UPSCALING ZERO-EMISSION DELIVERY AND RETURN MODELS

BARRIERS AND OPPORTUNITIES

Deliverable D4.4

Version number: V2

Date for release: 14/11/2025

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This project has received funding from the European union's Horizon Europe research and innovation programme under grant agreement Nr. 101146909.

Deliverable administrative information

Deliverable Administration					
Grant Agreement	101146909	**Project short name**	CodeZERO		
Deliverable no.	4.4	**Name**	Upscaling zero-emission delivery and return models – Barriers and opportunities		
Status	Draft	**Due**	14/11/2025	**Date**	14/11/2025
Author(s)	Finn Winkelmann, Pauline van Beusekom (TNO)				
Related tasks	T4.4				
Dissemination level	PU				

Document history	Version	Date	Submitted	Reviewed
	V.01	08/10/2025	Finn Winkelmann, Pauline van Beusekom (TNO)	Claudia de Stasio (TRT)
	V.02	dd/mm/yyyy	Name	Name
	V0.3			

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Abstract

CodeZERO Deliverable 4.4 presents the findings of an exploratory qualitative study which aims to better understand the opportunities and barriers of scaling sustainable and zero-emission last-mile delivery solutions for e-commerce in urban areas.

Drawing on fifteen semi-structured interviews with logistics service providers and e-tailers across Belgium, Italy, Norway, and the Netherlands, the study identifies key barriers and opportunities for scaling innovative delivery models.

The analysis reveals that governmental support and collaboration are perceived as critical enablers, while barriers such as limited grid capacity, ineffective policy design, and high operational costs persist across contexts.

The study also highlights the dual role of certain urban areas measures, such as parcel lockers and zero-emission zones, which may function both as barriers and opportunities depending on their implementation. A geographical perspective underscores significant contextual differences, particularly in infrastructure readiness and cultural acceptance of active transport modes.

The findings contribute to a nuanced understanding of the systemic and context-specific factors influencing the scalability of sustainable delivery models and will inform the further evaluation and refinement of CodeZERO solutions. Limitations of the study include the small and uneven sample size, suggesting the need for broader stakeholder engagement and the application of larger quantitative methodologies including surveys or Q-methodology.

Executive summary

CodeZERO Deliverable 4.4 employs an exploratory qualitative methodology drawing on fifteen semi-structured interviews with logistics service providers and e-tailers across Belgium, Italy, Norway, and the Netherlands to identify barriers and opportunities for scaling innovative delivery models across diverse geographical and operational contexts. This approach enables a nuanced understanding of stakeholder perspectives and contextual factors influencing the scalability of sustainable logistics solutions.

Governmental support and collaboration emerged as critical enablers for scaling sustainable delivery models. Interviewees consistently emphasised the importance of structured public-private dialogue and flexible, locally tailored policymaking. Conversely, barriers such as limited grid capacity, ineffective policy design, and high operational costs were identified across all contexts. The availability of energy and charging infrastructure was cited as a particularly pressing constraint, with companies facing challenges in installing private charging stations due to grid limitations and high costs.

The study also highlights the dual role of certain measures, such as parcel lockers and zero-emission zones, which may act both as barriers and opportunities depending on their design and implementation. Parcel lockers, for instance, can reduce failed deliveries and improve efficiency, but lack of interoperability and increased consumer travel may undermine their benefits. Similarly, zero-emission zones can incentivise cleaner delivery practices but may also lead to inefficiencies if not carefully planned and coordinated.

Seven key barriers and opportunities were identified through the interviews. Governmental support and collaboration were the most frequently emphasised opportunity, while lack of governmental insight, ineffective policy design, and operational costs were the most prominent barriers. These findings underscore the need for systemic and context-sensitive approaches to scaling sustainable logistics solutions. Regarding active transportation modes, additional barriers include limited transport capacity, inadequate infrastructure, and cultural resistance among delivery personnel. Opportunities specific to active modes include improved stopping capabilities, access to restricted areas, enhanced customer satisfaction, and the potential for increased vehicle standardisation. These insights offer a more targeted understanding of the factors influencing the scalability of active transport solutions.

From a geographical perspective, the study identifies notable differences in the transition towards sustainable delivery models. In the Netherlands and Belgium, the shift towards electric vehicles is constrained by grid limitations, despite the early implementation of zero-emission zones. Italy demonstrates a more fragmented approach to access restrictions, necessitating context-specific operations. Belgium showcases successful collaboration between government and industry, while Norway's transition is driven primarily by internal company policy rather than regulatory mandates.

The adoption of active transportation modes, such as cargo bikes and walking, also varies significantly across countries. In Italy, cultural attitudes and insufficient infrastructure present substantial barriers, whereas the Netherlands and Belgium benefit from well-established cycling infrastructure that facilitates integration into logistics operations. These contextual differences highlight the importance of tailored strategies that reflect local conditions and stakeholder dynamics.

The study concludes that cost-efficiency remains the primary driver in logistics operations, where profit margins are typically narrow. While operations are often optimised, alternative delivery models, such as cargo bikes, may reduce efficiency but are necessary to comply with access

regulations. The findings suggest that a single universal delivery model is not feasible; rather, diversification based on delivery area and freight type is required. Replication of delivery models is highly context-dependent and tends to occur when regulations necessitate it and the value of delivery justifies the investment. As part of the CodeZERO project, the findings of this study will inform the evaluation and refinement of the selected solutions that will be developed through pilot initiatives.

