
- A platform for supply and demand to share loads with other cargo bike couriers;
- Insight into transport rates and vehicle leasing.

Other applications identified during the experiment were:

- Furniture transport and house removals;
- Products from garden centres and flowers.

Following the pilot in 2017, Het Lokaal did not extend deployment of the CargoBikeXL: the investment was too high for 2Wielkoeriers. 2Wielkoeriers still delivers to Het Lokaal, but with their Bullitt, a two-wheeled cargo bike. This allows the company to deliver online orders from other organic supermarkets and a bakery, mainly to customers in the centre of Amersfoort. CycleSpark has continued to conduct experiments with the CargoBikeXL in collaboration with larger companies, including wholesale construction supplier Stiho.

Martin from 2Wielkoeriers would advise that a short training session be given to new users of the CargoBikeXL: *"You can't let just anyone ride the bike. In the beginning it takes some getting used to and you have to remain vigilant. For example, cornering on the CargoBikeXL does not feel the same as on a bike; you have to keep pedalling and steering. You have the feeling that you are being thrown off. This is because it is a tricycle. Informing users about this in advance will allow them to get used to it more quickly. Power steering also is an option."*

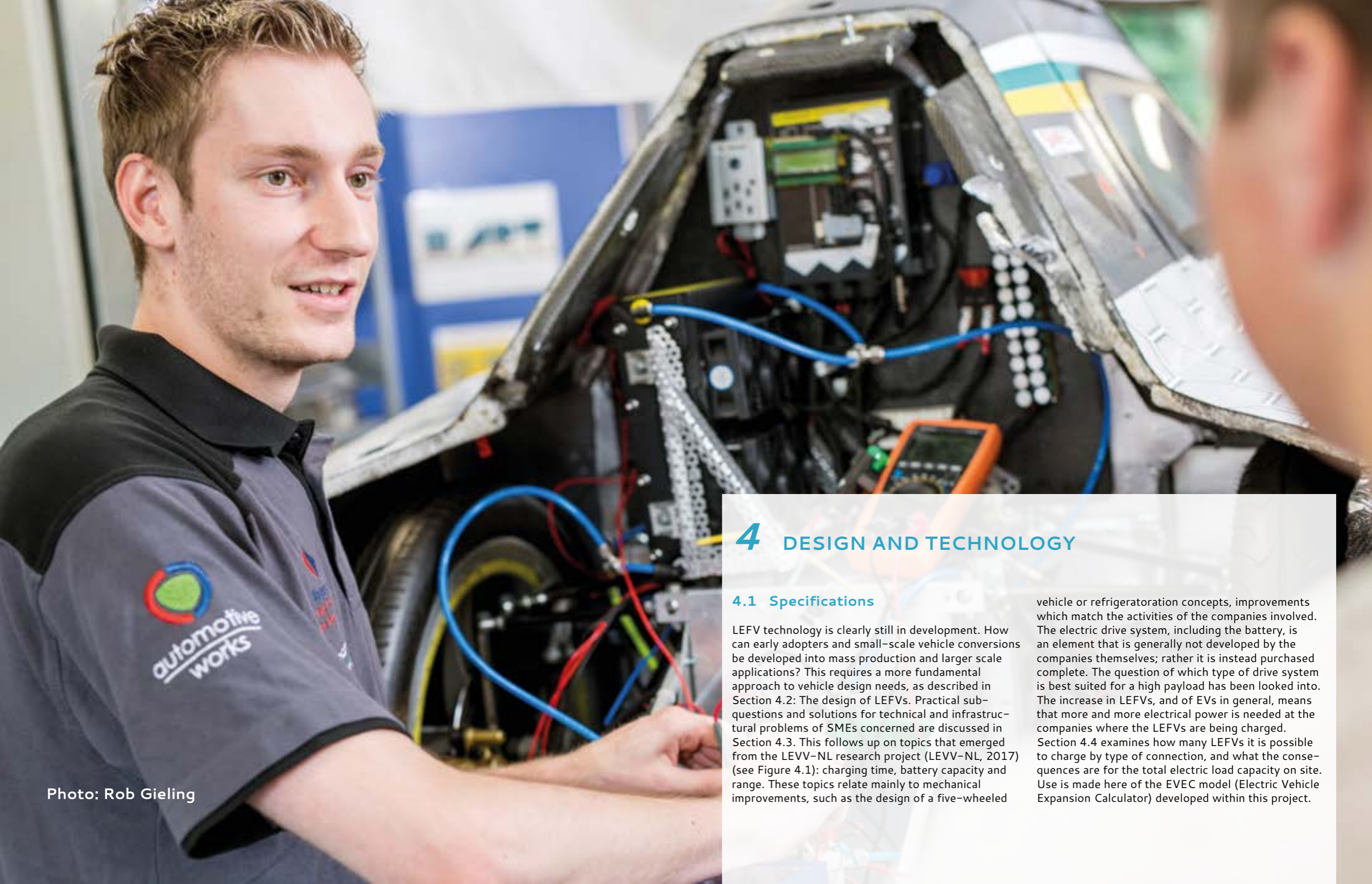


Photo: Rob Gieling

4 DESIGN AND TECHNOLOGY

4.1 Specifications

LEFV technology is clearly still in development. How can early adopters and small-scale vehicle conversions be developed into mass production and larger scale applications? This requires a more fundamental approach to vehicle design needs, as described in Section 4.2: The design of LEFVs. Practical sub-questions and solutions for technical and infrastructural problems of SMEs concerned are discussed in Section 4.3. This follows up on topics that emerged from the LEVV-NL research project (LEVV-NL, 2017) (see Figure 4.1): charging time, battery capacity and range. These topics relate mainly to mechanical improvements, such as the design of a five-wheeled

vehicle or refrigeration concepts, improvements which match the activities of the companies involved. The electric drive system, including the battery, is an element that is generally not developed by the companies themselves; rather it is instead purchased complete. The question of which type of drive system is best suited for a high payload has been looked into. The increase in LEFVs, and of EVs in general, means that more and more electrical power is needed at the companies where the LEFVs are being charged. Section 4.4 examines how many LEFVs it is possible to charge by type of connection, and what the consequences are for the total electric load capacity on site. Use is made here of the EVEC model (Electric Vehicle Expansion Calculator) developed within this project.

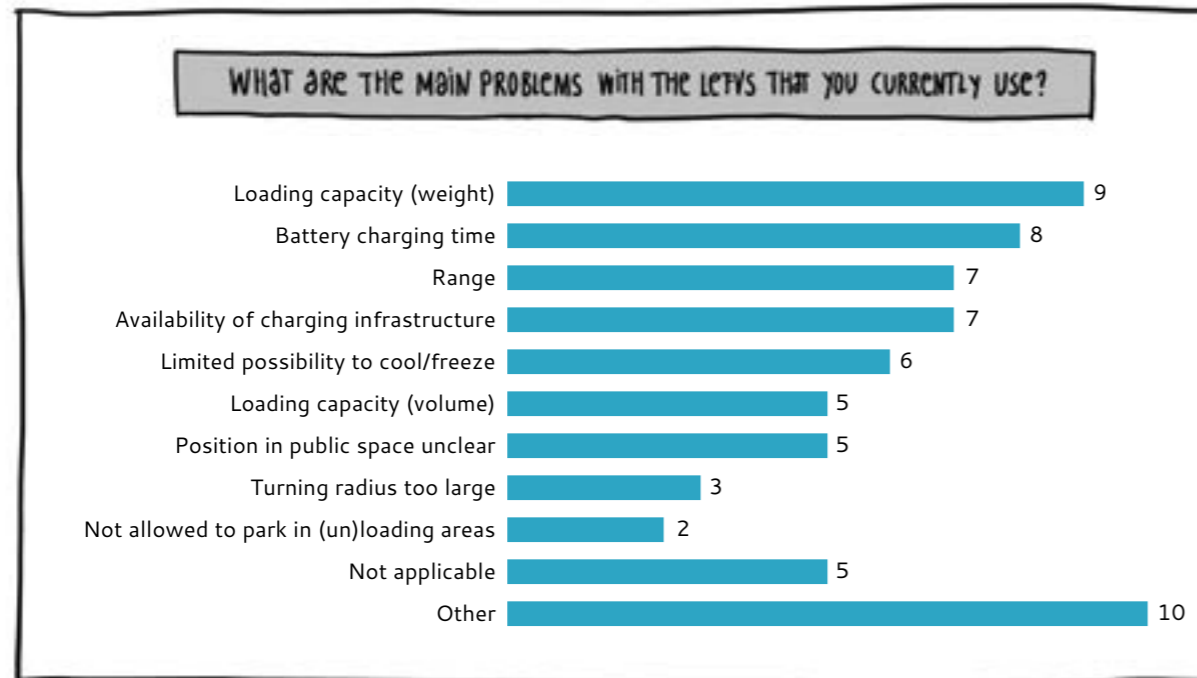


Figure 4.1: Technical aspects that emerged from the LEVV-NL survey (LEV-V-NL, 2017).

4.2 The design of LEFVs

In city logistics, there is an increasing demand for high payload vehicles, in order to improve the ratio between payroll costs and payload. In a growing market there is also a greater need for standardisation in volume and loading units. For each vehicle concept, the broadest possible employability must be striven for in order to achieve sufficient scale in production and service continuity. This enables professional mobility solutions to be developed for affordable, reliable and sustainable logistics services.

Motor vehicles are mostly developed as a universal product, in which enough space, power and range are present for a variety of intended purposes. To achieve a successful transition to a large number of LEFVs in city logistics, it is necessary to understand functional requirements, implementation and passive and active safety. Traditionally, LEFVs have often been developed from two perspectives: either the scaling up of cargo bikes or the scaling down of freight trucks.

This was also evident from a first exploratory study by 25 students from Rotterdam University of Applied Sciences: LEFVs tend to be derived from vehicles that have been designed for other applications, such as park maintenance or transporting children. In addition, none of the existing vehicles was developed the hardware associated with city logistics in mind, such as portable boxes or crates, and roll containers. Pallets are less suitable for use with LEFVs because loading and unloading them tends to require delivery staff to bring with them a hand truck or lifting device.

There is therefore a need for different LEFVs with related hardware and matching charging infrastructure that are specifically designed to meet the requirements of city logistics. A first elaboration on how this could work for sectors such as mail and parcel, retail, service logistics and food delivery is described below.

LEFVs for retail deliveries

On the basis of the exploratory research, the concept of a vehicle for small-scale shop supply with standardised roll containers, which can drive on all roads in and around the city and can easily be parked in small parking spaces was developed. This concept is characterised by a low central loading floor for the roll containers and vehicle stability, space-saving and efficient electric wheel motors and excellent ergonomics for the driver. Out of the research came the first guidelines for the design of category L6e and L7e LEFVs, with dimensions based on the standardised roll container (length 800mm, width 640mm, height 1600mm), including drive technology and charging infrastructure. The guidelines are:

Design Guidelines for the drive mechanism:

- Reduce the required drive power by reducing rolling resistance and air resistance;
- Assume the average usage profile;
- Take technical measures to minimise the consequences of worst-case scenarios (for example, if the battery is charged too little not at all, distance travelled could be shortened by adding diversions to the route, or range could be reduced in extreme weather conditions).

Design guidelines for loading:

- Place loads on the lowest floor area close to the centre of the vehicle;
- Maximise the vehicle width and length within the maximum permitted values (1500mm and 3000mm, respectively). See also Appendix C.
- It is important for auto-related LEFVs which will be used on public roads to be homologated (confirmed by official bodies such as RDW in the Netherlands), which requires compliance with the existing European L-category.

Table 4.1: L6e category LEFV specifications for transporting roll containers.

Specification	Design	Maximum value for homologation
Length (m)	2,83	3,00
Height (m)	1,99	2,50
Width (m)	1,38	1,50
Engine power at 45 km / h (kW)	2 * 3	6

Guidelines for optimising the drive mechanism:

- In order to keep the roll containers manageable, their weight must be limited to no more than 125kg each. A LEFV could carry eight roll containers at 1000kg maximum load weight. However, the volume will be limited meaning that there is only likely to be space for a minimum of two and a maximum of four roll containers within the dimensions of the vehicle.
- In the example below, we assume a total of 250 kg for two containers.
- The minimum required capacity of the battery is therefore 3 to 4 kWh.

Table 4.2 shows the required battery capacity in more detail.

Safety

- Provide a sufficiently wide base to prevent the vehicle or load from rolling over.
- Avoid dramatic accelerations, both longitudinally and laterally, as well as a combination thereof (such as when braking in a bend).

Hogt et al. (2017) go further into these guidelines. In addition to the more general design approach, as described above, research into sub-aspects has also been performed by student teams. These are discussed in the following section.

Table 4.2: Required battery capacity in kWh, depending on vehicle speed, weight of the load and driving distance.

Driving speed (km/h)	Load (kg)	Driving distance (km)		
		30 km	50 km	70 km
20 km/h	200 kg	1.2 kWh	2.0	2.9
20	400	1.5	2.5	3.6
20	600	1.8	3.0	4.2
30	200	1.6	2.7	3.8
30	400	1.9	3.2	4.5
30	600	2.2	3.7	5.2
40	200	2.2	3.7	5.1
40	400	2.5	4.2	5.8
40 km/h	600 kg	2.8	4.7	6.5 kWh

4.3 Sub-studies

The approach in the sub-studies consisted of morphological charts that map design choices for specific requirements. Based on the needs of the practice partners and clients, and the possibilities of legislation, the next steps are drawn up. Students learn to address the issues and achieve results in a

structured way. This includes, amongst other things, the preparation of functional block diagrams, such as the example in Figure 4.2.

A summary of the completed sub-studies can be found in Table 4.3. In the following sections, these studies and the most important results thereof are explained in brief.

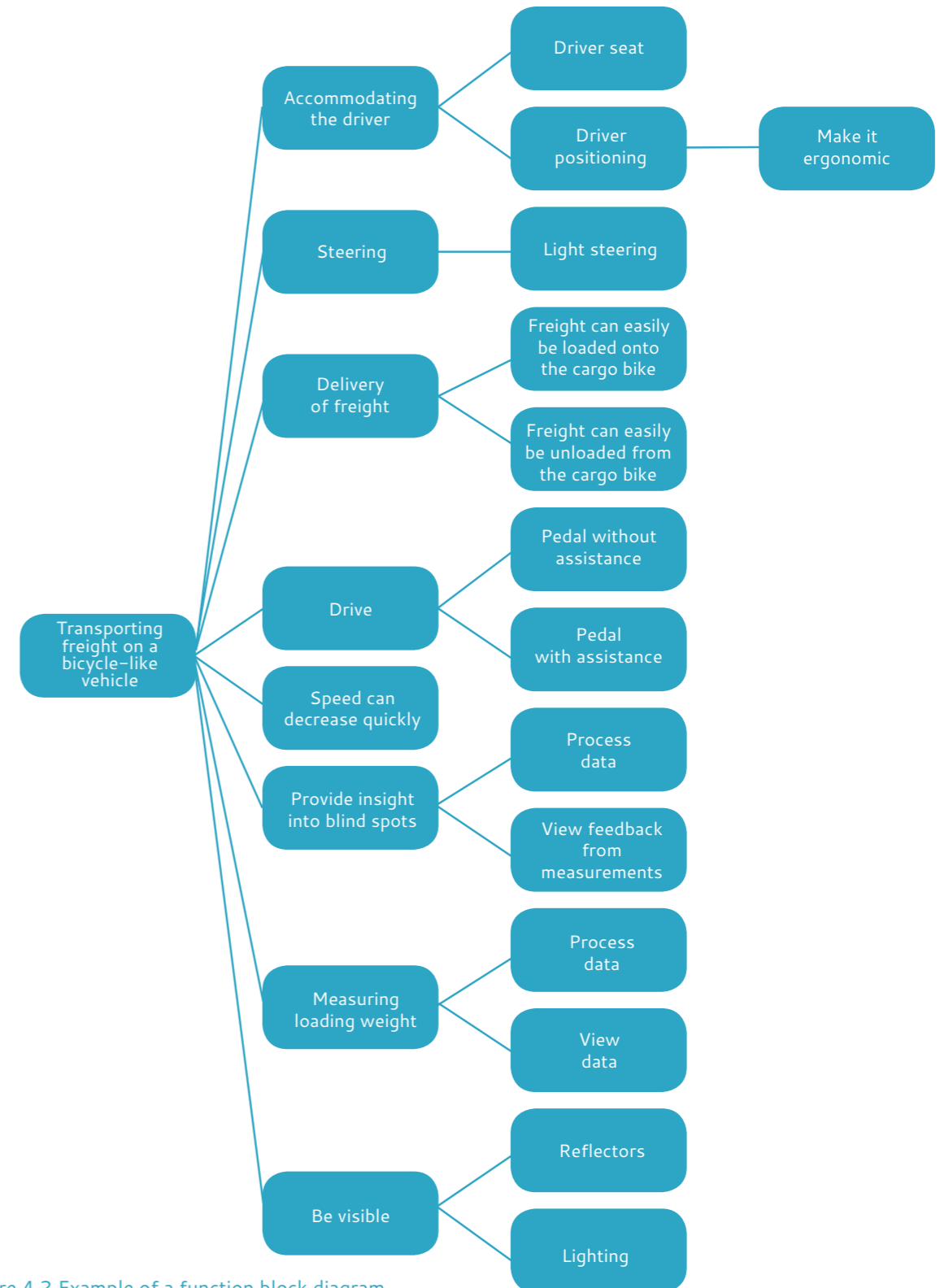


Figure 4.2 Example of a function block diagram.

Table 4.3: Overview of the sub-studies.

Sub topic	Research sub-topic title
Load capacity	Vehicle design for small-scale retail deliveries
	Development of a five-wheeled vehicle
	Making cargo easier to move: pallet stacker
	Making cargo easier to move: containerisation
Drive mechanisms	Vehicle drive design for portable package transport
	Drive mechanisms for high payloads
Refrigeration and freezing	Optimised refrigeration and freezing concepts
Other	Smart and convenient lock on the box
	A simple collapsible stand

4.3.1. Loading capacity

Vehicle design for small-scale retail deliveries

A LEFV design was developed for City Hub in which the developed guidelines for light electric freight vehicles were adhered to. City Hub currently uses a Goupil type G3-1 LEFV. The G3-1 is not suitable for roll containers; the loading floor is too high to accommodate them and the loading space is not high enough. For these reasons, roll containers are transported with a trailer that is pulled by the G3-1. The disadvantage of fully loaded trailers is that the range of vehicles is dramatically reduced. Moreover, it is inconvenient to manoeuvre and park with a trailer in city centres (see images 4.1.1 and 4.1.2).