Limitations of the study include the small sample size, indicating the need for broader stakeholder engagement and the application of methodologies such as Q-analysis in future research. Further studies should also explore alternative strategies such as asset sharing, consumer nudging, and the integration of logistics into urban planning areas that remain underexplored but are essential for long-term sustainability.

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Acronym	Meaning
B2B	Business-to-Business
B2C	Business-to-Customer
EU	European Union
EV	Electric Vehicle
LEV	Light Electric Vehicle
LEZ	Low-Emission Zone
SME	Small-Medium Enterprises
WP	Work Package
ZEDM	Zero-Emission Delivery Model
ZTL	Zona a traffico limitato – Limited traffic zone

1 Introduction

1.1 About CodeZERO

CodeZERO is a three-year Horizon Europe research project aiming to co-create sustainable and zero-emission last-mile delivery and return solutions for ecommerce that align with **consumers'** preferences while being sustainable for **retailers, logistics operators** and **local authorities**. Additionally, the project is focused on providing clear, consumer-friendly communication and developing tools for local authorities to promote eco-friendly behaviour.

CodeZERO is articulated in four phases:

- An **ANALYSIS** phase which provides (1) an analysis of existing delivery and return options and an understanding how they are shaped by the needs and constraints of all involved stakeholders; (2) an in-depth intersectional analysis of various groups of online consumers to understand what are the features of delivery and return options making them attractive, with the aim to identify mechanisms to incentivize behaviour changes; and (3) develops an assessment framework to measure the impacts in the environmental, economic and social domains of new solutions.
- A **DESIGN** phase, in which CodeZERO engages in a co-design process involving retailers, transport operators, consumers and local authorities in developing (1) guidelines for retailers to raise awareness among customers; (2) a set of zero-emission and sustainable delivery and return options for retailers and transport operators; and (3) a toolset for local authorities to accelerate the transition towards sustainable solutions in last mile consignments in e-commerce.
- A **TEST** phase running 4 pilots in 4 different European cities in Italy, Netherlands, Belgium, and Norway to test a set of sustainable solutions identified in the previous phase with the aim to prove their feasibility, to fine-tune their design and to assess their impacts from the perspective of all stakeholders.
- A **CONSOLIDATION** phase where (1) CodeZERO outcomes are fine-tuned based on the lessons learned from real life applications, (2) requirements for up-scaling of solutions at European level are discussed (3) recommendations are formulated and (4) directions for future research are outlined.

Engagement with consumers and retailers' associations, industry stakeholders, cities and researchers contributes to shaping project results.

Running from June 2024 to May 2027, CodeZERO is organized along eight WPs:

- WP1 Analysis of current delivery models
- WP2 Analysis of consumers' behaviour
- WP3 CodeZERO assessment framework
- WP4 Design of CodeZERO solutions
- WP5 Testing solutions: CodeZERO living labs
- WP6 Conclusions and recommendations
- WP7 Dissemination, communication, and exploitation
- WP8 Project management.

1.2 Aim of this deliverable

This deliverable reports the activities performed under CodeZERO Task 4.4 ‘Upscaling of zero-emission delivery models’.

Building on previous CodeZERO outcomes from WP 1 to 4 and in specific on Task 4.2, which co-designed innovative delivery and return models in Milan, Antwerp, Oslo, and Utrecht, Task 4.4 aims to present these results to a broader audience of retailers and transport operators.

The objective is to refine and upscale the solutions developed in CodeZERO pilot cities by incorporating feedback from this wider stakeholder group. This will support the design of a more comprehensive set of delivery options applicable across diverse geographical contexts and goods flows, in alignment with the taxonomy developed in Task 1.2.

The results of Task 4.4 will contribute to the broader objectives of the CodeZERO project, particularly the replicator activities in WP 5. These results enhance understanding of the measures that retailers and cities can adopt to support the development of an indicative action plan for replicating zero-emission delivery models across diverse contexts and varying geographical locations. Accordingly, the findings from D4.4 will primarily inform the evaluation and refinement of the CodeZERO delivery and return solutions, as documented in Deliverable D6.2.

As part of Task 4.4, we have opted to collect data through in-depth interviews to gain more comprehensive insights. Consequently, the originally planned workshop, as outlined in the grant agreement, has been replaced by these interviews.

1.3 Structure of the document

Deliverable 4.4 is structured as follows:

- Section 2 explores the diversity of e-commerce delivery models and the constraints that shape their development, followed by an overview of scaling strategies in subsection 2.3.
- Section 3 outlines the research methodology and study design.
- Section 4 presents the results, which are subsequently discussed in Section 5.
- Finally, Section 6 provides the conclusions.

2 Scaling and transferring delivery models

2.1 Theoretical background

E-commerce deliveries in urban areas have received extensive scholarly attention and represent a familiar phenomenon to the general public. This is partly explained by the significant growth of e-commerce over the past decades. The impact of these deliveries, primarily conducted by light commercial vehicles or vans, has been widely documented in terms of emissions (Bjerkan & Babri, 2024), congestion (Boysen et al., 2021), and operational costs (Ghazal et al., 2025).

From an urban logistics perspective however, this predominant focus on e-commerce-related trips may be misleading as parcel deliveries, typically associated with e-commerce flows, account for only approximately 5% of total logistical vehicle movements and vehicle kilometres in urban areas (Rondaij et al., 2023). In contrast, vehicle movements related to construction, retail, service logistics, and fresh/conditioned flows are significantly more voluminous (Rondaij et al., 2023).

This raises the question: 'Why does this segment receive such disproportionate attention?'

One explanation lies in its visibility and familiarity. Due to the extremely high stop density of parcel carriers, delivery vans are highly visible and frequently obstruct urban streets (Allen et al., 2018). Additionally, cruising for parking substantially affects delivery efficiency (Figliozzi & Tipagornwong, 2017). Another reason is that many innovations in last-mile logistics tend to emerge within this supply chain. In the ongoing pursuit of optimization and customer satisfaction, new solutions are continuously introduced (Janjevic & Winkenbach, 2020). Furthermore, this transport flow offers rich opportunities for research across disciplines, including operational studies, policy analysis, and consumer behaviour. Finally, e-commerce related deliveries include more than purely (B2C) parcels. There is a growing diversity in types of goods and subsequent supply chains that operate in the e-commerce universe (Risberg & Jafari, 2022).

Several innovations have found their breakthrough in this delivery segment including the electrification of vans, the deployment of light electric freight vehicles, the use of micro hubs as transshipment points in dense urban areas, nudging customers to more sustainable ordering behaviour, which includes the use of pick-up points (He & Haasis, 2020). These innovations have considerably reshaped delivery models[1]. Many of these innovations have started as small scale (in-company) experiments and pilots. Other innovations, such as the use of drones and mobile depots, remain pilots for the time being.

Despite the impact of this delivery segment in driving the cost-efficiency, and often, sustainability of deliveries, the upscaling of innovative delivery models remains limited.

In the context of this study *innovative* delivery models are defined as **the optimization of last mile delivery models for e-commerce that are:**

1) cost-efficient to companies

[1] For this study, we define delivery models as (Kin et al., 2025): '*the configurations of transport and logistics activities required to physically transport a product from a retailer (distribution centre or store) to a customer (or pick-up points).*'

2) provide a high service level to customers; and

3) minimize their impact upon the urban area in terms of emissions (i.e., zero-emission), safety, and nuisance.

Applications of innovative delivery models are limited to (Halldorsson & Wehner, 2020; Kin & Quak, 2025):

a) specific areas which we see with e-vans and even more with light electric freight vehicles in dense areas and zero-emission zones.
b) specific goods with parcels providing a higher potential for alternative delivery models than more bulky goods; and
c) to certain customers groups that have 'logistics capabilities.

Yet, the question raises: 'What are the reasons for limited upscaling of such delivery models?'

On-line retailers (termed as e-tailers in the remainder of this study) who transport on own account as well as transport operators to whom deliveries are outsourced, are responsible for the organization of the distribution network and choices regarding the vehicle fleet.

With these entities behind the buttons, one could say that it should be their responsibility to make a transition to, for instance, a zero-emission vehicle fleet or to nudge customers to more sustainable delivery choices. Although this is true to some extent, it is also a sheer simplification. These companies are, with differences between supply chains, generally constrained by several factors.

First, there is the power of customers. If one company starts pricing more their deliveries to compensate for investments in a cleaner vehicle fleet, than e-tailers or customers can easily shift to other transport operators or e-tailers with lower prices. Thus, operators optimize their transport within the constraints of customers' preferences.

Secondly, those companies must also consider the spatial constraints in the urban area, including regulations like low emission zones and time windows as well as the boundaries set by the physical environment like one-way streets and congestion.

A third constraint is the competition and low margins in the transportation sector which means that investments take time and cannot take place overnight (Kervall & Pålsson, 2022; Vieira & Fransoo, 2015).

Many studies address these constraints, albeit often considering one or two of them or in a more quantitative way (see the overwhelming number of studies in operations management).

2.1.1 Objective of CodeZERO Task 4.4

In this research we explore and identify *the barriers and opportunities to scale and transfer zero-emission and (cost-)efficient delivery models to different e-commerce flows and geographical contexts.*

The outcome of this study contributes to an enriched overview of zero-emission delivery options, by focusing on the barriers and opportunities that own account transporting e-tailers and transport operators face in upscaling innovative delivery models.

We adopted an exploratory research method to explore the key barriers and opportunities. Semi-structured interviews are conducted to identify subjective positions and dominant ones by different stakeholders, being them e-tailers and transport operators in various supply chains and countries.

2.2 Delivery models: the landscape

One's image of e-commerce mostly equates to parcel deliveries to individual households. Even though parcels can contain different types of goods, these are mostly assumed to be non-perishable (retail) goods such as fashion and electronics. However, the diversity of e-tailers and types of goods that are ordered online extends beyond this, a phenomenon that has been exacerbated since the COVID19-pandemic.