The newly designed vehicle can itself transport two to four roll containers and can be homologated in class L6e (<45 km/h, 750 kg load) and in class L7e (<90 km/h, 1200 kg load). Image 4.4 shows idea sketches for the transport of two containers.

The concept began with a mind map, which subsequently developed into a complete program of demands based on usage needs of City Hub and vehicle technical requirements of Dutch road transport authority RDW.

The design challenge is to have the vehicle meet all the 'automotive' requirements and wishes of City Hub and, at the same time, to take as many roll containers as possible within the legal dimensions. The team succeeded in creating a concept design that fits three roll containers of 80x64x170cm with ease (see image 4.3).

It is even conceivable that in a further elaboration of this design, by for instance using extra narrow but higher rear wheels, space could be made for a fourth roll container. For the continuation of this research a production partner would have to be approached for further design development and industrial upscaling (see Figure 4.8).



Images 4.1.1 and 4.1.2: The current situation at City Hub, the LEFV is used to tow trailers with roll containers.



Image 4.2: Three views of the LEFV concept for transport of roll containers.



Image 4.3: Fitting in three roll containers.



Image 4.4: Concept design for City Hub with space for three to four roll cages.

Development of a five-wheeled vehicle

Part of Urban Arrow's range of is a electric trike with an effective capacity of 300kg, tested with Dutch supermarket Albert Heijn for the distribution of customer orders. The trike uses a standard rear frame, standard rear wheel and standard drivechain. Wishing to further increase the load capacity, the possibility of developing a five-wheeled vehicle was researched. This design was to feature a special cargo box with a steerable wheel, linked to the standard rear frame.

The conclusion of the research said that it is likely that such a concept will not work in practice. The main reasons are:

- The torque that could be transmitted through the rear wheel on a slippery road is too low to drive uphill at full load. The wheel would slip due to lack of sufficient weight on the rear wheel.
- The steering forces required to change the course of the five-wheeled vehicle would be too large to easily manoeuvre through traffic.
- Safety is not optimal: the dimensions of the vehicle mean that driver visibility is limited, and the high weight of the vehicle would mean additional measures would need to be taken to ensure safety.



Figure 4.5: Five-wheeled vehicle concept.

Making cargo easier to move: pallet stacker

Pallets fit less well with a LEFV than with conventional vehicles. Because pallets are widely used, participants looked into whether there was a way to easily transport them by LEFV. In the case of small-scale applications, there is usually no pallet cart available, so participants investigated the feasibility of a pallet stacker that can be carried by bike. Requirements to be met by the device are, for example, that it must weigh no more than 50 kg, be able to lift 250kg on a standard europallet and easily be able to cope with mounting and dismounting 11cm kerbs. In addition, the delivery person must be able to carry out their delivery to the customer and return to the bicycle within 3 minutes. The developed concept resembles the stretcher that can easily slip into an ambulance: if the largest part of the pallet is on the cart, the wheels can be folded in. See Figure 4.10 for a mock up.

Making cargo easier to move: containerisation

A possible concept for standardisation is in the use of mobile containers, which can easily be moved with a bicycle. A group of students investigated the best ways to detach the container from the bike, to secure

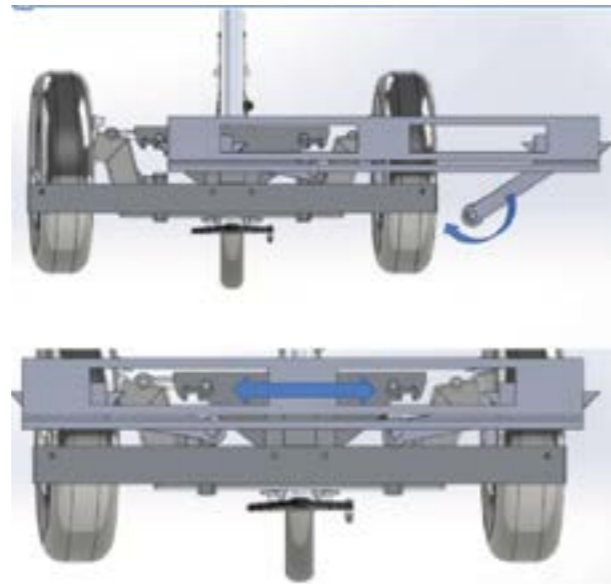


Figure 4.6: A possible solution for moving and transporting a pallet stacker..

it in place and to move it through space. Of the five concepts (scissor system, hand truck, fold-out ramps, retractable ramp and stretcher system), the stretcher concept appears to be the most useful. Important conditions for this are speed of action, required power and keeping the load horizontal.

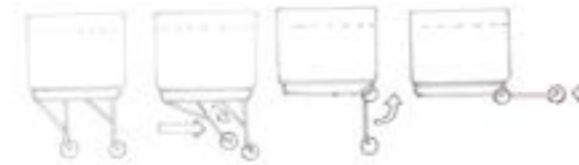


Image 4.7: Sketch of how the trolley system operates.

4.3.2 Drive mechanisms Vehicle drive design for portable package transport

For Stint Urban Mobility's new LEFV, which has to be recognised at European level, various drive mechanisms were investigated. Stint's customers demand two versions, one for 25km/h and one for 45km/h. Firstly, a simulation model was drawn up with which the energy requirement, power, speed and transmission ratio were determined. The slower Stint requires an output of 3kW with an optimum gear ratio and rotational speed. In the faster Stints, engines with a total power of 6kW and a larger transmission are necessary. On the basis of these requirements, a number of drive mechanisms were been selected and digitally modelled in 3D using the software program



Figure 4.8: Packaging of the drive mechanism with sequential transaxles, in-wheel motors and dual drive.

Autodesk Inventor. In this manner the layout of the vehicle including systems such as, in-wheel, dual drive and trans-axle engine have been drawn (see Figure 4.12).

The battery pack and electronics were also determined in this way. Based on this design-oriented research, the adoption of complex dual-drive systems was advised against. The transaxle received positive feedback because of the simplicity of the configuration. The in-wheel solution could also be successfully adopted, provided that no engines need to be placed in the front wheels. Stint Urban Mobility will, on the basis of this technical evaluation, be able to make informed choices for further development and testing.

Drive mechanisms for high payloads

CycleSpark expressed their wish to develop a vehicle that is allowed to ride in cycle lanes as a special moped, has a payload of 800 kg, a speed of 20km/h fully loaded and a speed of 15km/h on a gradient of 10%.

Based on these wishes, a vehicle design was calculated. This showed that not all of CycleSpark's requirements were feasible with current technology (the speed requirement on a slope, in particular, is impossible with the maximum permissible power). For this reason, a new set of requirements was drawn in consultation with CycleSpark that can be realised. The most important conclusions are:

- Restrict payload to 550 kg;
- Limit gradients to 6% at a speed of 10 km/h.

With these new requirements, various concepts for the drive mechanism were calculated and weighed up on the basis of relevant selection criteria. The conclusion is that a drive mechanism with a parallel hybrid direct drive motor is the best solution.

As the maximum payload of an electric cargo bike increases, the design requirements increasingly resemble a compact electric distribution vehicle. This begs the question; are the supposed advantages of a bicycle still sufficiently visible?

Vehicle weight (kg)	Battery capacity (kWh)
800	10.41
900	11.22
1,000	12.02
1,100	12.83
1,200	13.63
1,300	14.44
1,400	15.24
1,500	16.05
1,600	17.34

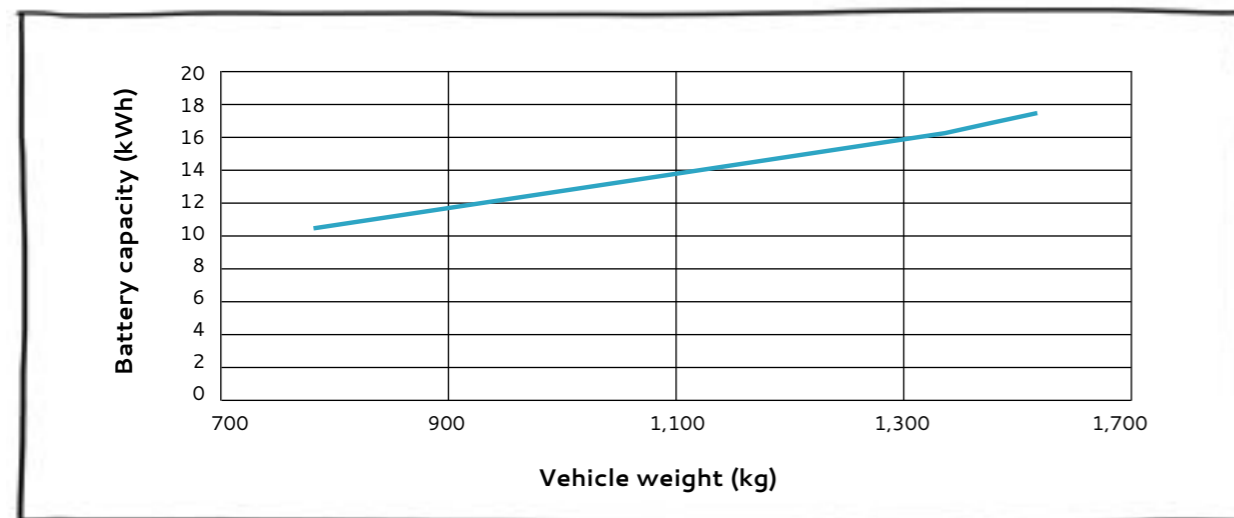


Figure 4.3: Relation between the vehicle weight and battery capacity.

4.3.3 Refrigeration and freezing

Optimised refrigeration and freezing concepts

CycleSpark already offers a solution for customers who need to transport sustainably refrigerated goods such as foodstuffs and flowers; a standard trailer with a standard cool box. However, an improved concept was developed in response to the stricter requirements and wishes of customers. There must be space for at least two roll containers, which must remain for at least five hours at a set temperature between +2 and + 25°C) and that can be transported at a speed of up to 20km/h.

A concept was successfully developed in which all requirements were fulfilled. The design is based on a self-supporting construction of pipes, covered with insulating foam and reinforced with plastic composite. In this composite 'sandwich', the strength of the materials and their insulating properties are integrated so that weight is minimised. The safety requirements were met by choosing to keep a low centre of gravity, stable wheel suspension, solidly attaching the roll containers, a strong trailer coupling, powerful brakes and good lighting. The energy management is efficient because high-quality insulation is combined with solar panels and an economical arrangement.

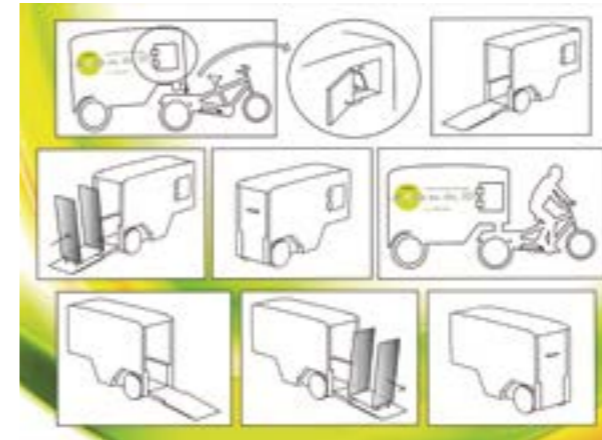


Figure 4.9: Design of improved fridge-freezer trailer.

4.3.4 Other design solutions

Smart and convenient lock on the box

Current cargo bike box locks take delivery personnel too much time to unlock and then lock again. This research sub-topic assignment was therefore to develop a lock that works in a faster, more modern and easier manner. A remote control lock was designed which can be operated at from distances up to 18 metres from the bike. Once the large button is pressed, the lock is unlocked for 10 seconds, during which time the rider can open the box. When 10 seconds have elapsed, the lock automatically closes again.

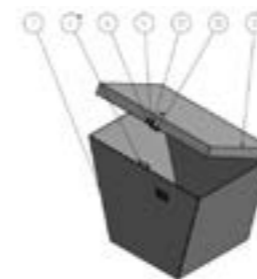


Figure 4.11: The lock design



Figure 4.10: Model of the improved fridge-freezer trailer.

A simple collapsible bike stand

For a cargo bike to be put onto its stand using current designs, its full weight must be lifted over the dead centre point. The heavier the cargo bike, the more difficult this is, so new stand design must make this task easier. The best way appears to be a toothing arranged around the axis of the stand, which can lock and unlock via a freewheel mechanism. The lever of the freewheel is operated by a handle located on the frame under the handlebars. A spring, stretched around the axis of the stand with the frame as reference, causes the stand to collapse again when released.

4.4 Electric charging capacity by location – the EVEC model

An increase in electric transport is anticipated in the next few years. In addition to LEFVs, this will include vehicles with higher electrical capacities such as electric passenger cars, delivery vans and trucks. Charging all of these electric vehicles puts an extra burden on electrical infrastructure, with possible extra costs due to exceeding contracted power limits, or power failure due to overloading of the grid.

Users often do not know how much electricity they already consume at their property, and therefore do not know how much more capacity is available on their current grid connection for charging electric vehicles. To this end, the Amsterdam University of Applied Sciences has developed the EVEC model (Electric Vehicle Expansion Calculator) (Warmerdam, 2018). With information about the different charging needs of various EVs (varying from electric bikes to electric trucks) and about their own energy consumption (from a smart meter or with self-measured data), the model provides insight into what is possible for a given location.

The model first calculates how many vehicles can be charged at a location with a particular electrical grid connection. Other electricity users on the site are not yet taken into account. The results are shown in table 4.4.

A typical advantage of an LEFV is that much less energy is needed per kilometre or per package than with an electric delivery van. LEFVs can therefore operate with smaller batteries and consume less energy, which means less load on the electricity network. Or,

as can be seen in table 4.4, many LEFVs can already be loaded on the existing network. LEFVs also have small batteries, so there is potential for battery swapping systems. Swapping is difficult and costly for passenger cars and trucks, but with a LEFV it can easily be done by hand. Such an exchange system also makes it possible to spread the load on the electricity grid more evenly.

The EVEC-model was tested at the premises of Deudekom in the Duivendrecht area of Amsterdam. Deudekom is a transport and removals business that already has several electric vehicles in use and wants to deploy a lot more. The maximum electrical capacity at the premises is about 2700kWh per day. About 700kWh of this is currently being used, meaning that there is still about 2000kWh available, of which 1300kWh must be used in the evening/at night. If the vehicles are all simultaneously charged at the end of the working day, the maximum capacity would already have been reached had three additional trucks of 22 kW each been added. With smart charging (for example delayed charging) the capacity can better be used throughout the night, meaning that three times as many vehicles can be charged. Figure 4.4 shows a snapshot of the EVEC-model as used in the Deudekom case study.

Table 4.4: Number of vehicles to be charged, by grid connection type, without any other electricity consumption at the site.

Type of electric vehicle	Bicycle	Light LEFV / Cargo Bike	Mid-weight LEFV (Stint)	Heavy LEFV / Small Car	Passenger car	Truck	Truck quick charger	Tesla super charger
Load (kW)	0.1	0.3	1.4	3.7	11	22	44	89
Mains connection								
1*10A = 2.3 kW	23	7	1	0	0	0	0	0
1*25 A = 5.8 kW	58	19	4	1	0	0	0	0
3*25 A = 17 kW	170	56	12	4	1	0	0	0
3*35 A = 24 kW	240	80	17	6	2	1	0	0
3*50A = 35 kW	350	116	25	9	3	1	0	0
3*63A = 44 kW	440	146	31	11	4	2	1	0
3*80A = 55 kW	550	183	39	14	5	2	1	0
100 kVA	1000	333	71	27	9	4	2	1
160 kVA	1600	533	114	43	14	7	3	1
630 kVA	6300	2100	450	170	56	28	14	7

The first version of the EVEC-model was made available in 2017. The model will be expanded step-by-step, to include such elements as the charging demand of individual vehicles, charging profiles of each vehicle, the usage profiles of the current (not yet electric) fleet, more detailed calculation of extra possibilities with

smart charging, standard consumption profiles, battery storage on the premises, installation of solar panels, vehicle to grid possibilities (V2G), the user-friendliness of the model and the addition of financial calculations. The manner in which the model will be expanded will be tailored to market demand.

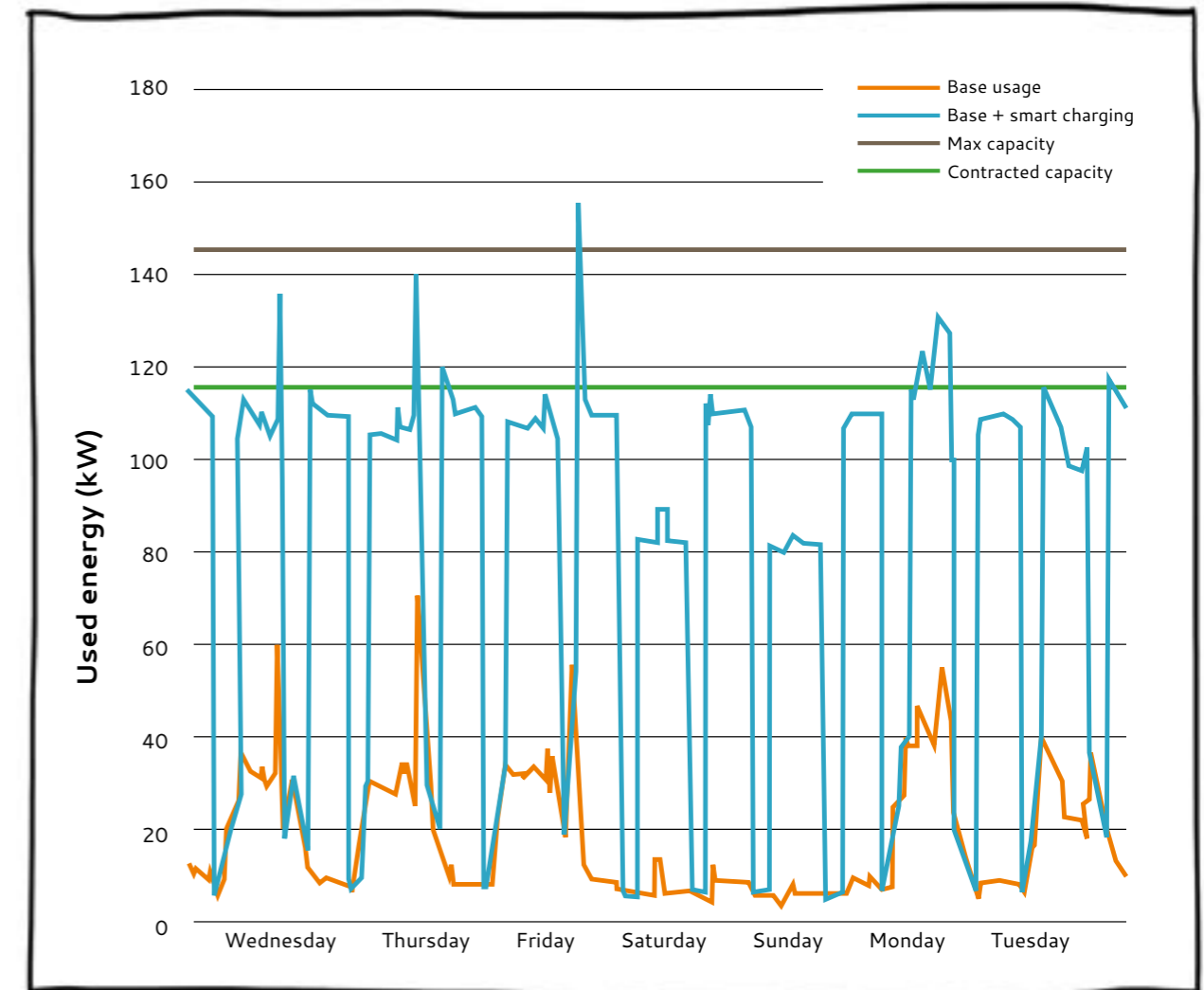


Figure 4.4: Basic electricity consumption with smart charging of the electric vehicles.

4.5 Conclusions

This research into design guidelines for light electric vehicles has shown how LEFVs for professional city logistics applications could be developed. This makes it possible to design automotive products that comply with usage requirements and legislation and that are characterised by high production quality and service continuity. The demand for each design needs to be so large that it can be produced in large numbers. Only then will it be possible to offer quality products at competitive prices in such a way that ensures that logistics service providers are able to deliver their freight safely, on time and in a cost-effective manner. LEFVs can be used frequently and successfully because they represent a tangible contribution to emission-free urban distribution. Cooperation between actors in the fields of logistics and vehicle technology has proven crucial, and is an engaging challenge for LEFV-related education.

Various issues and themes have presented themselves for follow-up study. The sub-studies teach us that there are still many opportunities to optimise LEFVs for specific uses by integrating design. As a result, for example, the weight can be greatly reduced, which has direct beneficial effects on energy consumption, manoeuvrability and safety. The functionality of the product can also be greatly improved. LEFVs are not only light but also small, which is beneficial for the manoeuvrability but not for the volume capacity. As a result, driver costs are high compared to the payload. Optimisation of the useable space is essential, but it could also be investigated whether or not these vehicles could drive autonomously (see box). Market research necessary to get an idea of the scale of the market for each of the different LEFV designs in terms of volume, weight and speed. In addition, further research is needed into the integration of vehicle technology with logistic planning systems, so that working with and charging electric vehicles can be optimised.

Self-driving vehicles: Cargo Pods

In order to compete with freight trucks in terms of costs, a compact distribution vehicle in class L6e or L7e must be able to transport six to eight standard roll containers. Currently available vehicles with a low floor can not handle more than four roll containers. Recently, the idea of self-driving 'CargoPods' that can transport six to eight roll containers without a driver has gained attention. CargoPods offer a solution for, for example, automated night time supply at night (especially in cities), for shopping centres or in port areas and on business parks where normal vehicles are not permitted. With the CargoPods project, Rotterdam University of Applied Sciences has offered the opportunity for a joint follow-up study on this topic.

Practical Research at the Universities of Applied Sciences

Practical research at the Amsterdam University of Applied Sciences: Faculty of Technology Innovation Lab

In the second year, students from the Engineering program conduct projects in which practical research is carried out together with SMEs. This takes place in the Innovation Lab where groups of four to six students, taking a set of requirements as a starting point, develop different solutions. The most promising of these solutions are developed into prototypes.

Practical research at the Rotterdam University of Applied Sciences: RDM Campus

Design and application research on automotive-related vehicle technology for LEFVs was carried out by Rotterdam University of Applied Sciences at the RDM Centre of Expertise by students and lecturers from the Automotive and Future Mobility educational programmes. The RDM Campus is the home base for Smart e-Mobility at Rotterdam University of Applied Sciences.

Practical research at the HAN University of Applied Sciences: Mobility Innovation Center

Groups of second and third-year students from the Automotive, Electrical, Mechanical Engineering and Industrial Product Design programs carry out their activities in the Mobility Innovation Center (MIC) of the Clean Mobility Center (CMC) foundation. The CMC responds to mobility demands from the market and offers students from different disciplines the opportunity to work together with clients in the MIC on clean, smart and safe mobility issues. The student groups are supported by lecturers and experts from the HAN University of Applied Sciences. The aim of the CMC is to create a Community of Practice (COP) in which experts from business, knowledge institutions and students work together and learn from each other in the field of clean mobility.



Photo: Rob Gieling



Experiment – City Hub: retail and hospitality in Amsterdam

City Hub offers handling and storage areas on the outskirts of cities (including Roermond, Amsterdam, Utrecht and The Hague) from where goods are transported to city centres in small electric vehicles with trailers. The experiment focussed on the launch of a City Hub location in the South of Amsterdam as a franchise model with The Loogman Group, and consists of a trial for two customers: CB Logistics with the transport of roll containers and packages and Blycolin with the transport of linen to hotels.



City Hub

Plan

In collaboration with a graduate student from the Amsterdam University of Applied Sciences, research was conducted into which product-market combinations Amsterdam were most likely to generate turnover for City Hub. In addition, the ideal design of a LEFV for City Hub was examined (see chapter 4). The scalability of the City Hub business model was also evaluated (see chapter 6).

Results

After the trial period, both CB and Blycolin decided to continue cooperation with City Hub. City Hub is now focusing on further expansion to Utrecht and The Hague.

"Sustainable transport fits in seamlessly with the vision of Blycolin. Together with laundry partner 't Heycop, Blycolin will supply three hotels in the centre of Amsterdam with clean linen with the electric vehicles operated by City Hub. 't Heycop brings the clean linen to the distribution centre on the outskirts of Amsterdam. From there, an electric car from City Hub drives into the centre. The dirty linen is also collected in this way. This is not only good for the environment, but also very efficient because City Hub can reach every part of the city with LEFVs. In addition, the company bundles a number of deliveries, meaning it is rare for a vehicle to drive half empty" (Jacobs, 2018).

'Every morning, early on, CB will deliver to City Hub on the outskirts of the city. City Hub in turn then takes care of the last kilometres. Deliveries are bundled as much as possible and delivered into the city centre by e-cars with trailers. Cees Pronk, Director of Operations at CB, said: 'We are working more and more with transport partners. By cooperating with City Hub, we are further expanding our network of transport partners. A good network makes us flexible and ensures that we deploy exactly the right amount of transport in the correct area and at the correct moment. By expanding our partner network to include City Hub, we can work even more efficiently and sustainably.'" (CB Logistics, 2017)

City Hub was advised to focus on customers in areas that deal with: 1) a high commercial property price per square metre 2) a strong increase in rental rates and 3) nuisance caused by city distribution and loading and unloading activities. An analysis of these three factors by an Amsterdam University of Applied Sciences student lead to a selection of the following streets: De 9 Straatjes, Haarlemmerstraat, Haarlemmerdijk, Ferdinand Bolstraat, Utrechtsestraat, Kinkerstraat, Reguliersbreestraat, Cornelis Schuytstraat, PC Hooftstraat, Raadhuisstraat, Van Baerlestraat, Damstraat, Spui and Spuistraat. See figure below.



Focus areas with high levels of loading and unloading activities and nuisance caused by city distribution. Bottlenecks are indicated in pink. Areas with the highest commercial real estate prices and rent increases have been circled green.



5 APPROPRIATE POLICY

The development and use of LEFVs plays an important role in shaping (future) mobility policy. This chapter discusses the different roles of government actors and the position of the LEFV in traffic, and concludes with some recommendations for policymakers.

5.1 Liveable cities

LEFVs contribute to a city logistics that is emission-free and compatible with car-free cities. Both good reasons to stimulate use. However LEFVs can also raise questions and provoke resistance. There are questions about the safety of LEFVs when they use the road together with regular car and bicycle traffic. There is resistance to their use on already crowded cycling infrastructure, especially when the LEFVs involved are large. There are fears that the safety of other road users may be endangered and that the pavement will be blocked by LEFVs. And studies indicate that local infrastructure and traffic regulations in the Netherlands are not prepared for an increase in LEFVs (Koolstra et al, 2017). This raises the question: how do these vehicles fit into urban infrastructure and what measures can municipalities take to facilitate LEFVs?

This chapter describes various measures municipalities can take to influence the extent to which LEFVs can be successfully used. We examine the position LEFVs occupy in traffic and the experiences of users, as studied during the LEVV-NL and SICLEV projects. We conclude with recommendations for municipal policy. An overview of the admissibility requirements (dimensions, power, driving license, etc.) and traffic regulations (road position) for different types of LEFVs is included in Appendix C.

The LEFV-LOGIC consortium entered into discussions with mobility experts from the Dutch Touring Club ANWB, exhibition organisation RAI Association, Dutch government entrepreneurial support department RVO and the municipalities of Rotterdam, Amersfoort, Delft and Amsterdam. In addition, policy documents, policy advice reports and reports from council meetings served as input. As part of the SICLEV study (commissioned by the municipality of Amsterdam) interviews were held with seven logistics service providers that use LEFVs in Amsterdam (Koolstra, 2018). In this chapter, experiences from practical experiments have also been included.

Pieter Litjens, Councillor for Traffic and Transport at the Municipality of Amsterdam in 2017:
“The other side of innovation is that things move much faster than the regulations can be changed.”

These items make policy around LEFVs extra complicated

LEFV and LEV

The light electric vehicle (LEV) for passenger transport, such as the Biro and the cargo bike, is just like the LEFV. For traffic rules the dimensions and speed of the vehicle are the important factors, not the application (freight versus people). That makes for a complicated discussion about which regulations are desirable. For logistics trips, it is clear that a LEFV helps prevent a larger freight vehicle from driving through the city (Meeting of the Amsterdam Board Committee on Infrastructure and Sustainability, 1 June 2017). This could be a reason to stimulate and facilitate the use of LEFVs. For passenger transport the situation is less clear. Is the Biro a replacement for a larger car, or does it replace a bicycle or public transport? Should LEV use be encouraged or regulated? Jan-Bert Vroege of Dutch political party D66 wrote a "discussienota" to request that these issues be put on the agenda of the city council. Following elections, comments were made in the new coalition agreement (2018) about a ban on the parking of light electric vehicles on the sidewalk.

Amsterdam wants parking ban for small vehicles on the sidewalk

Source: Het Parool, 1st June, 2017

Cargo bike terror: is the elite bike to wide or are bike paths too narrow?

Parool, 7th April, 2018

Enforcement without number plates

Bicycles, special mopeds and motor vehicles with limited speed are not obliged to be registered. This makes it more difficult to collect fines for violations and leads to the question of whether new traffic regulations for LEFVs can be enforced effectively.

NIWO licence for professional haulage

Delivery personnel who drive on behalf of third parties in a vehicle with a payload of more than 500 kilos require a licence from NIWO (the Dutch National and International Road transport Organisation) (Article 2.1, paragraph 3. Road Transport Act 2008). NIWO assesses whether the professional transport company meets the requirements set: creditworthiness, reliability, professional competence and real establishment. No NIWO permit is required for the use of an LEFV with a payload of up to 500 kilos. In order to guarantee the quality of transporters using LEFVs, the question of whether the limit of 500kg should be reduced could be asked.

Note:

- NIWO: the Dutch National and International Road transport Organisation
- Professional haulage: transport of goods with one or more trucks, performed in return for remuneration from one or more third parties

Limited speed mopeds on the road

In December 2017, a majority of Amsterdam's councillors approved the proposal to no longer allow mopeds with a limited speed (the so-called snorfiets, all of which have a blue license plate in the Netherlands) from bicycle lanes to the carriageway. This is expected to take effect in 2019, and also entails a mandatory helmet for snorfiets riders. Minister Cora van Nieuwenhuizen of Infrastructure and Water Management believes that Amsterdam and other interested municipalities should be given the freedom to make such choices themselves (Het Parool, 2017; Municipality of Amsterdam, 2018).

5.2 The role of municipalities

Municipalities can take various roles in the development of LEFVs: stimulatory, regulatory, facilitative, coordination or experimentation role (ROB, 2012). Here we go further into each of these roles with some practical examples.

Regulation: environmental zones

Environmental zones come in several forms and are often different between cities. In Amsterdam, old delivery vans and old two-stroke and four-stroke engine mopeds are no longer allowed into the city. The year of the vehicle's construction is the starting point, because it can be checked via license plate recognition. Similar restrictive measures have been applied in Utrecht, Arnhem and Rotterdam. Environmental zones are a signal for entrepreneurs that municipalities have a commitment to clean vehicles, which in turn reinforces the incentives for owners to renew vehicles and fleets. The conditions for access to environmental zones vary city by city. With more and more local environmental zones, the various schemes are becoming overall less and less transparent for businesses. As long as it is unclear when rules around particular environmental zones will become stricter, their introduction represents only a limited incentive to replace existing vehicles and fleets with innovative, clean vehicles – a radical move for many.

Regulating: privileges

Utrecht has granted an exemption allowing participants of the CityServiceBike pilot scheme to deliver all day

in pedestrian areas. A disadvantage of this exemption is that it is not widely known about or clearly visible to pedestrians, who can consider cycling through a pedestrian zone as antisocial. In that case, the driver may still prefer to walk, but for three or four-wheeled bicycle, cycling is easier than walking next to it.

In March 2017, the Amsterdam municipal cabinet approved the plan to structurally introduce the eRVV exemption. The eRVV exemption is a separate category within the Regulations of Traffic Rules and Traffic Signs (RVV) exemptions that can be requested for electric delivery and freight vehicles. With an eRVV exemption, vehicles can load and unload outside window times and in pedestrian zones (Choho, 2017). The exemption does not (yet) apply to LEFVs.

Coordinate: bring supply and demand together

Amsterdam municipality coordinates the supply and demand of energy charging solutions. The municipality is looking into how it can link companies who want to charge vehicles to parties with innovative charging solutions. With that goal in mind, a special demand and supply session called 'koffie elektrisch' was organised in 2017, attended by around 200 companies (Choho, 2017)..

The supply and demand of logistics facilities, for storage and transshipment from large to small electric transport, can also be coordinated by the government. This can happen during the drafting of zoning plans for spatial developments or by bringing together residents and businesses to increase the support for and use of logistics facilities (municipality of Haarlem, 2017).

Tabel 5.1: Roles of municipalities

Role of the municipality	Measure	Government participation
To regulate	<ul style="list-style-type: none"> • Environmental zone for polluting traffic • Privileges for LEFVs 	<p style="text-align: center;">Low</p> <p style="text-align: center;">High</p>
To coordinate	<ul style="list-style-type: none"> • Bringing supply and demand of facilities together • Making current traffic data available 	
To stimulate	<ul style="list-style-type: none"> • Subsidy for clean transport • Sustainable procurement 	
To facilitate	<ul style="list-style-type: none"> • Logistic facilities and loading capacity • Remodeling roads into bicycle only streets 	
To experiment	<ul style="list-style-type: none"> • Deploying LEFVs for own services 	

Coordinate: share traffic data

Municipalities are already providing real-time local traffic data via the NDW (National Road Traffic Data Database) to TMS providers including Google Maps, PTV, Ortec, Quintic and TomTom. If the government was to also include routes, loading and unloading places and privileges (for example access to pedestrian areas) for LEFVs, service providers would be able to plan more efficiently. For this purpose, it is desirable for the National Road Database to be supplemented with data on accessibility for different vehicle categories, on exemptions and on privileges.

Stimulate: financial incentives with purchases of clean vehicles or cargo bikes

In The Hague, Utrecht and Maastricht and in the Dutch regions of Zwolle-Kampen, Twente and Stedendriehoek, subsidies for the use of cargo bicycles were granted during the term of LEFV-LOGIC. Subsidy amounts ranged from 1500 to 4000 euros, with various different conditions attached, such as trip registration (see Appendix D). In some cities free week-long bike trials were made available and in Deventer the subsidy could also be used to try out the services of a bicycle courier (Puylaert, 2018, JIJ & Overijssel, 2018). Amsterdam has a subsidy for the purchase of electric delivery vans. Car-like LEFVs, with a closed loading space of at least 2 m³ or open loading space of 2 m² are also eligible for this subsidy (Municipality of Amsterdam, 2018). Cargo bikes and electric scooters / mopeds are not (yet) subsidised in Amsterdam. In March 2018 the municipality offered the following reason for their decision not to subsidise cargo bicycles: 'bicycles do not need a subsidy and it is already very busy on the cycle paths' (Event CityLab, 2018).

The advantage of subsidies is that the threshold for adopting an innovation is reduced. A risk is that an unrealistic picture is created of the purchase price, with the potential consequence that the sale collapses as soon as the subsidy disappears. It may also lead to less motivation for producers and sellers being less encouraged to strive to reduce prices.

At the Dutch national level, environmentally friendly technologies are financially stimulated via the Environmental Investment Allowance (MIA) and the Random Depreciation of Environmental Investments

(Vamil) (RVO, 2018). Electric (cargo) bikes with canopy of non-flexible material also fall within this scheme (Veloplu, 2018).

Stimulate: sustainable procurement

Municipalities can use their own purchasing power to stimulate the development of sustainable alternatives, such as the deployment of LEFVs. Not only can they organise their own logistic activities such as mail delivery and waste collection with LEFVs, but they can also encourage suppliers of inbound goods to use LEFVs via tenders. Since 2016, the University of Amsterdam and Amsterdam University of Applied Sciences have been asking their suppliers to bundle shipments at Deudekom's hub in the Duivendrecht area of the city. From here, electric freight trucks and LEFVs are deployed in cooperation with PostNL.

Facilitate: remodel roads as bike streets

A fietsstraat (bicycle street) has a lot of space for cyclists, whilst cars are treated as guests and the maximum speed is 30 km/h. This speed limit fits well with the deployment of LEFVs and the bicycle street offers users more space to overtake each other safely than on the traditional bike path. This boost for road safety and quality of life is at the expense of the speed of cars. An evaluation of Sarphatistraat, a fietsstraat in Amsterdam, showed that the majority of cyclists (88%) found the fietsstraat to be an improvement (Municipality of Amsterdam, 2016).