Products characteristics put up a first constraint on transportation possibilities and a subsequent transition towards a different delivery model. As already elaborated in CodeZERO D1.2 (based on Allen et al., 2018; Bergling & Engberg, 2019; Bjørgen et al., 2021; Buldeo Rai et al., 2023; Lauenstein & Schank, 2022; Peppel et al., 2022), there are two product groups (with different sub-groups) having different transport requirements:

- **Non-perishable and not (always) time-critical goods**
  - **Retail goods** that are sent as **letter-box packages**, which can be delivered unattended through the mailbox. Whether it is sent as a letter-box package depends mostly upon the size and weight of the product(s), the responsible transport company, and the value of the product. Deliveries are mostly done on foot (with handcart), by bike or with a light electric freight vehicle.
  - **Retail goods** that are sent as **parcels**, which often contain similar products as letter-box packages but are larger in size, weight and/or require a signature because of their value (attended delivery). These goods are increasingly delivered to pick-up points. Deliveries are mostly done with a van.
  - **Retail goods** that must be transported in **large packages with non-regular sizes**. Those distinguish themselves from parcels by their weight and/or size, which has its limitations as deliveries can often not go to a pick-up point and require at least a van.
  - **Two-person deliveries of retail goods** (e.g. furniture) with goods exceeding the weight and/or size that can be handled by one person (the driver). At least a van and sometimes trucks are used. In most cases goods are delivered behind the front door.

- **Perishable and time-critical goods:**
  - **Instant meals and groceries** that often have a **short lead time** ('quick commerce'), are transported locally and light electric freight vehicles such as e-(cargo)bikes and scooters are mostly used (e.g. Deliveroo).
  - **Meals with longer lead times** that often come in boxes with recipes and pre-portioned ingredients, which are transported in light commercial vehicles (e.g. HelloFresh).
  - **Groceries** that generally have longer lead times than instant meals, are larger in volume, and are mostly delivered in crates. Vehicles vary from light electric freight vehicles to small trucks.
  - **Medicines** that are potentially (highly) time-critical and expensive, transport is either local (from a pharmacy) or from a wholesaler.

Delivery models are different configurations of transport and logistics activities needed to fulfil a delivery option and to physically transport a product from a retailer to a customer (or a pick-up point). This mostly comes down from the design of the distribution network or last mile fulfilment

strategies along two main aspects (Halldórsson & Wehner, 2020; Janjevic & Winkenbach, 2020; Kin et al., 2018; Onstein et al., 2021; Rodrigue, 2020):

- **Logistics facilities**: different types of facilities with different functions and varying sizes (e.g., inventory, picking, transshipment, etc.) that together can form a multi-echelon network. This includes attended and unattended pick-up points (e.g. parcel lockers) where customers can pick-up or return their products.
- **Transportation modes**: different transportation modes or vehicle types are deployed for the last mile. In case there is a multi-echelon network, facilities often also function as a cross-dock locations where goods are transhipped to smaller vehicles.

As elaborated and developed in CodeZERO D1.1 and D3.1, categories and attributes for designing and assessing zero-emission delivery models, are shaped by four main constraints:

- **Supply**: the transportation capabilities including the network of distribution centres and available vehicles. This refers to either the e-tailer transporting on own account or a transport operator.
- **Demand**: the delivery options that customers get offered when they order online, which include the choice of delivery location and delivery times.
- **Context***:* the physical environment in which the transport to the customer takes place. This includes (access) regulations that (local) authorities implement. A zero-emission zone is an example.
- **Impact:** refers to the various types of impacts stemming from delivery options, namely the service efficiency, transport impact, environmental impact, and the labour impact.

Figure 2.1 illustrates these four constraints. In the reports of D1.1 and D3.1 this framework is further elaborated in detail for zero-emission delivery models. It refers to the supply aspect, the transport operator must consider various criteria underpinning efficiency, i.e. service organization, distribution network, size and composition of the vehicle fleet etc. The demand aspect is represented by customers who expect a high service level shaped by convenience not only in terms of costs and delivery times, but also in terms of flexibility and reliability of deliveries. The physical environment in which those activities take place, is managed by local authorities (the context), who aim for minimizing congestion, emissions, increasing traffic safety, etcetera. In the end, a delivery model must balance between all these constraints and stakeholders' interests to balance the preferred impact.

An e-tailer, or transport operator, can have multiple delivery models, even in the same region. A possibility is, for instance, the use of a mixed fleet, in which larger conventional diesel vehicles are deployed in suburban and more rural areas, whereas smaller electric freight vehicles deliver in dense areas and low/zero emission zones. In terms of logistics facilities, a transition from single- to multi-echelon networks appears. Furthermore, a diversification in the size and type of facilities emerges. In addition to the more traditional facilities with storage and cross-dock as main functions, stores increasingly come to function as facilities from where goods are shipped (Arslan et al., 2021; Hübner et al., 2016). E-commerce deliveries (and returns) are not necessarily all the way to (and from) the customers' doorstep as different types of collection points are also introduced in urban areas.

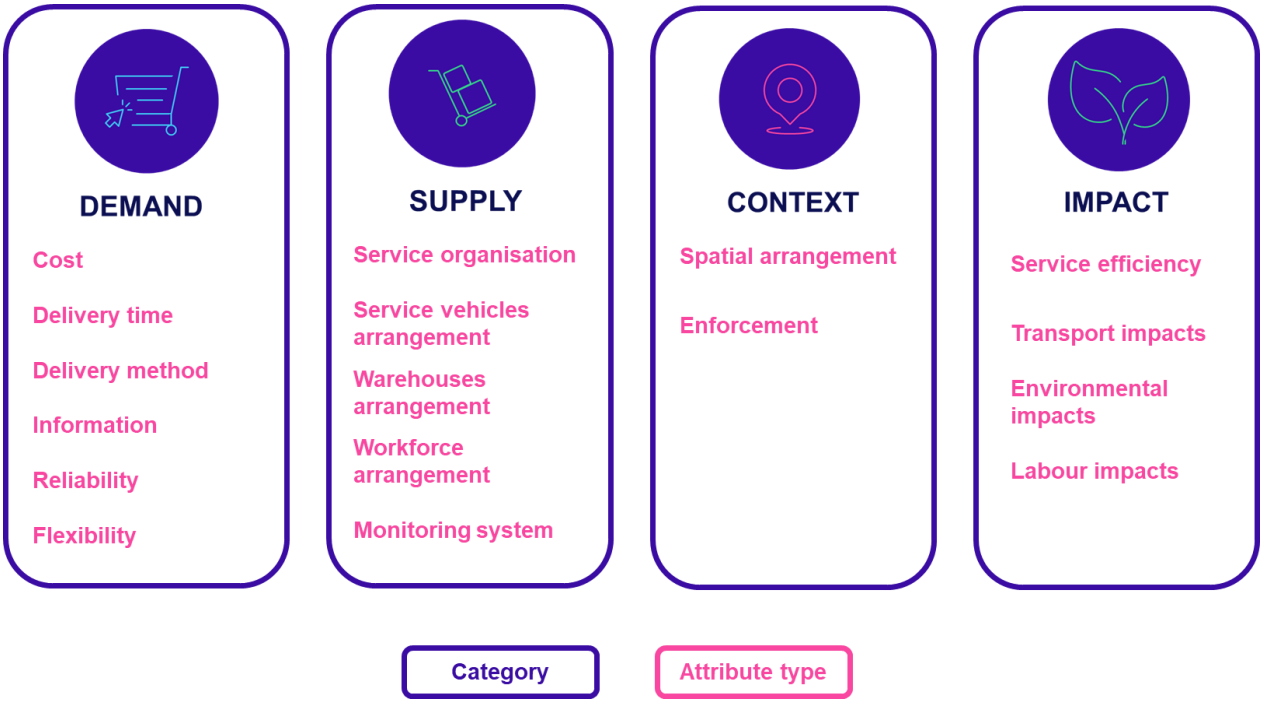

Figure 2.1: Framework for assessing zero-emission delivery options, its categories and types of attributes (Source: CodeZERO –T3.1)

2.3 Scaling strategies

Although the term **'upscaling'** can be used either when applying a delivery model to transport different goods in another context, or to transport goods in the same spatial context but in a different way, the term **'transferability'** is also relevant.

Literature on upscaling as well as transferring innovations in urban logistics is elaborate. A large part of it primarily discusses 'innovation ecosystems' (e.g. Pana Tronca & Rotaris, 2024). In this section we conduct a selective literature review, which is limited to **upscaling and transferability of delivery models in e-commerce**.

Van Winden (2016) and Sista & De Giovanni (2021) reviewed the upscaling of urban logistics smart city projects by distinguishing between **expansion**, **replication** and **spontaneous diffusion**, the latter also being termed as **roll-out** (see Figure 2.1).