Image 5.1: Fietsstraat Sarphatistraat Amsterdam

A fietsstraat is only workable in situations with a low intensity of motor vehicles and relatively high levels of cyclists (CROW, 2015; 2016). With an incorrect ratio of bicycles and cars (too many cars), drivers may not be able to adjust adequately to cyclists (perceived) safety, which may create dangerous situations. Barriers in the fietsstraat can reduce the intensity of motor vehicles to an acceptable level.

Facilitate: logistics facilities and loading capacity

In order to efficiently use LEFVs, there is a need for logistics facilities for the transshipment of goods, but affordable space for this is scarce in cities. Municipalities can play a role by making real estate available to logistics service providers at lower rates. Delft municipality has chosen this role in the realisation of a city logistics centre on the outskirts of the city, near the exit of the A13, a major road (Policy Expert Session, 2017). Charging infrastructure is also needed to provide the vehicles with energy. Provision of sufficient loading capacity (in terms of availability, reliability and speed) contributes to the efficient use of LEFVs.

Experiment: deploy LEFVs for their own services

The Dutch municipality of Zaanstad has been using Stints since 2015 to empty waste bins and collect street litter. Other municipalities are already working with electric vehicles, mostly for street cleaning work.

5.3 The position of LEFVs in city traffic

5.3.1 The current position of the LEFV in city traffic

What positions in the road do different LEFVs take? According to the Regulations of Traffic Rules and Traffic Signs (RVV), five categories can be distinguished:

- Bike-like LEFVs ride wherever possible on bike paths and park on the sidewalk;
- Two-wheeled mopeds (with and without a cover or hood) ride wherever possible on the cycle / moped path (and otherwise on the road) (see box on page 70 and park on the pavement;



Image 5.2: Traffic sign. Access forbidden with the exception of bikes and mopeds.

- Mopeds with more than two wheels ride on the road and park on the sidewalk;
- Car-like LEFVs drive on the road and park in parking lots or on the road

Bicycles and mopeds (without a cover or hood) are often excluded from the mandatory driving direction on one-way roads.

5.3.2 User experiences

LEFV users highlight their experiences of bicycle paths being too narrow, and the relatively low or high speeds of other vehicles as the main problems of operating LEFVs in public space (LEVV-NL, 2017). See image 5.1.

The seven businesses surveyed for the SICLEV research project (Koolstra, 2018) and four participants from the trial in Maastricht generally experience few problems when using LEFVs in city traffic. Although wider bikes (those with more than two wheels) may theoretically also ride on the road, according to the interviews, this hardly occurs in practice. Congestion-free riding on bike paths and faster parking are seen as major advantages. From the interviews and the practical experiments, a number of bottlenecks emerged that could cause more problems with the growing use of LEFVs:

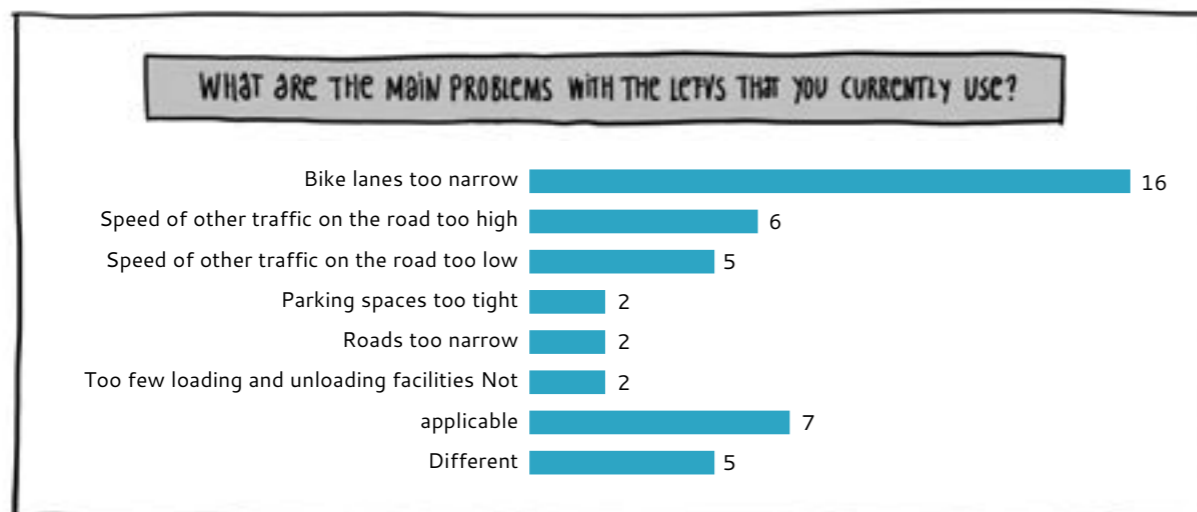


Figure 5.1: Problems with LEFVs in practice (LEV-V-NL, 2017)

- narrow cycle paths are problematic for wide cargo bicycles when they are overtaken or want to overtake;
- storage compartments are sometimes too short for long cargo bicycles (with trailer);
- due to kerb heights and lack of space, larger cargo bikes can not always be placed on the sidewalk;
- car-like LEFVs miss out on some of the cargo bike's advantages, such as shorter routes and parking on the sidewalk close to the destination;
- there is a lack of public loading and unloading facilities for cargo bikes that provide cover, are secure and also provide parking and recharging;
- the popularity of MmBS (Motor Vehicle with Limited Speed) among logistics service providers is growing, because these vehicles

are licence-free. The limited speed can lead to undesirable overtaking manoeuvres from following traffic, with associated safety risks. An MmBS has a legal maximum speed of 25km/h and is considered as a 'slow traffic' category that is not allowed to use facilities for bikes and mopeds. Users indicate, however, that the position on the road (cycle path versus car lane) of an MmBS is unclear or unknown in practice.

5.4 Conclusion

Based on practical experiences, policy makers are advised to consider the following points, preferably in the form of experiments. An experimental approach combined with subsidies makes it possible to try out measures before final policy choices. In addition, clarity and continuity is needed from national government, in particular as regards vehicle requirements, type approval, admission into road traffic and the maximum speed in traffic versus the designed-for speed.

Comfortable routes

Municipalities can facilitate and regulate LEFVs by providing fast, safe and comfortable routes through the following measures:

1. Set up more inner city streets as bicycle streets with a maximum speed of 30 km/h;
2. A speed limit of 30km/h on narrow roads with separated cycling infrastructure, in combination with the obligation for LEFVs with a certain speed, weight or width characteristics to drive on the road (see point 4);
3. Permission for all LEFVs to use one-way streets in the opposite direction.
4. Further research into the desirability of co-use of cycle and moped lanes and the roadway by various types of LEFVs. The reason for this is that the differences in width, weight, and speed between LEFV themselves are large.

Loading and unloading

Loading and unloading are important activities in city logistics. The loading and unloading of LEFVs can be controlled and facilitated through the following measures:

5. Stricter regulations for loading and unloading;
6. Creation of loading and unloading spaces for LEFVs;
7. All LEFVs permit in parking places;
8. Enforcement of rules;
9. Dispensation for the use of streets and pedestrian areas outside time windows.

Logistics, infrastructure and vehicles

In order for users of LEFVs to take the above points in logistical planning into consideration, the following coordination is desirable:

10. Open data sets made available (via a national platform such as the Dutch NDW) on accessibility, exemptions and privileges for different categories of vehicles, speed limits and parking, loading and unloading places.

Several parties see opportunities to optimise logistics using LEFVs and urban transshipment points. Municipalities can help by doing the following:

11. Coordinate and/or facilitate charging infrastructure and logistics facilities, through the development of zoning plans.

To discourage the use of (polluting) delivery vans and trucks, it is important that businesses are aware of when they may not use certain vehicles:

12. Make concrete plans for clean air and accessibility to increasingly stringent environmental zones and car-free areas for the coming years. The largest municipalities are asked to indicate the area in which zero-emission zones will be brought in from 2025, what the requirements will be and to which types of vehicles it will apply (TLN Review Session, 2018).

It is important that the LEFV is acknowledged and recognised as a mode of transport with its own characteristics, different from the standard bicycle, moped, car or delivery van. This also applies to autonomous vehicles (such as the Dominos pizza robot) and drones.

For all measures, harmonisation at the national level gives a boost to their effects. If, in addition, planned measures such as subsidies are communicated in good time, the opportunities offered can be better utilised by their target groups. Businesses (transporters, shippers, and manufacturers of both vehicles and charging infrastructure) need a reliable and consistent government policy as a basis for investing in people and resources. Finally, specific training may be required for LEFV drivers, especially when it comes to goods transport in busy inner cities and residential areas. Different vehicle providers take responsibility themselves by offering training or making it mandatory.

Cargo Bikes in Rotterdam: infrastructure and public space

www.cargobikesinrotterdam.nl

Cargo bikes can ensure that a city remains accessible and liveable. For this, infrastructure and public space must of course be suitable. A team of students from the Infrastructure and Mobility minor at the Rotterdam University of Applied Sciences (Sjouke et al., 2018) carried out research into the requirements that must be set for the infrastructure as well as what possibilities exist in public space. LEFV-LOGIC offered a platform for knowledge exchange, allowing for quick and easy collaboration with researchers, experts, government bodies and businesses.

Urban infrastructure can be quickly improved by correctly applying design guidelines. There are also improvements to be made in the design of public space. Based on two innovative design frameworks, Traffic in the City (Immers, et al., 2015) and Functional Ambiance (Verheijen & Smidt, n.b.), infrastructure and public space can be quickly improved. To make this process simple and transparent, seven factors were drawn up to make the quality of public space measurable (see list of symbols).

On the basis of these seven factors, streets were analysed and improvements introduced. In some cases, a whole street would have to be upgraded to improve the safety of (cargo) bike users. In other cases, small adjustments can make a world of difference.

-  A correct arrangement of the road for the area, and the associated speed regime. (City Traffic)
-  Sufficient space in the cross section of the street to make separation and / or mixing of traffic flows possible. (City Traffic)
-  The function of the buildings in relation to the activities undertaken by the cargo bike. (Functional Ambiance)
-  The traffic function goes hand in hand with the quality of the public space. (Functional Ambiance)
-  Multifunctional space ensures that limited space is used optimally, and increases the quality. (Functional Ambiance)
-  The bicycle friendliness must be high enough to make use of the cargo bike safe and pleasant. (Functional Ambiance)
-  There must be sufficient space to carry out the activities of a cargo bicycle in the unloading area(s). (Functional Ambiance)



De Meent is a wide, bicycle-friendly street in a 30km zone. There are many shops and restaurants, so a lot of activity is to be expected here. The street layout is spacious, so that there is plenty of room on the sidewalks to park (cargo) bikes. The loading and unloading spaces serve as parking space outside the window times.



The **Van Oldenbarneveltstraat** has a modern outlook, but there are several improvements to be made. For example, the speed regime of 50 km/h does not match the function as a shopping street. Furthermore, there are too few loading and unloading places present, meaning that loading and unloading often takes place in the cycle lane.



Nieuwe Binnenweg is a neighbourhood access road with an outdated layout. The part of the road used by cyclists is insufficiently separated from trucks, trams and heavy traffic. The end of the street, where restaurants and cafes are located, is a residential area, and therefore a 30km/h limit would not be out of place.



The **Witte de Withstraat** would be an ideal street for cycling, were it not for the maximum speed of 50km/h. During the day the street is full of lorries supplying the shops and restaurants, but in the evening it buzzes with people. A dynamic arrangement in which the loading and unloading spaces function as a bar or restaurant terraces in the evening would fit well here.



Snellinckstraat is a quiet residential street close to the old centre of the city. A typical city street – just one of many. Although this is a narrow street, most residents find it more important to have their car in front of their front door than to reside in a liveable street. As long as this does not change, there is no room here for any adjustments.



Experiment – Maastricht Bereikbaar: purchase subsidies for entrepreneurs in Maastricht

In June 2017 Maastricht Bereikbaar (Accessible Maastricht) launched a subsidy scheme for the purchase of electric cargo bicycles. The impetus came from the closure of the Noorderbrug, a large road bridge, for major works. In order to limit traffic disruption and to ensure that supply to the city centre remained uninterrupted, businesses were encouraged to exchange their delivery vans for a cargo bike. Four organisations made use of the subsidy: coffee roasting company Blanche Dael, hairdresser HairVisit, student service company Jules and event agency PP Events. With the subsidy they purchased cargo bicycles from Urban Arrow and Babboe.

Plan

Conditions for the subsidy included monitoring with a GPS logger for six months and participation in two telephone evaluation interviews. On two occasions during the six months, participants also kept a logbook for two weeks.



Participants of the experiment in Maastricht (Photo: Aron Nijs)

Results

The activities and goods of the four participants differed greatly: parcels, domestic materials, hairdressing supplies and artist's items. The practical experience of each of the participants was predominantly the same: they were enthusiastic. The trial makes it clear that the electric cargo bike can be of value to businesses in various ways: it increases efficiency, it is a form of corporate social responsibility and it gives businesses a distinctive image.

"The electric cargo bike is surprisingly handy. You can take a lot with you, such as a tool box and a drill; even a lamp or toilet seat. The capacity of the container is also sufficient for cleaners to carry all of their equipment. Efficiency is the most important reason for us to use the e-cargo bike. However, without the subsidy scheme it would have been a considerable investment" participant Jules

Value creation

- Time savings are only achieved with journeys in the inner city. Blanche Dael and Jules, who spend much of their time in the inner city, mentioned time savings as an advantage. HairVisit and PP Events, both of whom travel long distances across the city, said that trips with the e-cargo bike lasted on average as long as those taken by car.
- Electric cargo bike use has an impact on participants' 'vehicle fleets'. PP Events and HairVisit decided to get rid of their delivery vans after using the cargo bike. Jules has postponed purchasing a new car. The saving on fuel costs is limited due to the limited number of kilometres travelled and the energy required to charge the battery.
- Participants received positive reactions from members of the public, and stated that the electric cargo bike (and the stickers) helped to make their businesses stand out. The means of transport contributed to the image and visibility of the company.
- The two independent entrepreneurs, PP Events and HairVisit, mentioned that using an e-cargo bike was enjoyable and helped them to feel fitter.

"The electric cargo bike has led me to sell my vans." Participant PP Events

"With the electric cargo bike, we are faster in the city centre than with the delivery van. The bike is more agile, you do not have to search for a parking space and you can drive right up in front of the store. It is nice that our delivery van no longer has to go into the city every day, because it contributes to pollution and traffic jams. You have to be careful that you remember to charge the bike, but that is a matter of routine." participant BlancheDael

Details about the use of the cargo bikes

- Riding an e-cargo bike can take some getting used to at first. The reasons for this are the higher speed, the charging of the battery and extra caution on speed bumps.
- All participants were satisfied with the capacity of the container. However, they also said that larger containers come at the expense of manoeuvrability.
- The battery had sufficient capacity for the daily distance the participants traveled. HairVisit took a spare battery to ensure that all rides could be made.
- Two participants (Jules and HairVisit) revised the way they plan to adapt to the e-cargo bike, so that it can be used even more efficiently.
- HairVisit was the only participant to comment on how annoying bumps in the road are. This could possibly be related to the three-wheeled construction of their cargo bike. All of the other cargo bikes in the test had two wheels.

Experiences in public space

- The participants said that sometimes they were extra cautious around other road users, who may not have yet have been used to cargo bicycles in traffic. Wider bicycle paths would offer a solution.
- There are hardly any public parking facilities for cargo bikes. Participants parked on the sidewalk when visiting clients.
- An exemption was offered to participants which could be used to cycle in pedestrian areas outside the window times. However there was little need for it, either because they do not go there frequently or prefer to avoid busy shopping hours by going before 11am.

"Cycle lanes are not well suited to cargo bikes. It would be good to have wider cycle paths or two-lane cycle paths." – participant HairVisit

Subsidy scheme learning experiences

- Businesses that make lots of trips with smaller volumes, such as service providers, can make significant strides towards sustainability by using LEFVs. Especially when participants have an intrinsic motivation to cycle. It is good to focus on this group of service providers instead of just on traditional package deliverers.
- In order to keep the participation threshold low, a broad target group was deliberately chosen and a generous subsidy offered. This meant that results were quickly visible on the streets, acting as an example for other businesses. An acquisition subsidy of up to 50% is recommended for any follow-up schemes, so that participants are encouraged to make their own financial assessment for the adoption of cargo bikes (see also Chapter 3 for a cost comparison).

The following results have been achieved on the basis of recorded journeys and kilometres. The data was provided by eCarConnekt.

- The four participants' average ride length was 3.9km.
- During the monitoring period, the participants jointly made 1,211 journeys with the e-cargo bike, half of which criss-crossed each other.
- With the 4,753 kilometres cycled, 5,720 car/van kilometres were avoided and 1,150 kilograms of CO₂ were saved.
- On average, car routes were 20% longer than cycling routes.
- 30% of the 1,211 journeys took place in rush hour: 153 in the morning rush hour (07.00–09.00) and 215 in evening peak hours (16.00–18.00).
- HairVisit participant rode the furthest: an average of 26km per day, six days per week.



Participant HairVisit (Photo: Jean-Pierre Geusens)



Photo: Buro JP

6 UPSCALING WITH LEFVS

The LEFV fleets of Picnic and PostNL are growing fast, whilst other LEFV initiatives have remained small, or have found it impossible to get off the ground. Logistics service providers that want to grow their business with LEFVs need to answer the following question: What does a scalable business model with LEFVs look like? This question takes centre stage in this chapter. First we present the scalability model (6.1), then we apply it to practical cases (6.2) and finally we respond to the wishes of senders and receivers (6.3).

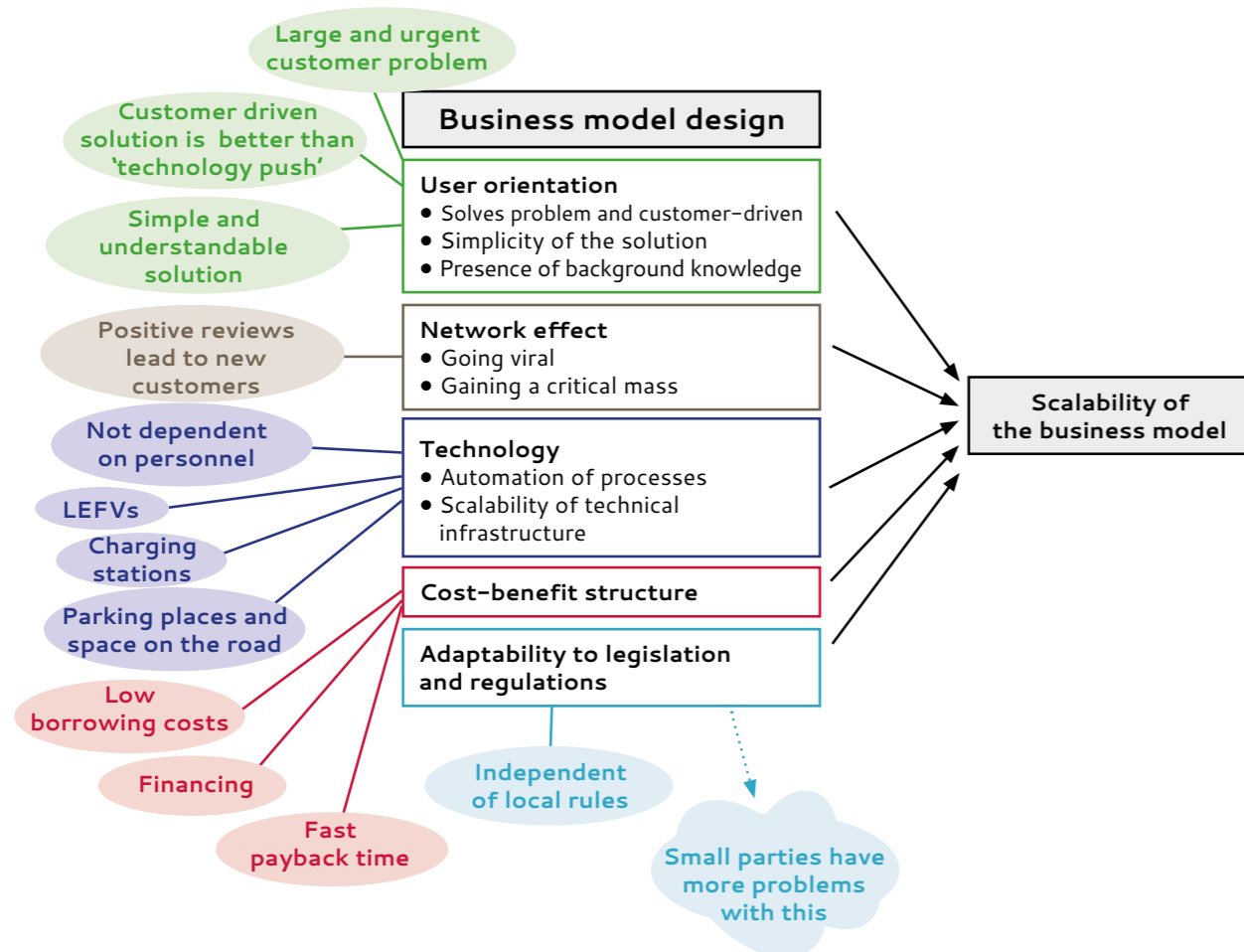
6.1 The scalability model

A literature study into the factors that are crucial for the scalability of business models led us to use the scalability model of Stampfl et al. (2013). The model is used

to test, predict and improve the scalability of business models with LEFVs. In this, five factors are central:

1. User orientation
2. Network effect
3. Technology
4. Cost-benefit structure
5. Adaptability to legislation and regulations.

By applying this model to different business cases with LEFVs (see 6.2), it is possible to identify barriers and improvements for the scalability of a business model.



Checklist	
User orientation How big and how urgent is the problem? Is the solution easy to understand and apply? Are there already existing customers?	Cost-benefit structure How big is the investment required and how quickly does it pay f Is the financing easy to find? Is the financing easy to find?
Network effect Can many people be reached quickly and can they give positive reviews about the solution?	Adaptability to legislation and regulations To what extent are there legal barriers that delay upscaling?
	Technology To what extent is the solution dependent on personnel? To what extent are production and delivery of physical materials necessary and scalable?

Figure 6.1: The scalability model with checklist for the assessment, prediction and improvement of the scalability of a business model. Based on Stampfl et al. (2013).

Explanation of the factors in the Scalability Model

User orientation

- **Problem solving:** if the solution resolves an 'urgent problem' experience by many people, scalability is more obvious;
- **Customer-driven:** a 'customer-driven' solution is more scalable than a 'technology push';
- **Simplicity and prior knowledge:** users must be able to quickly understand how the solution works. If use can be made of customers' previously acquired knowledge, scalability is greater than if the knowledge and perception of future users must first be changed via communication campaigns.

Network effect

- **Going viral and reaching a critical mass:** If within a short period many people make use a solution and if there are positive reviews, then more and more people will begin to use it. If a critical mass is then reached, a network effect is created and the diffusion continues automatically. This network effect is clearly visible with platform companies (intermediaries between supply and demand). To illustrate this point: companies like Google, Uber, Apple, Facebook and Alibaba have all followed the platform business model and all have grown to market values of many billions of dollars.

Technology

- **Automation of processes:** when a business is dependant on the deployment of (extra) staff, this limits the scalability. Automation of processes makes it possible to limit dependence on personnel. As an example, to increase scalability order intake and delivery could take place via automated systems. An online platform as a business model, such as that employed by Fietskoeriers.nl, where clients are linked via software to a multitude of independent couriers, contributes to the scaling up of activities with LEFVs.

- **Scalability of technical infrastructure:** if it is necessary to use physical resources, scarcity limits scalability. In contrast software, for example, is easily copiable and scalable. The use of LEFVs requires, amongst other things, the following physical means: vehicles (including maintenance), charging stations, roads and parking places.

Cost-benefit structure

- **Low costs and short payback time:** low fixed costs and the early realisation of revenues promote the scalability of a business model. These reduce the need for financing which, when not necessary, is less able to form a barrier to scaling up. A business model in which a large number of different investors provide funds instead of one company, is quickly scalable. Financial risk is spread across multiple investors. In a short time, Airbnb has grown into the largest hotel chain in the world, with virtually none of it's own assets, thanks to the linking of third-party assets – namely accommodation – to those searching for it.

Adaptability to legislation and regulations.

- If there are separate regulations that the company must adapt to for each municipality or country they operate in, scalability will be reduced. That is why it is important to be able to connect with general national or international regulations. The smaller the start-up, the more negative the impact of any legal barriers (Beck et al., 2005).

6.2 Applying the model in practice

To get answers to the question of how we can achieve scalable business models with LEFVs, the model was applied to several different cases. The scalability model checklist was developed for this purpose (see Figure 6.1). In a workshop on 25 January 2018 the scalability of City Hub's business model was tested by 20 professionals from the LEFV field (see 6.2.1). The model was applied to six other cases by a team of experts from Amsterdam and Rotterdam Universities of Applied Sciences, in order to arrive at generic insights (see 6.2.2.).

6.2.1. The case of City Hub

City Hub offers transshipment and storage space on the outskirts of cities and last-mile distribution with light electric freight vehicles (LEFVs) to businesses in the city centre. The idea is that prices per square metre in city centres are so expensive that the space in the shops themselves can be better used for sales, whilst a large proportion of the stock is held at the City Hub storage area on the outskirts of the city, where the price per square metre is lower. Table 6.1 presents the most important results, questions and advice from the 20 professionals, obtained from the workshop on the scalability of the City Hub business model.



Image 6.1: City Hub



Image 6.2: Workshop with professionals, januari 2018



Image 6.3: CityServiceBike for Stedin

Tabel 6.1: Application of the scalability model upon City Hub

Scalability factors	Application of the scalability model upon City Hub
User orientation	<ul style="list-style-type: none"> In addition to shop owners, logistics service providers are interesting potential customers, although they may see City Hub as a competitor. The City Hub solution reduces inconvenience for shoppers. Communication on this is desirable, because shop owners may not be aware that many of their customers prefer to stay away during the deliveries. The concept of City Hub can be difficult to understand. Possible questions are: how long does it take for a product from City Hub stock to become available? Which articles should be stored in the shop and which ones at the City Hub storage location?
Network effect	<ul style="list-style-type: none"> Approach retail and trade associations to bring the concept to their attention. When selecting a storage location, pay attention both to the place where the customer is located and to where the logistics operators come from.
Technology	<ul style="list-style-type: none"> The systems of City Hub and the Customer that, for example, inform about current stock levels or new orders, must be linked to each other. Otherwise the customer will not be prepared to make use the service, or will be less prepared. Because different systems and data requirements exist in different sectors (fashion, hospitality, etc), it is desirable to look for customers within a sector. This prevents too many different requirements being imposed on the technical infrastructure.
Cost-benefit structure	<ul style="list-style-type: none"> The benefits to customers of City Hub must be made clear, as well as the savings of the carriers. These carriers no longer need to enter the city centre for City Hub customers.
Adaptability to legislation and regulations.	<ul style="list-style-type: none"> Future parking policy is uncertain. Take account of access window times for restricted areas and check whether it is possible to obtain exemptions for LEFVs. Ensure good contacts with municipalities.

6.2.2 Generic insights after application to multiple cases

The researchers also applied the scalability model to seven other cases from the field of LEFVs. These were: Bubble Post, Het Lokaal, CityServiceBike, Cyclone, Deudekom, E-Bakkie and PostNL. This led to the following generalised insights into the scalability of a business model:

User orientation

Almost all of the LEFV cases do not seem to have an *urgent and large customer problem*. This is a relevant bottleneck if a business model needs to be scaled up quickly. Take the company CityServiceBike, which offers LEFVs to service and installation engineers. There will be fitters who can use a LEFV for transport in the busy city centre, however technicians often already have a delivery van that offers other advantages. When the number of city centre jobs rises, the urgency of agile transport increases. We see this in technical businesses that have to install a large number of smart meters in cities in a short period of time (Stedin, 2018).

Certain companies want to connect with 'sustainable transport' as part of their business objectives. An example is Het Lokaal in Amersfoort (see case page 48), which supplies fresh local produce and also links its transport choice to this sustainable objective. Other

businesses seem to want to use innovative and striking LEFVs as a way to catch the eye of customers, with a view to marketing. In both cases, however, there is no real question of an urgent or major problem.

Network effect

Consumers often do not seem to care much about the way their package is delivered, as long as the time and cost are suitable. Customers of a repair engineer are keen for malfunctions to be fixed in a timely manner. Student research in Rotterdam shows that a large number of hospitality businesses see added value when a LEFV drives onto the sidewalk next to their terrace instead of a polluting vehicle. But even in cases where businesses are positive about transport by LEFVs, the network effect seems low. Because of this, fast upscaling is not encouraged.

Technology

The business model of new start-ups that use LEFVs is sometimes insufficiently scalable because business clients do not want to deal with the hassle of *integrating a new system* with a new logistics party specifically for transport to the city centre. The speed with which LEFVs are produced and finding drivers can both be bottlenecks. The use of correct load carriers is also important to prevent extra handling and transport loss. In the case of refrigerated products, cooling technology is also required.

Low costs and short payback period

For small and medium-sized businesses the investment in LEFVs is relatively high, the payback period is long and certainty over whether it will be a good investment or not is low. Large scale financing is difficult for small parties to realise. To illustrate: City Hub joined forces with 2DOK and started a crowd-funding campaign to finance growth (City Hub, 2018).

If a LEFV user partners with a large financially strong party, this provides access to capital for new investments. After all, switching to LEFVs often involves the internal replacement of programmes of regular investments in other freight vehicles. Moreover, the investment risk reduces because of the certainty given by the presence of existing customers at the larger investing party. Examples are the partnerships between Fietskoeriers.nl and DHL and between Cyclone, Tielbeke and Wadinko.

A point of attention in the scalability of a LEFV-based business model is that the viability of the business case must be clearly demonstrated in comparison with the traditional mode of transport, in order to convince transporters and shippers (the senders) and their customers (the recipients) (see 6.3)

Adaptability to legislation and regulations

For the time being in the Netherlands, there are few legal barriers to the use of LEFVs. However, traffic regulations are not yet specifically aimed at LEFVs and will possibly be tightened up in the future. This brings uncertainty about the continuity of the (current) benefits of LEFVs, such as being able to use cycling infrastructure and parking on the sidewalk. Despite European vehicle admission rules (type approval), we see differences in admission policies for certain vehicles in traffic by country or city. The electric Stint is allowed on the road in the Netherlands as a special moped and in Belgium as a "voortbewegingstoestel" (forward-motion vehicle) (see appendix C). This permission does not (yet) apply in other countries. Parties wanting to scale up their business model with this vehicle outside the Netherlands and Belgium therefore face legal barriers.

6.3 Wishes of senders and receivers

Who is the user of a business model with LEFVs? This is not always clear due to the number of stakeholders in the logistics chain. The use of a LEFV is a service for the transport between the sender and the recipient of goods. It is therefore important to pay attention to the wishes of the sender and the recipient.

In figure 6.2 we illustrate the complexity of the logistics business model with the following example: Wehkamp (a shipper), DHL and Fietskoeriers.nl (transporters) and the consumer who orders online (recipient). In 2017 Wehkamp started delivery by LEFV, a choice they outlined in a press release (Wehkamp, 2017). Consumers see the bicycle courier at their doors, but DHL is the direct user of the services of Fietskoeriers.nl.

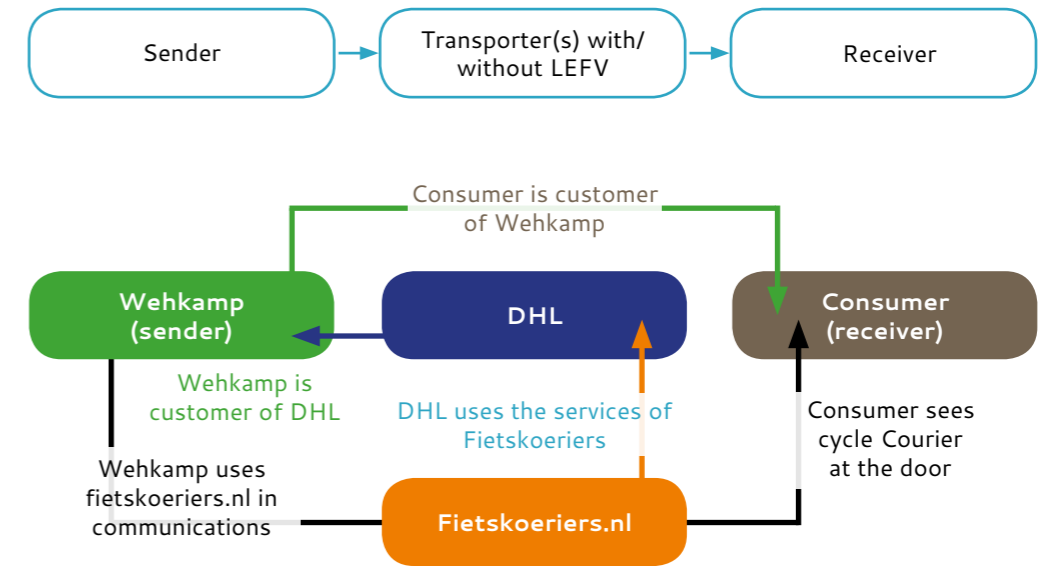


Figure 6.2: The relationship between the sender, carriers and receiver



Image 6.4: Fietskoeriers.nl ride for Wehkamp

'Wehkamp is opting for the bicycle to be able to continue to meet the wishes of our customers and to keep cities accessible. As a Dutch company, delivery by bike fits well with us. After all, the Netherlands really is a cycling country. In this way we can physically reach the customer even better.'
 Sander Bolmer, director warehousing & distribution of Wehkamp (Wehkamp, 2017)

Coolblue launches: CoolblueFietst (Coolblue cycles). Why? Because we know it will make our customers very happy. You no longer have to be home all day to wait for your package. We are going to deliver within a one hour period. A cheerful Coolblue-er will now bring you your package. And CoolblueFietst is of course very green.' (Coolblue, 2018).

6.3.1 Wishes of the sender

AUAS students were commissioned by E-Bakkie to study the wishes of twenty wholesalers of food and consumer products. The following aspects were identified as important when choosing a carrier:

1. The ability to accept urgent and additional orders;
2. The capacity to deliver orders quickly;
3. Friendly delivery personnel;
4. Timely communication of all relevant information;
5. Uniforms;
6. The capacity to deliver large orders;
7. To promote an environmentally conscious image;
8. Contribution to the reduction of environmental impact.

The study also showed that wholesalers who currently deliver their own deliveries are willing to pay a higher price for the delivery service than wholesalers who already outsource the transport to a logistics service provider. One reason for this may be that wholesalers currently carrying out their own deliveries also deliver more added value and are therefore willing to pay more for a better outsourced service.

6.3.2 Wishes of receivers

In a student study into the role of recipients on behalf of The Student Hotel, eleven members of the Knowledge Mile Business Investment Zone (BIZ) in Amsterdam were asked about the criteria of delivery and the desirability of different alternatives with LEFVs. The respondents were hotels, a school, a lunch cafe, a bank, a consultancy firm, a cultural institution, a resident and the municipality. The proposed alternatives were:

1. The current situation, in which only 6 of the > 130 suppliers of the participants deliver with LEFVs.
2. More suppliers use LEFVs. The BIZ starts a campaign to promote their use.
3. Goods are delivered to a hub in the BIZ and then delivered by LEFV. The BIZ is the customer of the hub.
4. Goods are delivered to a hub on the outskirts of the city and then delivered with electric transport. The recipient is a customer of the hub and can also purchase storage space.
5. Recipients use LEFVs (their own LEFVs or via a sharing concept) to collect goods themselves.

Each participant evaluated the alternatives on the basis of a set of self-chosen criteria such as: financial results, accessibility, noise nuisance, quality of delivery and staff satisfaction. The evaluation was carried out using the online MAMCA tool for Multi-Actor-Multi-Criteria Analyses (Macharis et al., 2009, Kim et al., 2017). A more detailed explanation of the alternatives and an overview of the criteria and the mutual weighting are included in Appendix E. Figure 6.3.1 presents the results of the MAMCA with the actors on the bottom axis and with the five alternatives shown as coloured lines. The higher a line, the more valued that alternative was by the actors.



Figure 6.5: E-Bakkie delivers fresh fish from Jan van As

The study showed that there is no single outstanding proposed solution, for which support among the participants of the Knowledge Mile is shared. The most important factors for this are:

1. Priorities lie elsewhere (this was already apparent when approaching the target group).

2. Businesses expect the scenarios to have a negative impact on the financial results of their company.
3. Businesses are of the opinion that responsibility for change lies mainly with the supplier.
4. Businesses feel certainty about the current situation.