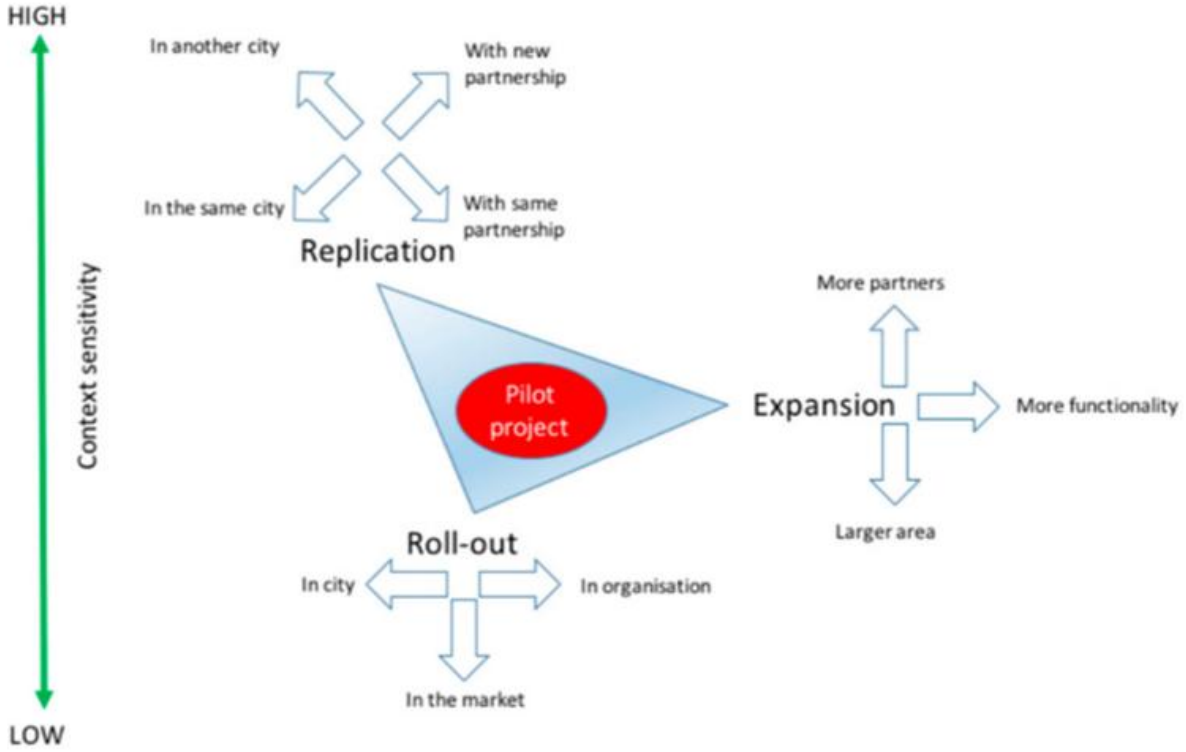

Figure 2.1: Three types of scaling (van Winden, 2016)

Zimmermann and Palgan (2024) sketched pathways for upscaling based upon the typology proposed by Naber et al. (2017), who focus on the scaling of niches (or experiment). Four pathways are mentioned regarding a niche: **growing** (within the same context with more actors/users), **replication** (growing in other contexts), **accumulation** (different niches in different contexts are linked to each other) and **transformation** (niches causing regime change).

Riddell and Moore (2015) elaborate on three approaches for scaling of societal innovations: **scale up** (changing institutions at the level of policy, rules and law), **scale out** (replication and dissemination, increasing number of people and communities impacted) and **scale deep** (changing relationships, cultural values and beliefs).

Based on interpretation of the authors in combination with the aforementioned sources, translating these types of scaling to the context of this research leads to the following:

- **Expansion** (or **growing**) that takes place within the organization and can be done in three ways: by covering more areas within a city and/or more cities (geographic expansion), by involving more partners (quantitative expansion) or by adding additional functions (functional expansion). Overall, this is more complex as transaction and coordination costs are higher.
- **Replication** (or **scaling out**) entails the reproduction of a delivery model in a different context, which can be another city in another country. The complexity lies in having to deal with a different environment, other rules and regulations as well as partners.
- **Accumulation** means linking each other different delivery models in various locations, which is already inherent to the whole process of sharing among project partners itself.

- **Roll-out** entails that the solution [delivery model] is made available to all consumers (market roll-out), the entire organization (organizational roll-out) or to the city (city roll-out). Roll-out does not require major changes to the product or solution and therefore no significant changes in partnerships or within the organization are required.
- **Transformation** (or **scaling deep** and **scaling up**) means that an alternative delivery model is being facilitated by changing policies (e.g., a zero-emission zone) and behaviour by consumers.

In the context of this research the focus is on the applicability of a delivery model to another e-tailer (possibly selling other types of products) with a different delivery model (transportation capabilities) in other geographical contexts, which might mean that there is also another consumer base. The scaling strategy that is therefore most applicable is **replication**. Replication has the highest context-sensitivity level.

When replicating a delivery to other locations, e-tailer and/or goods, several factors must be considered (based on Sista & De Giovanni, 2021). First, the technical factors which refers to the replicability in terms of (data) infrastructure (capabilities). Second, economic factors apply to the feasibility of the business model. Whereas these two groups of factors are particularly relevant to the 'owner' of the delivery model, i.e. the e-tailer, the other two types of factors are more depending upon the outer context i.e. stakeholder-related factors, and legislative and regulatory factors.

In line with replicability – the reproduction of a delivery model in another context – the concept of 'transferability' is also coined (Janjevic & Ndiaye, 2014; Klose et al., 2022; Timms, 2014). When it comes to transferability, existing studies focus on different aspects such as transferring urban freight planning measures (Timms, 2014) and micro-consolidation centres (Janjevic & Ndiaye, 2014). Several context-specific factors, barriers as well as enablers, are identified by these studies: accessibility, loading and unloading infrastructure, access restrictions and commercial density.

2.4 Factors affecting the replication and scaling of zero-emission delivery models

The replication and upscaling of zero-emission delivery models across diverse urban and regional contexts in Europe require a comprehensive understanding of specific geographic factors and of the policy environment. These dimensions jointly shape the feasibility, effectiveness, and scalability of sustainable logistics interventions.

1. Urban density and spatial configuration

Urban morphology significantly influences the suitability of delivery models. High-density cities with compact infrastructure may support micro-consolidation centres and cargo bike deliveries, while low-density or peri-urban areas may necessitate hybrid models involving electric vans or shared pickup points. Spatial distribution of consumers, retail nodes, and logistics hubs affects route design, vehicle choice, and service frequency (Shin et all., 2025).

2. Local policy frameworks and regulatory incentives

Policy plays a pivotal role in enabling or constraining the adoption of zero-emission logistics. Municipal regulations such as low-emission zones (LEZs), vehicle access restrictions, and urban freight plans can accelerate the transition to cleaner delivery modes. Conversely, fragmented, or inconsistent policies across jurisdictions may hinder scalability. Financial incentives (e.g., subsidies for electric vehicles, tax exemptions) and public procurement strategies can further support adoption, while enforcement mechanisms ensure compliance and long-term viability (Bai et al., 2024; Lund, 2024).