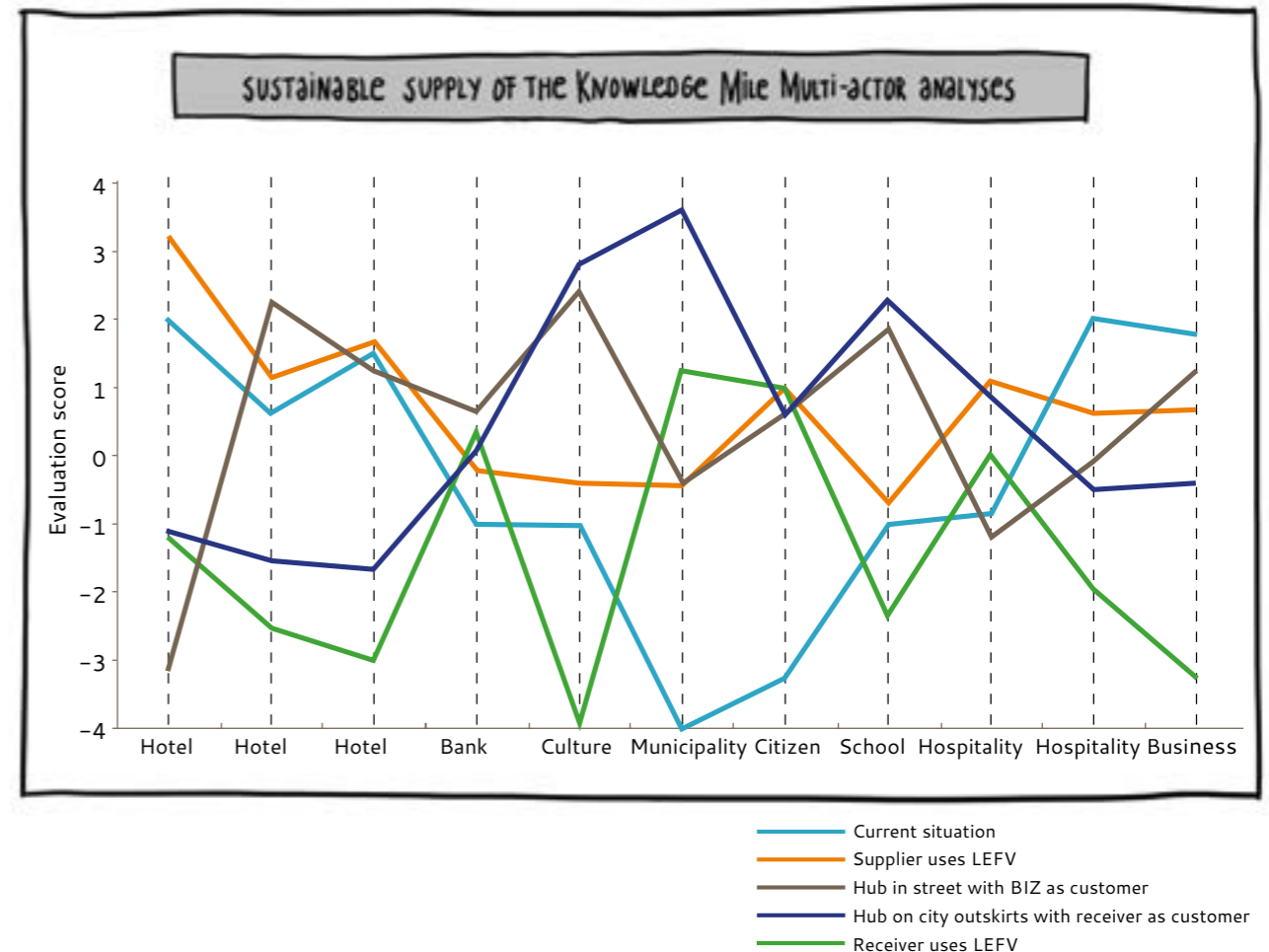


Figure 6.3.1: MAMCA outcomes. An example: The 'Hub on city outskirts with receiver as customer' solution is valued positively by the cultural institution, municipality and school, and negatively valued by the three hotels.

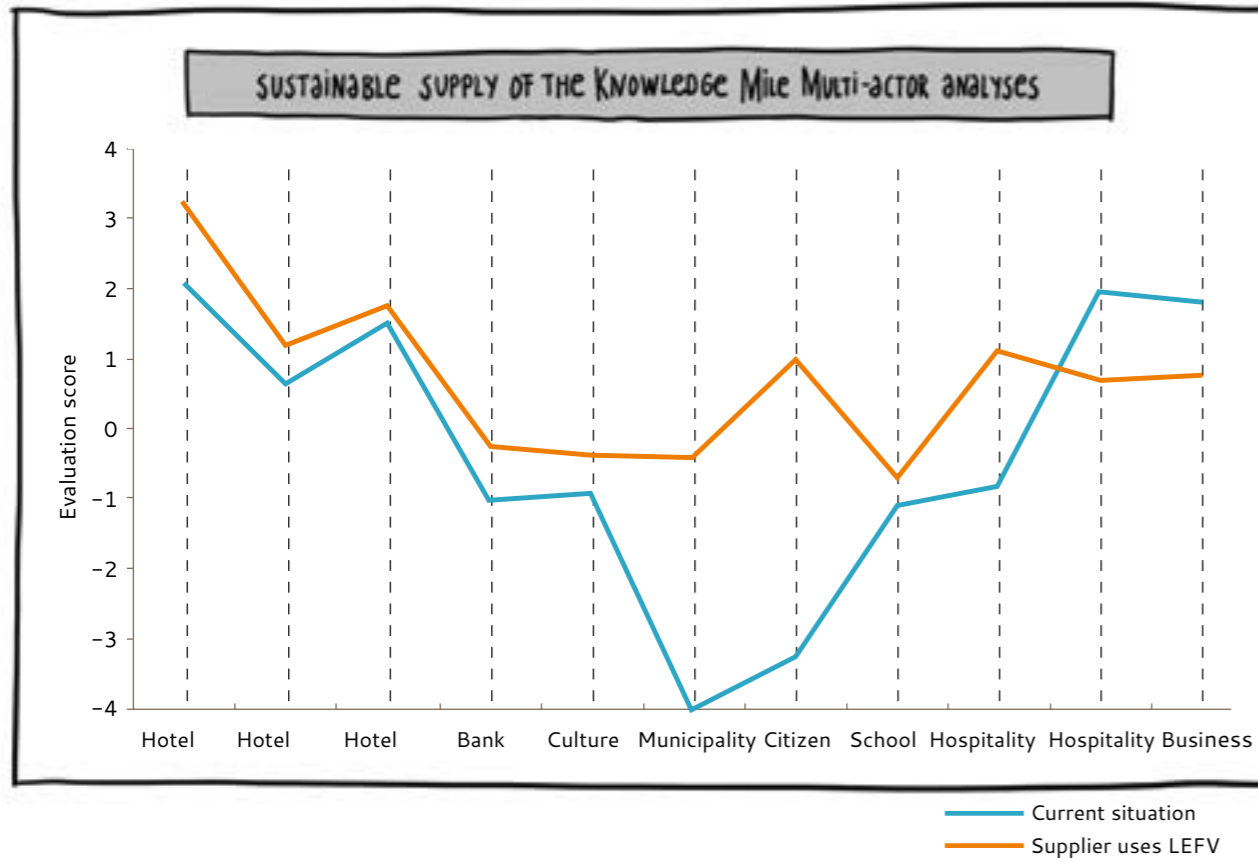


Figure 6.3.2: The 'supplier uses LEFVs' solution scores better than the current situation for 9 of the 11 actors

What is a Business Investment Zone (BIZ)?

'A Business Investment Zone (BIZ) is a defined area in which businesses invest time and money together to make their shopping street or business park safer and more attractive. The aim is to improve the competitive position and increase sales of all businesses involved. This is done on the basis of a jointly formulated activity plan for which there is a large support base. Businesses who set up a BIZ together can easily arrange the financing of their activities themselves. In practice, the municipality tends to pay an annual contribution to the BIZ and that the businesses (the BIZ board) will implement the activity plan with the proceeds.' (Griffioen, 2016)

Figure 6.3.2 illustrates the 'supplier deploys LEFVs' solution (the orange line). From this it is clear that with the exception of two actors, the solution is valued (slightly) more positively than the current situation. If the Student Hotel wants to work on this topic together with the Knowledge Mile BIZ, encouragement of this solution is recommended through a campaign consisting of:

- *Information:* set up information meetings and communication messages to make suppliers and BIZ members aware of the opportunities offered by LEFVs;
- *Encouragement:* encouraging suppliers to consider using LEFVs, through BIZ members who are their clients;
- *Co-ordination:* connecting those who may want to use LEFVs with LEFV suppliers in the area;
- *Gaining experience through experimentation:* setting a test period in which transport takes place as much as possible without emissions, and monitoring the results. In this way, the BIZ itself gains extra recognition as a driver of sustainability.

However, as already described in 6.1 in 'user orientation', it is not possible to scale up quickly if a communication campaign is needed first to change user perceptions.

6.4 Conclusion

Based on scalability factors and the wishes of senders and receivers, the following conclusions can be drawn:

A scalable business model:

- offers a solution to an urgent problem for a large group of people;
- offers a solution that is easy to understand;
- quickly reaches many people who talk positively about the solution;
- is customer-driven (not a technology push);
- is not, or is only to a limited extent, dependent on personnel when the business grows;
- is not, or is only to a limited extent, dependent on the production and delivery of physical materials and new infrastructure;
- is not, or is only to a limited extent, dependent on funding (low lending costs and fast payback time);
- has no legislative or regulative barriers.

A business model with LEFVs is scalable when the following factors are present:	A business model with LEFV is not scalable, or is only scalable to a limited extent when the following factors are present:
<ul style="list-style-type: none"> • There is transport with characteristics that are suitable for LEFVs such as: small shipments, short distances between stops and time-critical deliveries where use of LEFVs leads to internal process optimisation and higher delivery reliability (cost advantages in working hours, service level and vehicle costs); • There are delivery areas with low-traffic areas or access restrictions; • There is a logistics concept based on LEFVs where a social, distinctive or innovative image is part of the proposition (clean, quiet, friendly and cheerful, socially disadvantaged personnel with 'distance to the labour market'). 	<ul style="list-style-type: none"> • Technology push: beginning by looking for an application for LEFVs instead of starting with customer demand; • Customers who need to be mobilised to use the solution (insufficient urgency); • Uncertainty for, or adjustments to be made by the customer when using LEFVs; • Dependence on the expansion of vehicles in combination with limited investment capital.



Experiment – CityServiceBike: service logistics in Utrecht

CityServiceBike, initiated by Elza van Genderen, offers a transfer location where service and installation technicians can park their delivery vans and switch to an electric cargo bike. The concept was tested between May and August 2017 in Utrecht. Initially Coca-Cola, Douwe Egberts and KPN participated in the pilot. Later, after the evaluation period, four more parties joined, including Feenstra and Stedin, and the pilot was extended. The aim of the pilot was to test whether the concept creates value for the service logistics sector in terms of efficiency, image, health and job satisfaction of employees. In addition, the location (Vaartsche Rijn, a parking garage on the southern edge of the city centre) and products (bicycles, locks) were evaluated to see if they met certain requirements. Dealer Juizz supplied Urban Arrow cargo bikes and Mobilock delivered the box lock with an accompanying app.



CityServiceBike



CityServiceBike

Plan

The evaluation consisted of an internship study by an AUAS student, two workshops (logistics concept and business model), an online survey and telephone interview for the pilot participants, and joint evaluation of the data collected via the Mobilock app.

"I like that I can participate in this pilot. I have not worked much with bikes, but the time I spend working with a cargo bike is fun. I also notice that I have to get used to, for example, picking up the bike computer from the handlebars, locking the bike and closing the lid properly. It is also fun to ride."

Pilot participant from KPN

Results

The extent to which pilot participants have used CityServiceBike is very different. This is mainly due to how service visits are planned. When a technician has the opportunity to visit several city centre-based customers in succession, CityServiceBike can help them to save time. Mechanics indicate that they arrive sooner by bike and that they can save 15 to 20 minutes per customer because there is no need to search for a parking space. The exemption granted for pedestrian areas was seen as positive, but at busy times with a lot of shoppers in the centre, mechanics preferred to take a different route or to walk with the bike.

The media attention, customer reactions and involvement of their marketing departments all confirm the positive contribution CityServiceBike makes to the image of companies using the service. The mechanics themselves were all satisfied with the bikes and about cycling. The location also met requirements. To increase the applicability of CityServiceBike, several hub locations in the city were discussed. 'Keyless unlocking and sharing of bicycles' was seen as a good thing. This technology can be extended and improved by connecting the app to box lock, the bike stand and the battery. For example, the tailgate could open automatically when the stand is folded out. The reliability of such a system (the connection of lock and app) is of great importance for the success of the bike share concept.

The most important recommendation is that businesses adapt their planning to make use of CityServiceBike. This means that customer visits in the city centre should be clustered together. When attracting new users, it is advisable to mention CityServiceBike as a condition of service, or to at least advise them that it will be frequently used, so that cargo bikes can be used as much as possible. Potential users are advised to prepare current and future employees for the deployment of more cargo bikes and to encourage them, for example with rewards, during use.

Following the pilot, it turned out that several participants experienced insufficient urgency to implement the CityServiceBike concept quickly and on a large scale. Other participants have started to view the bicycle as a practical and efficient solution for transport in the city and have made the necessary adjustments to their procedures. For example, from April 2018, six Stedin mechanics will use CityServiceBike to access the centre of Utrecht every day to install smart meters. Coca-Cola is also still visiting its customers in Utrecht as much as possible by bicycle.



Photo: E-Bakkie

7 AND NOW ONWARDS!

7.1 An alternative to the delivery van

More and more delivery vans in the city

There are almost one million delivery vans driving around the Netherlands, a large proportion of which are in cities. The number of delivery vans in city logistics is increasing due to growth in the hotel and catering industry, online purchases by consumers and businesses, construction and renovation projects and changes in customer demand, with shipments becoming smaller and more time-critical. This growth in freight traffic has negative consequences for the livability of cities and residential areas. The productivity of city logistics is also encountering problems: loss of time due to congestion and searching for loading and unloading spaces, a low load factor and inability to deliver reliably to customers. In the meantime, the

objective of making city logistics emission-free in 2025 becomes more and more tangible; some cities have even chosen to ban diesel vehicles. Light electric freight vehicles (LEFVs) can contribute to a solution for different city logistics flows, because they are quiet, agile, emission-free and take up less space.

Light electric vehicles as an alternative

There are many large companies that deliver a share of their local deliveries with LEFVs, such as CoolBlue, Wehkamp and construction wholesaler Stiho. Larger logistics service providers such as PostNL, UPS, DPD and DHL operate networks in Europe with LEFVs, sometimes even with self-driving units. Food delivery services Foodora, Deliveroo and Uber Eats have all grown further with the use of (e-)bike delivery personnel. There are also new parties, from small and

medium-sized enterprises (SMEs), that use LEFVs to deliver goods, such as City Hub, Fietskoeriers.nl, Picnic, E-Bakkie and Byondo. Fietskoeriers.nl is a Dutch network of local bike courier businesses who now work together via a nationwide digital platform. More and more businesses are also using LEFVs to provide services in the field of care, entertainment or maintenance, partly thanks to local purchase subsidies.

LEFV-LOGIC project

The LEFV-LOGIC project carried out research into the use of LEFVs in city logistics. LEFV-LOGIC started in 2016 from the needs of SME logistics service providers to use LEFVs cost-effectively. During this project, the Universities of Applied Sciences of Amsterdam, Rotterdam and of Arnhem and Nijmegen worked together with logistics service providers, shippers, vehicle providers, network organisations, knowledge institutions and municipalities. Together, through workshops, practical research and experiments, they have developed new knowledge about logistics concepts and business models for the use of LEFVs.

The project partners wanted to contribute to objectives of organising city logistics more efficiently, quietly and cleanly, by using LEFVs. At the start of the project it was not known for which city logistics flows the use of LEFVs could be suitable and to which technical requirements LEFVs had to comply. Existing processes in the city logistics chain are geared to the use of traditional delivery and freight vehicles. What does the use of LEFVs mean then, for business operations?

Practical cases in city logistics have shown that when it comes to journeys that are not exclusively inner-city, many points of attention in the area of operational management with LEFVs are raised. Operational management with LEFVs requires good hub locations in the distribution network, robust processes, adapted ICT, enthusiastic and collaborative employees and good organisation. Different requirements apply to each flow of goods, such as a return flow or refrigerated transport for food, as a result of which the transfer can look different. In addition to

a well-developed logistics concept, a suitable vehicle is of course also required; sometimes that is a LEFV, sometimes that is a delivery van. The use of suitable information systems makes it possible, in the presence of different vehicles, to always use the optimal vehicle for a specific route.

7.2 Promising sectors for LEFVs

Promising sectors for the use of LEFVs include time-critical deliveries, packages and post, and smaller food, construction and service related consignments. Each product-market combination has its own requirements and characteristics. In these sectors, national and international logistics service providers are often dominant. Their customers prefer universal, national-scale logistics services and ICT connections. SMEs can work as subcontractors within the networks of the big players. Promising sectors that are still under development are local-for-local retail platforms, new postal services that are developed following the amendment of the Postal Act in the Netherlands, local food deliveries (for example to consumers, hospitality and specialty stores) and online food products.

Researchers estimate that LEFVs are an efficient alternative for 10 to 15 percent of the total number of delivery van trips in the city (see Table 7.1). In cities like Amsterdam and Rotterdam this would involve 3,000 to 4,000 LEFVs, mostly bicycle and moped-like vehicles. The use of compact distribution vehicles is still a relatively costly alternative compared the small electric delivery vans, which have a larger payload, higher maximum speed and larger range. The potential of LEFVs becomes higher when municipalities impose more space restrictions that limit the access of delivery vans.

7.3 Practical experiences

Practical experience shows that the LEFVs are most suitable for small, light shipments, high network density, time-critical shipments and segments that offer opportunities for growth and innovation in city logistics. The project partners have carried out practical research and experiments, from which the most important lessons are listed on page 100.

Table 7.1: The potential of LEFVs as a percentage of the number of delivery van trips in cities

Segment	Percentage of delivery vans in cities	Potential deployment of LEFVs in cities	Potential	Potential for LEFVs of the total number of delivery van trips in cities
Food	25%	15%	<ul style="list-style-type: none"> Smaller shipments, back orders, orders for additional items or return order corrections to hospitality and catering businesses Local-for-local delivery (fresh) Groceries home delivery (limited, considering the growth of the market and the resulting loading capacity) 	4,5%
Service	25%	20%	<ul style="list-style-type: none"> Conditional upon the adaptation of logistics concepts and clustering of journeys Potential: independent entrepreneurs delivering within limited geographical areas 	4,0%
Construction	25%	10%	<ul style="list-style-type: none"> Conditional upon the adaptation of logistics concepts Back orders, orders for additional items or return order corrections 	2,5%
Packages and post	10%	20%	<ul style="list-style-type: none"> For extremely busy areas and in the vicinity of transshipment points Just-in-time deliveries 	2,0%
Retail non-food	5%	10%	<ul style="list-style-type: none"> Deliveries come from large distances away and are often heavy or large Little support among retailers for delivery via hubs and LEFVs Potential: new local-for-local concepts (from store to customer at home) 	0,3%
Private	10%	Outside the scope of this research		
Total	100%			10 to 15%

What were the lessons from the practical experiments and business cases?

- LEFVs are suitable for a wide range of applications, from independent entrepreneurs with a briefcase to logistics service providers who transport roll containers.
- The costs of the LEFVs are up to 20 to 30 percent cheaper than those of the traditional delivery van
- The use of LEFVs for short journeys in (inner) cities yields time savings due to the presence of cycle paths and one-way roads. The surveys show that bicycle routes in cities are on average 15 to 20 percent shorter than car routes. With long journeys on roads where a higher speed can be driven, delivery vans are faster.
- One advantage of the LEFV is that there is no need to search for a parking space for long. Usually it is possible to park in front of the receiver's door.
- LEFVs have various advantages for businesses. Efficiency in time, cost reduction, distinctive image and corporate social responsibility were mentioned.
- In order to deploy LEFVs efficiently, adjustments must be made in how logistics are planned, for example by clustering orders (even more) geographically and using planning software with routes suitable for LEFVs. This requires sufficient shipment density, or short distances between the stops.
- LEFVs' position in traffic, including the rules for the use of cycle lanes and pedestrian areas, is not unambiguous and requires further investigation.
- Experimenting with LEFVs leads to greater awareness, knowledge and behavioural change.
- The driving of a LEFV takes some time getting used to in the beginning, but is perceived as simple.
- Drivers of LEFVs receive positive reactions from customers and the general public. More pleasant than the grumbles that truck drivers often get when they are unloading.
- In contrast to electric delivery vans, many LEFVs, particularly those that are bicycle-like, have the advantage that the range is less dependent on interim charging.
- With limited use of LEFVs, businesses do not experience any barriers when charging. With an expansion of electric vehicles in the fleet, smart charging offers a solution to balance out any peaks and troughs in energy demand.

7.3 Points for attention

What are the points of attention for LEFVs in city logistics?

A city logistics solution such as transport with LEFVs requires adaptations to:

- Transport technology
- Logistic concepts
- Policy
- Personnel

A. Vehicle Technology

The vehicle technology is not yet mature – it is still relatively young. Moreover, LEFVs are not yet produced in large enough numbers with standard dimensions, meaning the production costs remain high and the delivery time is long. Relevant points of attention for the further development of the technology are:

Electric cargo bike

- Bicycle-like LEFVs have a maximum 350 kg net loading capacity. More weight than this can be too heavy for the rider and endanger road safety. For heavier transport by bicycle-like LEFVs, drive mechanisms must be further developed.
- LEFVs with two wheels fit better into the width of cycle lanes and maintain the feeling of cycling: you can ride and stay agile, but you can also walk next to the bike. The place on the road of cargo bicycles with more than two wheels is uncertain. The debate about who is allowed to ride in cycle lanes and who can park on the pavement is still in full swing.
- Active movement can be experienced by the rider as an advantage, but also as a disadvantage. Aging among drivers in the Netherlands is high, as is absenteeism. Use of bicycle-like LEFVs requires targeted recruitment of staff who like to cycle.

Electric moped

- These LEFVs are suitable for heavier products for which the cargo bike and its rider do not have enough capacity. They are agile and still realise many of the general benefits of the LEFV, such as easy parking and the use of shorter routes.
- The disadvantage of the vehicles is that they depend on the available range. After all, the driver can not themselves pedal. The range, depending on the battery and energy consumption, varies in practice from 20 to 100 km.
- The position of these vehicles on the road is uncertain. In the Netherlands there is still discussion about whether mopeds and 'special mopeds' should be allowed to ride in cycle lanes, and also whether they can park on the sidewalk. If the vehicles have to go to the road, it is important that their speed does not differ too much from the maximum speed of the rest of the traffic. For the time being, this is 50 kilometres per hour on most roads in cities.

Compact electric distribution vehicle

- The compact distribution vehicle (vehicle classifications L6e and L7e) fill the space between the current delivery van and the cargo mopeds/bikes. The vehicle has a higher payload than a cargo bike or moped and also offers a protected environment for the driver. The latter also offers comfort and protection for the driver in bad weather conditions and at higher speeds.
- Current LEFVs are usually adapted from vehicles designed for other applications, such as park maintenance or for transporting children. As a result, the transport of, for example, standard roll containers is generally not included in the designs.
- The compact distribution vehicle looks more attractive on city streets than the delivery van, because it is narrower and smaller. The electric delivery van is indeed becoming a competitor to the compact distribution vehicle because of factors such as price, speed, payload and life-cycle costs. In order to maintain the benefits felt by LEFVs, it is important to be able to deliver outside window times and to use one-way roads against the flow of traffic.

B. Logistics Concepts

Practical research has shown that city logistics with LEFVs requires good locations for hubs in the distribution network, robust processes, cooperation between customers, logistics service providers and suppliers, good insight into the costs involved, modern ICT and good organisation. LEFVs lend themselves to logistical flows with the following characteristics:

- Time-critical shipments
- Those with small numbers of shipments per trip
- Short distances between stops
- Those in busy areas where the speed of cars is relatively low
- Areas with strict vehicle restrictions or privileges for LEFVs

What is needed in order to successfully deploy LEFVs for city logistics?

- A LEFV is usually a solution alongside other solutions. A mixed fleet guarantees flexibility and offers certainty that customer demand can be met. Not all shipments lend themselves to the profitable use of a LEFV.
- Planning and control systems must be able to distinguish between the different loading capacities of the available vehicles: which consignments should go in which vehicle? And which routes are ideal for which vehicle?
- Transshipment points must be located close to or inside the city. The further the distance to transshipment points, the less suitable LEFVs become. For trips with long initial distances (more than 5km to the first stop) and long journeys (more than 30 km), the LEFV is often not an appropriate option. Due to the relatively large number of transshipment points, it is essential that facilities at the hubs in the distribution network, such as receiving and storing goods, loading facilities and parking facilities, are shared at an affordable cost. Affordable facilities are not available in all cities. The development of

standards for containerisation reduces the amount of activity necessary at transshipment points, meaning lower costs. It is therefore wise to follow and contribute to developments in this area.

C. Policy

When discussing local and national policy for LEFVs, the following points are important:

- The integration of the vehicles into the urban traffic networks. Examples include the design of comfortable and safe routes, such as bicycle streets, and the creation of loading and unloading areas.
- Facilitating transshipment points.
- Harmonisation of rules at national level and realisation of ambitions, so that businesses who want to use LEFVs know what they are investing in.

D. Personnel

The current driver shortage encourages operators to search for other solutions, such as LEFVs for which no driving license is required. The use of LEFVs does not require personnel with as many qualifications as for, say, delivery vans. There is also the possibility of employing socially disadvantaged people, with a 'distance on the labour market'. However, at present there is a real shortage in large cities.

7.4 Recommendations

How can SMEs earn money with LEFVs?

There is still no great urgency among shippers or logistics service providers to use LEFVs for city logistics. Their expectation is not that local authorities will introduce widespread vehicle restrictions. Moreover, the electric delivery van is also a good alternative, which is in line with existing logistics concepts. The use of LEFVs is still a niche market that focuses on low costs or a conscious image.

For SMEs who want to use LEFVs successfully, it is important to opt for market segments with suitable logistic characteristics, such as small and light shipments, high network density, time-critical shipments and sufficient opportunities for growth and innovation.

These characteristics are often present in consignments in local-for-local niche markets or in a part of the supply chain of a shipper who also uses other vehicles in addition to LEFVs. For these shipments, LEFVs allow internal processes to be optimised and higher delivery reliability (punctuality, rush and return deliveries) to be achieved. This is made possible by lower vehicle costs, shorter working hours, the possibility to increase the service level and access to neighborhoods with low-traffic areas or restrictions

for freight traffic. In this segment it is all about operational excellence. More often than not, LEFV providers will need to link up with a larger logistics service provider or a joint venture.

In addition, there are market segments for logistics or services with LEFVs where a social, distinctive or innovative image is part of the business proposition, for example clean, quiet, friendly, active, just-on-time or the deployment of socially disadvantaged personnel with a 'distance to the labour market'.

As an SME, why cooperate with Universities of Applied Sciences on practical research?

Jorrit Kreek: "Urban Arrow makes electric transport bicycles via a so-called open source model. This means that we are open to the ideas of professionals, students and fans, with which we can make our products even better. By participating as a partner in the LEFV-LOGIC project, we not only got the chance to test our concepts at the various participating universities but also to share them with other companies that are active within the domain of the Smart Urban Mobility. Only if you can share can you also multiply."



Image 7.1: Fietskoeriers.nl

Recommendations for scalable business models for SMEs

Based on the identified barriers and opportunities, the following recommendations have been drawn up to meet the conditions of a scalable business model using LEFVs.

LEFV users from SMEs: use LEFVs for:

1. transport in the city of shipments that require fast and punctual delivery, such as food, medicines, luggage, gifts, back orders, orders for additional items or order corrections in which the deliver must return following a first delivery to catering and construction sites (for example outside window times), local-for-local retail applications and package deliveries on-demand. The ability to take rush orders and additional orders and deliver them quickly and reliably is an important element of the proposition of a successful business model with LEFVs in freight logistics.
2. transport of deliveries where it takes a lot of time to find a suitable parking space with a (delivery) van, for example in the case of service providers in city centres where personnel need to work at customers' premises for long periods of time.
3. applications in which LEFVs provide a distinctive value and / or job satisfaction.

For a scalable business model, cooperate with other LEFV users (for example via a platform that brings together demand) or with a large party for better market access, for financing, for transshipment points and to overcome customer uncertainty (and resistance to change).

LEFV suppliers from SMEs: when developing load carriers and choosing vehicle dimensions, ensure that you adhere to any standards that are developed by larger companies such as DHL. The same is also true for refrigeration-freezing concepts. Also focus on the many independent entrepreneurs who deal with small amounts of material, for whom LEFVs can offer a distinctive value compared to competitors ('the artist or hairdresser who comes to you on a LEFV') and for whom driving pleasure or convenience besides the costs plays an important role in their choice of vehicle. To future-proof the design of your LEFVs, closely follow developments in the field of autonomous driving and concepts from the sharing economy.

Government: environmental zones and low-traffic zones create urgency among suppliers, carriers and receivers to more quickly scale up the introduction of LEFVs. Make clear, concrete objectives with regard to emission-free city logistics, so that businesses know what to invest in. Consider logistics facilities as part of the necessary infrastructure for a liveable city. Experiment and stimulate knowledge gathering and behavioural change. Further speed restrictions on roads, the construction of bicycle streets and the realisation of loading and unloading places all offer opportunities for the integration of LEFVs into traffic to go smoothly.

Business associations (such as business investment zones): by setting stricter requirements on suppliers with regard to access to the area, smart and clean transport can be stimulated. This is the recommendation in situations in which members experience problems such as poor accessibility or inconvenience caused by traffic, or when they have joint ambitions in the field of sustainable transport.



Experiment 5 – LEFV-Battle: for students and teacher-researchers in Amsterdam

During the LEFV-Battle, two teams of students and lecturer-researchers from AUAS Faculty of Technology were given an assignment to deliver ten shipments with various light electric vehicles. They had access to an electric cargo bike from Urban Arrow, an electric cargo moped from Stint and a compact electric distribution vehicle from Goupil. The battle took place in Amsterdam, starting and ending at the premises of logistics service provider Deudekom in the Duivendrecht area south of the city. The battle involved a dozen different shipments, from a fruit basket and a Christmas tree to boxes with coffee and packs of toilet paper, as well as the reception locations made available by different organisations¹.

Plan

At the beginning of the day, the team members were informed about the assignment and they decided among themselves which teams would deliver which shipments and with which LEFV. They then determined the routes with RoutiGo's planning software. For RoutiGo, this was a great opportunity to test how well their software worked with smaller vehicles. Through a corresponding app, the team members received information about navigation and expected arrival times and were able to scan barcodes upon receipt. A team member stayed behind and took care of the customer service and the management of the delivery personnel. The vehicles and / or drivers were equipped with cameras to allow later analysis of team members' experiences in traffic.

Susanne Balm of the AUAS: *'We mimicked reality as closely as possible. The teams have to take account of window times, customer service gets a disgruntled customer on the phone and halfway through the battle a rush order is added, which must be scheduled with one of the delivery personnel. All options that can also occur in real life with deliveries.'*



The LEFV Battle started at logistics service provider Deudekom



The LEFV Battle Stint



Receipt of a Parcels delivery in central Amsterdam

'The battle was really fun. Finding the right route and spontaneously navigating through the city was challenging and fun. The fact that it was kind of a race made everything more exciting.'
Industrial Engineering Student

1. The following partners participated in the LEFV-Battle by making goods available, receiving them or by publicising the event: Fruitful Office, Praxis, Canon, Maas, CWS, BalkonBar, Het Werkmanspaleis, BedAffair, RGtects, Café Goos, Het Amstelhuis, Parcels, The Studenthotel, Bas met Dubbel A, evofenedex and Amsterdam Logistics.





Routigo planning software



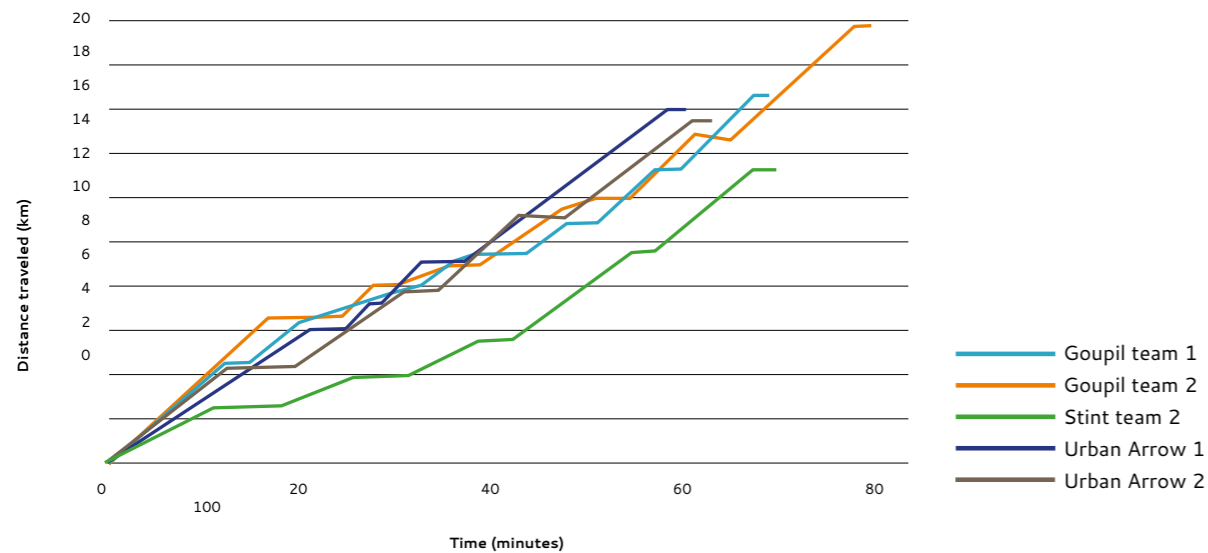
Dashcam image from the Goupil LEFV

Resultats

Winning team: team 1 won the first edition of the battle. The teams were judged on three aspects:

- **Vehicle efficiency:** Vehicle efficiency was calculated using the formula (vehicle length * width * height * driven km) of each of the three vehicles. In this way the aim was to drive around with as little empty space as possible.
- **Duration:** the total driving time of the three vehicles together for team 1 was 3:57 hours and for team 2 4:07 hours. Both teams were docked time because of various traffic violations that were made, including driving through a red light with a cargo bike, driving in the opposite direction to traffic with the Stint and driving on the cycle path with the Goupil.
- **Customer satisfaction:** both teams delivered all shipments successfully and within the set times.

Ride profiles of the vehicles in the LEFV battle



Ride profiles. Note: data is missing from the use of the Stint by team 1

Driving on the bike path with the Goupil turned out to gain a lot of time. Team 2 was able to save 15 minutes at the Munt, between the delivery address Parcls and RGTects. The stretch between Muntplein and the Amstel is a one-way street. Cars need to detour to the south via Raadhuisstraat and the 9 Straatjes area.



Using the bike lane: 3 min (Source Google Maps)



Using the road: 18 min (Source Google Maps)

Integration of education and research: students and teacher-researchers got to know each other during the battle in a fun and active way and worked together with the research team. The participating students were from six different programs: Logistics Management, Logistics Engineering, Architecture, Technical Business Operations Engineering and Industrial Engineering.

Exploring the practical context of LEFV research: the team members found it a valuable experience to drive the vehicles themselves in the city. There were clear advantages and disadvantages, with the most important points being the speed with regard to other road users and uncertainty about the position on the road. By involving more vehicles, actual deliveries, more delivery addresses and customer requests, future LEFV-battles can be made more complex and even more realistic.

Testing products and collecting practical data: The battle offers businesses a chance to demonstrate techniques and, in doing so, bring greater attention to them. In addition to vehicles, planning software and cameras, for example, battery testing systems could also be tested. Because vehicles are driven in different ways, a comparison could be made of the impact on different LEFVs of different circumstances.

Profiling of research at universities of applied sciences: the battle led to attention through an online publication, a professional publication, and an aftermovie. A total of 26 companies contributed to the battle, half of whom had not previously been involved in the LEFV-LOGIC study.

'It was fun to finally see things in practice and actually experience what I have been working on in theory.'
Student Logistics Engineering

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Appendix B: Participating organisations and students

The LEFV-LOGIC consortium was formed by seven organisations. In addition, around sixty organisations from the public and private sectors, as well as more than a hundred students, participated in the project. The Amsterdam University of Applied Sciences thanks all those involved for their contribution and cooperation. Below is an overview of the consortium partners, the participants and the student assignments. The LEFV-LOGIC study was co-funded by Regieorgaan SIA, part of the Nederlandse Organisatie voor Wetenschappelijk Onderzoek (Netherlands Organisation for Scientific Research)(NWO).