3. Infrastructure and technological readiness

The availability of supporting infrastructure, such as EV charging stations, safe bike lanes, and urban consolidation centres, varies geographically and directly impacts on operational feasibility. Technological readiness, including digital platforms for routing, tracking, and coordination, also differs across regions and influences the scalability of innovative delivery models (Bukhari et al., 2025).

4. Socioeconomic and cultural factors

Consumer preferences, digital literacy, and openness to alternative delivery solutions (e.g., parcel lockers, click-and-collect) are shaped by local socioeconomic conditions and cultural norms. These factors affect the uptake of behavioural interventions and the success of demand-side measures aimed at reducing emissions (Saes et all., 2023).

5. Climatic and topographical conditions

Weather and terrain influence the reliability and practicality of certain delivery modes. For instance, cargo bikes may be less viable in regions with frequent extreme weather conditions or steep gradients, requiring seasonal adjustments or alternative vehicle types (Kay et all., 2022).

6. Logistics ecosystem and market structure

The composition and maturity of local logistics networks, including the presence of third-party logistics providers, platform-based services, and retail partnerships, affect coordination and integration. Market dynamics, competition, and stakeholder alignment are critical for scaling collaborative delivery models (Halvorsen, 2022).

7. Policy as a catalyst for replication and upscaling

Policy interventions are not only enablers but also catalysts for replication. Strategic alignment between local, regional, and national policies can create a coherent framework for scaling. Harmonized standards for vehicle emissions, data-sharing protocols, and urban freight zoning facilitate cross-city replication. Participatory policy design, engaging retailers, logistics providers, and municipalities, ensures that delivery models are context-sensitive and broadly supported (Lund, 2024).

In summary, previous studies emphasise seven geographical and policy dimensions that should be explored and integrated into the design and evaluation of zero-emission delivery model replication. A place-based approach, informed by local conditions and supported by coherent policy frameworks, is essential for achieving scalable, replicable, and impactful logistics solutions across Europe.

3 Methodology

3.1 Approach

Given the limited body of research on scaling strategies related to zero-emission delivery models (ZEDM) for e-commerce in urban areas, there is a pressing need to deepen our understanding of the factors that drive the acceleration and scaling of existing sustainable delivery models across diverse geographic and operational contexts.

Moreover, as this is a multi-stakeholder issue, it is essential to identify the needs and preferences from the key perspectives: shippers and logistics service providers. To address this, we employed an exploratory qualitative study design to generate robust insights.

Qualitative research is particularly suited to contexts where problems are complex, solutions are not straightforward, and decisions are influenced by a multitude of variables and stakeholders (van Beusekom et al., 2024).

Our research aims to examine and understand the phenomenon of zero-emission delivery models for e-commerce in urban areas, focusing on the interactions among stakeholders across various geographical and operational settings. Our objective is to identify key opportunities and barriers to scaling zero-emission delivery models for e-commerce, thereby uncovering the drivers behind potential scaling decisions.

To this aim, we adopted a research approach based on semi-structured interviews, which allowed us to explore the context in depth and produce more compelling results (Yin, 2018). By remaining open to emergent phenomena, we aim to enhance our understanding of the dynamics involved in scaling strategies for these zero-emission delivery models.

3.2 Data collection method

We conducted fifteen semi-structured interviews using a protocol informed by the theoretical framework presented in Section 2. Firstly, a list of statements (see Annex 7.1) was created, on the base of the prompts within each category of the framework (see Figure 2.1). Out of these statements, a semi-structured interview guide was developed in order to explore all themes discussed in the framework (see Annex 7.2).

Interviewees were selected to represent a supply chain role and geographic context, ensuring data triangulation and enhancing the robustness of our findings (see Table 3-1). The selection was based on two main criteria: (1) their position within the supply chain (either e-tailer or logistics service provider), and (2) their involvement and responsibility in the strategy decision-making process related to delivery models. Some participants were recruited from the existing network of researchers within the CodeZERO consortium, while others were identified through snowball sampling.

The diversity in geographical and sectoral backgrounds of the interviewed organisations - including cargo bike couriers, furniture logistics providers, grocery and food delivery services, and national postal operators - should offer valuable insights into the scalability of zero-emission delivery models across different contexts.

The interviews were conducted in the period September until November 2025. The aim of these one-on-one semi-structured interviews was to gather rich, in-depth data on experiences and perspectives regarding scaling decisions for zero-emission delivery models (see Annex 7.3).

Table 3-1: Overview of interview participants

Interviewee	Function	Organisational group	Regional Focus
A	Senior project leader	Logistics service provider	Belgium
B	Sales and Marketing Director	Logistics service provider	Belgium
C	Director of Sustainability	Logistics service provider	Belgium
D	Operations manager	Logistics service provider	Italy
E	Transport strategy & policy specialist	Logistics service provider	Italy
F	Public affairs manager	Logistics service provider	Italy
G	CEO	Logistics service provider	Italy
H	Channel developer	E-tailer	Netherlands
I	E-commerce	Logistics service provider	Netherlands
J	Supply Chain Analyst	E-tailer	Netherlands
K	Manager Supply Chain	Logistics service provider	Netherlands
L	Service fulfilment manager	E-tailer	Norway
M	OPS Manager Sustainability	Logistics service provider	Norway
N	Manager	Logistics service provider	Norway
O	EU public policy associate	Logistics service provider	Europe

3.3 Analysis

All interviews were transcribed in full using an automated transcription tool (Amberscript) and afterwards checked manually for completeness and accuracy. Transcript texts were coded using an abductive research approach, which combines elements of both deductive and inductive reasoning. This approach enabled us to build theory while simultaneously collecting data over different research phases (Håkan & Gyöngyi, 2005). The conceptual framework (see Figure 2.1) was applied as a flexible guide (Lämsä & Takala, 2000) to develop the interview protocol and to organize and categorize the findings.