The LEFV-LOGIC Consortium

Amsterdam University of Applied Sciences (Coordinating Partner)

Walther Ploos van Amstel (Professor of City Logistics)
 Susanne Balm (Project Leader, Sustainable City Logistics)
 Robert van den Hoed (Professor of Energy and Innovation)
 Jos Warmerdam (Teacher-Researcher, Engineering)
 Kaspar Koolstra (Teacher-Researcher, Traffic Management)
 Martijn Altenburg (Teacher-Researcher, Logistics)
 Martin Boerema (Teacher-Researcher, Business Development)
 Niles Anand (Senior Teacher, Logistics)
 Ilana Visser (Project Assistant)
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Rotterdam University of Applied Sciences

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 Frank Rieck (Professor, Smart e-Mobility)
 Ron van Duin (Professor, Port and City Logistics)
 Ewoud Moolenburgh (Teacher-researcher Logistics RDM CoE)
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HAN University of Applied Sciences

Toin Peters (Project Manager, Automotive Research)

Fietsdiensten.nl

Jos Sluijsmans

LeanCargo Consultancy

Said Arslan

DOET

Freek Willems

Deudekom

Eric Sens

All participating organisations

Logistical service provider	2Wielkoeriers Bubble Post Chris brengt THUIS City Hub Deudekom Fietskoeriers.nl Leen Menken MSG Post & Koeriers MYPUP Parcls PostNL	Suppliers of mobility solutions	4Wieler Cargoroo CityServiceBike CycleSpark Easy Go Electric JUIZZ Maproloc MobiLock RoutiGo Stint Urban Mobility Urban Arrow
Suppliers of goods and services	APS Glass & Bar Supply Blanche Dael Coca-Cola Douwe Egberts Energiewacht HairVisit Het Lokaal Jules KPN Picnic PP-Events The Office Service The Student Hotel Vers bij u thuis	Advice and network organisations	DOET ANWB BonoTraffics Clean Mobility Center (CMC) Arnhem Connekt Ecorys European Cycle Logistics Federation Evofenedex Fietsdiensten.nl Knowledge Mile LeanCargo Consultancy Maastricht Bereikbaar RAI Vereniging TNO Transport en Logistiek Nederland Turn2Improve
Public organisations	Municipality of Amersfoort Municipality of Amsterdam Municipality of Delft Municipality of Rotterdam RVO.nl Municipality of Amsterdam Southern District	Universities of Applied Sciences	HAN University of Applied Sciences Rotterdam University of Applied Sciences Amsterdam University of Applied Sciences

Students from Amsterdam University of Applied Sciences

Assignment client / supervisor	Project / Title	Student name	Year
City Hub	Product-market combinations	Fabian Huguenin	2017/2018
Easy Go Electric	Market potential	Two students from Technical Business Administration	2016/2017
E-Bakkie	E-Bakkie value proposition: Requirements of wholesalers in Amsterdam	Thomas, Dennis Leicher	2017/2018
Energiewacht	Logistics Concept: Smart meters	Joeri, Chantal, Robbert Leemans, Joris Peters	2017/2018
Municipality of Amsterdam Southern District	Traffic in the Oude Pijp area of Amsterdam	Nick Heijdeman	2016/2017
Amsterdam University of Applied Sciences - Urban Technology	Organisation and monitoring of the LEFV-Battle	Nick Heijdeman, Stella de Koter, Joost van der Lee, Remco Timmermans	2017/2018
LEFV-LOGIC, Doet	Research about the influence of the deployment of e-cargo bikes on public space and traffic safety	Piraveen Thangarajah	2016/2017
LEFV-LOGIC, Cycle-Spark, 2Wielkoeriers, Het Lokaal	Light electric freight vehicles: The holy grail of B2B transport of Food	Gabrielle Veldhuijzen	2016/2017
LEFV-LOGIC, Vers bij u thuis	Research into the deployment of LEFV for meal box delivery	Anjo Witte	2016/2017
LEFV-LOGIC, Deudekom	Reinventing the concept of an Urban Consolidation Centre using Light Electric Freight Vehicles: The case of a coffee and vending machine supply company	Nick Heijdeman	2016/2017
LEFV-LOGIC, APS Supply	LEFVS in the flow from Wholesaler to Horeca	Klaas Roozendaal	2016/2017
LEFV-LOGIC, CityServiceBike	Research into the deployment of LEFVs for servicing and maintenance services	Islam Morse	2016/2017
LEFV-LOGIC, MSG Post & Koeriers	Research into the deployment of LEFVs for collecting and delivering mail in the city for the business market	Hari Nabi	2016/2017

Assignment client / supervisor	Project / Title	Student name	Year
LEFV-LOGIC, Parcls	Research into the deployment of LEFVs in the retail market	Ajoy Sarnakar	2016/2017
LEFV-LOGIC	Tool for comparison between LEFVs and delivery vans	A team of students from the Urban Logistics Minor	2016/2017
LEFV-LOGIC	Market potential of the EVEC-Model	Bart, Mark Otten	2017/2018
LEFV-LOGIC	Vehicle monitoring: The practical difference between the delivery van and the LEFV	Four students from the Urban Logistics minor	2017/2018
Maproloc	Vehicle monitoring: The practical difference between the delivery van and the LEFV	Student Engineering	2016/2017
The Student Hotel	The role of Business Investment Zones for the deployment of LEFVs	Stan Hoogteijling	2016/2017
Urban Arrow	Lock on the box	Hidde, Stefan, Nick, Tjebbe, Hidde Bajjards, Stefan Buitelaar, Marijn van Dijk, Tomas Duinkerken, Fahad al Janadi, Joey Moreau	2016/2017
Urban Arrow	Research into bike stands for cargo bikes	Luc de Braaf, Jim Draijer, Job, Hugo, Sjoerd van der Geest	2017/2018
Urban Arrow	Research into bike stands for cargo bikes	Jesper, Duco, Rik, Lex Meijer, Omar Nokrett	2017/2018
Urban Arrow	Containerisation and LEFVs	Duco, Lex Meijer, Omar Nokrett, Luc de Braaf	2017/2018
Urban Arrow	Research into loading mechanisms: pallet stacker	Roald Brouwer, Sten, Martijn Eeltink	2017/2018

Studenten Hogeschool Rotterdam

Assignment client / supervisor	Project / Title	Student name	Year
Breytner, DOET, City Hub, Stint Urban Mobility, Municipality of Rotterdam	Logistical and enviro-technical consequences using LEFVs in the context of the Zero Emission City Distribution 010 target	Toon, Vincent van Galen	2017/2018
Bubble Post	Research into which customers in Rotterdam are suitable for LEFV transport	Burcu Bayram, Adriana Buitenhuis, Ebru Gömeli, Luca van Leeuwen, Abdullah Yiğit	2017/2018
City Hub	Research into which customers in Rotterdam are suitable for LEFV transport	Pieter Bremmer, Erwin van der Hoek, Bas Jansen, Hasan Kekik, Tony Valstar	2017/2018
CycleSpark	Research into which customers in Rotterdam are suitable for LEFV transport	Burak Akova, Haydar Baran, Mike van Beek, Nick, Martijn van der Helm	2017/2018
Fietsdiensten.nl and Rotterdam University of Applied Sciences	What are the infrastructure requirements of cargo bikes and what untapped possibilities are there?	Fred Hoogendoorn, Rik van Lonkhuizen, Robin van der Ree, Tim Sjouke, Fenno Visser	2017/2018
Fietskoeriers.nl	Research into which customers in Rotterdam are suitable for LEFV transport	Tom, Brenda, Jord, Nigel Masmeijer, Cos Nowé	2017/2018
Rotterdam University of Applied Sciences	Are electric freight vehicles or self-driving vehicles the solution for the inconvenience caused by city logistics?	Four students from the Infrastructure and Mobility Minor	2017/2018
Picnic	Research into which customers in Rotterdam are suitable for LEFV transport	Gerben van Eck, Aron Elferink, Jordy Hermes, Mohamed El Morabit, Youssef Moumouhi	2017/2018
LEFV-LOGIC, RDM CoE	Design of LEFVs for 3 standard loading units	Four students from the Infrastructure and Mobility Minor	2016/2017
LEFV-LOGIC, RDM CoE, City Hub	A design process for the development of new LEFVs	Jaap Nootenboom	2017/2018
Municipality of Rotterdam – Urban Development	The influence of the cargo bike on future infrastructure	Five students from the Infrastructure and Mobility Minor	2016/2017
Stint Urban Mobility	Further development of the Stint for distribution	Roeland Wielaard	2017/2018

Studenten Hogeschool van Arnhem en Nijmegen

Opdrachtgever	Opdracht / Titel	Studentnaam	Jaar
CycleSpark	Improving drive mechanisms	Five students from the MIC Module	2017/2018
CycleSpark	Refrigerated trailer and drive mechanism	Four students from the Drivetrain Minor	2017/2018
Urban Arrow	5-wheeled vehicle and drive mechanism	Nine students from the MIC Module	2017/2018

Appendix C – Vehicle categories

Vehicle category	EU category	Max. speed	Max. capacity	Max. vehicle weight	Driving licence category	Registration / number plates	Minimum age of driver	Number of wheels	Max. dimensions (HxWxL) in m	Place on the road	Helmet / seat-belt	Example
Bicycle with pedal assistance	n/a	25 km/h	0.25 kW	∞	None	No	0	2	∞ x 0.75 x ∞	Bike lane	None	Urban Arrow Cargo
								3+	∞ x 1.5 x ∞	Bike lane or road	None	Radkutsche Musketier
Special moped	n/a	25 km/h	4 kW	∞	None	No ¹	16		2.0 x 1.1 x 2.0	Bike lane	None	Stint
Moped	L1e	25 km/h	1 kW	∞	AM	Yes	16	2	4.0 x 1.0 x 2.5	Bike lane	None	
				3+				4.0 x 2.0 x 2.5	Bike lane or road	None	CargoBee TR50e25	
Moped or speed-pedelec	L1e	45 km/h	4 kW	∞	AM	Yes	16	2	4.0 x 1.0 x 2.5	Bike/moped lane	Helmet	Riese & Müller Packster HS
	L2e			270 kg				3+	4.0 x 2.0 x 2.5	Road	Helmet	
Cargo moped	L2e	45 km/h	4 kW	270 kg	AM	Yes	16	3	4.0 x 2.0 x 2.5	rijbaan	None	CargoBee TR50e 45
Three-wheeled moped / Light quadrimobile	L2e	45 km/h	4 kW	270 kg	AM	Yes	16	3	4.0 x 2.0 x 2.5	Road	Helmet/seatbelt	
	L6e		6 kW	425 kg				4	3.0 x 1.5 x 2.5		None	Renault Twizy 4kW
Motorcycle	L3e		11 kW	∞	A1	Yes	18	2	4.0 x 2.0 x 2.5	Road	Helmet	
Three-wheeled motor vehicle	L5e		∞	1000 kg	A1 ²	Yes	18	3	4.0 x 2.0 x 2.5	Road	Helmet/seatbelt	E-tuk Cargo
	L7e		15 kW	600 kg	B ³	Yes	18	4	3.7 x 1.5 x 2.5	Road	Helmet/seatbelt	Goupil G5
Motor vehicle with limited speed	div.	25 km/h	∞		T ⁴	No	16		12.0 x 2.6 x 4.0	Road	None ⁵	Goupil G3 25 km/h
Vehicle for the disabled	div.	45 km/h	∞		none	No ¹³	16		3.5 x 1.1 x 2.0	Road, bike lane or side-walk	None ⁶	Estrima Birò

Source: Koolstra, K. (2018). *Verkenning Stedelijke Inpassing Cargofietsen en Lichte Elektrische Voertuigen*. Commissioned by the Municipality of Amsterdam. Amsterdam University of Applied Sciences.

EU vehicle categories

EU legislation distinguishes four main categories of motor vehicles.

Category L:	Mopeds and motorcycles, including quads and other small vehicles on three or four wheels. In category L motorcycles are further divided into two groups (with and without sidecar). There is also a special subcategory for mopeds on three wheels: they have a smaller engine and a lower top speed than motorcycles.
Category M:	Vehicles on at least four wheels intended for the transport of persons. Of course, this primarily means cars.
Category N:	Vehicles intended for the transport of goods, classified by size. This mainly concerns trucks and vans.
Category O:	Trailers and semi-trailer

Source: European Commission (2017). *Vehicle categories*.

https://ec.europa.eu/transport/road_safety/topics/vehicles/vehicle_categories_nl

Admission of "special mopeds" into traffic

This bill added a new subcategory in the Dutch Road Traffic Act 1994 to the vehicle category "mopeds".

This gives the Dutch Minister of Transport, Public Works and Water Management the authority to designate vehicles from this subcategory and to permit them to join road traffic.

The vehicles in the new subcategory are mopeds that do not require European type approval on the basis of EC Directive 2002/24. Using this, for example, the Segway is allowed to join road traffic. In addition, a number of technical changes were made to the Dutch law; 1993 Driving instruction for motor vehicles.

This summary is based on the bill and the explanatory memorandum as submitted to the lower house of the Dutch parliament.

Source: *Eerste Kamer der Staten-Generaal (2009). Toelating bijzondere bromfietsen tot het verkeer.*

https://www.eerstekamer.nl/wetsvoorstel/32225_toelating_bijzondere

'Voortbewegingstoestellen', or forward-motion devices (Belgian legislation)

'Voortbewegingstoestellen', (forward-motion devices) are vehicles for which, under Belgian law, there were no specific rules in the past. Now these vehicles are accommodated with slow vehicles and are equated with pedestrians and cyclists. A distinction is made between two types of voortbewegingstoestellen:

- Non-motorised forward-motion devices: any vehicle that is moved by means of muscular force and is not equipped with an engine. This includes rollerblades, scooters, skateboards and wheelchairs.
- Motorised forward-motion devices: any motor vehicle with two or more wheels with a maximum speed of 18 km/h. These include electronic wheelchairs, and segways.

Source: Belgische Federale Overheidsdiensten (2018). Voortbewegingstoestellen.

https://www.belgium.be/nl/mobiliteit/andere_voertuigen/voortbewegingstoestellen

Appendix D – Examples of subsidy measures

Region	Conditions	Subsidy amount
Den Haag (The Hague) (2017)	The applicant must be based in The Hague and drive at least 3,000 kilometres per year with the vehicle.	€1,500
Utrecht (2016)	For the frequent business user, a minimum of 3,000 kilometres per year must be driven (for commuter traffic 2,000 kilometres).	€1,000
Zwolle-Kampen, Twente and Steden-driehoek (2017/2018)	<ul style="list-style-type: none"> • The entrepreneur must use the cargo bike (or bike courier) to replace trips taken by freight vans using fossil fuels or in connection with a growth in delivery. • Trip registration is required to demonstrate the reduction of the number of kilometres driven by vans. 	€1,500
Maastricht (2017)	<ul style="list-style-type: none"> • Cargo bike must lead to a reduction of car kilometres during rush hour • Rides with the cargo bike are monitored for six months with a GPS logger 	€4,000
Amsterdam (2016–2018)	<ul style="list-style-type: none"> • Delivery van (N1 category), or similar and with a loading capacity of at least 2m² / 2m³ • Driving 8,000 kilometres per year in Amsterdam • 3 times a week in Amsterdam 	€5,000 + €5,500

Sources

- Municipality of Den Haag (20th March 2018). Ondernemerssubsidie elektrische scooters en (bak)fietsen aanvragen. <https://www.denhaag.nl/nl/subsidies/subsidies-verkeer-en-vervoer/ondernemerssubsidie-elektrische-scooters-en-bakfietsen-aanvragen.htm>
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- Verkeer in beeld (5th March 2018). Vrachtvervoer per fiets: gratis proberen in Deventer. <https://www.verkeerinbeeld.nl/project/050318/slim-reizen-met-een-gratis-vrachtfiets-in-deventer>
- JIJ&overijssel (2018). Slim en ondernemer? Probeer een week lang gratis een elektrische vrachtfiets en krijg korting op de aanschaf. <https://www.jijenoverijssel.nl/vrachtfiets>
- Municipality of Amsterdam (2016). Subsidie voor elektrische voertuigen 2016–2017. <https://www.amsterdam.nl/parkeren-verkeer/amsterdam-elektrisch/subsidie/>

Appendix E – MAMCA scenarios

Scenario	Description
1. Current Situation	All businesses on the Knowledge Mile independently place orders with suppliers who then deliver to the address of the recipient. For this situation to continue, no change in current processes required and there are no direct costs for the recipients.
2. Suppliers use LEFVs	The Knowledge Mile BIZ will launch a campaign aimed at suppliers and receivers to create awareness about sustainable sourcing and its importance for the Knowledge Mile. The costs of the campaign are taken on by the BIZ. The desired results are that receivers of goods enter into new relationships with sustainable suppliers and that current suppliers deploy sustainable transport. This scenario is based on a campaign conducted in the Baker Street Quarter BIZ.
3. Hub in the BIZ of which the BIZ is the customer	<p>Receivers on the Knowledge Mile have their deliveries delivered to a hub in the BIZ, from where LEFVs complete the final part of the journey. The recipients pay for deliveries via their BIZ contribution. The hub provides the following benefits:</p> <ul style="list-style-type: none"> • Bundled delivery • Waste and large packaging material removal • Receiver can choose delivery times • Delivery from the hub with LEFVs <p>The costs of the deliveries via the hub have been estimated on the basis of research into literature and data from Parcls:</p> <ul style="list-style-type: none"> • €2.50 – €5.00 per package • €10.00 – €20.00 per pallet
4. Hub on the outskirts of the city of which the receivers are customers	<p>The receiver chooses to have their products delivered to a hub on the outskirts of the city, with the final part of the journey completed with LEFVs. This offers the following benefits:</p> <ul style="list-style-type: none"> • Bundled delivery • Waste and large packaging material removal • Receiver can choose delivery times • Delivery from the hub with LEFVs <p>In addition, the hub provides tailor-made services to the receiver that ensure that the financial benefits outweigh the extra costs.</p>
5. Receivers use LEFVs	<p>The Knowledge Mile purchases LEFVs for the receivers, the aim being that receivers use them to pick up products / deliveries. There is an option for a subconcept where the LEFVs are kept in a fixed location and can be rented by receivers (and consumers). There is an option for recipients to just own their own LEFV.</p> <ul style="list-style-type: none"> • Part concept: € 3 per hour • Own property: € 75 per month