To evaluate the quality of our exploratory research, we applied four criteria: credibility, transferability, dependability, and confirmability (Nowell et al., 2017).

- Credibility was ensured through peer briefings and prolonged engagement with the CodeZERO research team and stakeholders.
- Transferability was supported by providing thick descriptions and direct quotes to help readers immerse themselves in the context.

- Dependability was demonstrated through a logical, traceable, and well-documented research process.
- Confirmability was achieved via an audit trail and reflexivity, with the EU Horizon CodeZERO research team collaboratively interpreting the interview data.

4 Key barriers and opportunities for scaling delivery models

This section examines the key barriers and opportunities for scaling delivery models identified through the interviews.

The findings are presented in two sections: one explores the general opportunities and barriers to scaling up sustainable delivery models (4.1), while the other focuses specifically on these factors within the context of active transportation modes (4.2). This distinction is essential to ensure a more nuanced understanding of both general systemic factors influencing the scalability of sustainable delivery models and the specific challenges and opportunities associated with active transportation modes, thereby enabling more targeted and context-sensitive recommendations for CodeZERO.

Findings highlight that transitioning to sustainable delivery is not solely a matter of electrification or changing to active mode alternatives (which enables zero-emission transport); it also involves broader systemic changes, such as reducing the number of vehicles operating in urban centres, minimizing delivery stops, and decreasing total kilometres driven.

4.1 General emerged key barriers and opportunities for scaling delivery models

Based on the textual data generated in this study, seven key barriers and opportunities were identified (see Figure 4.1).

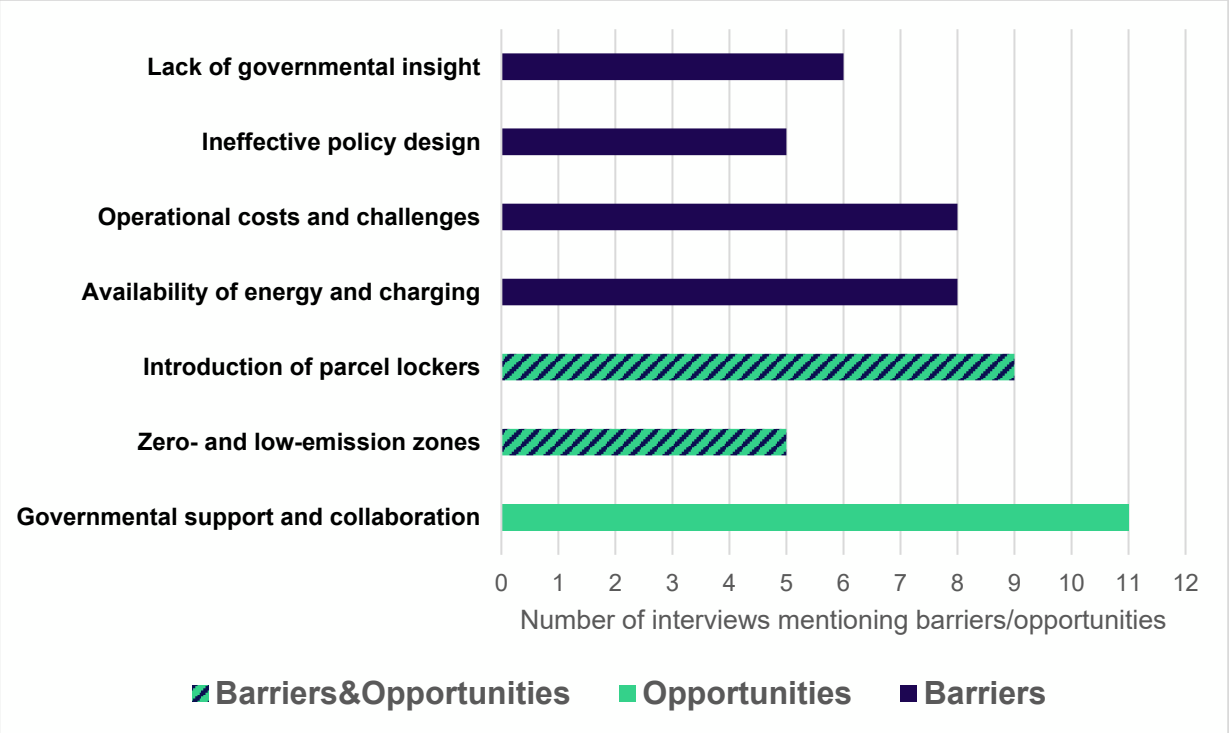

Figure 4.1: Key barriers and opportunities for scaling delivery models in general

Governmental support and collaboration emerged as the principal **opportunity** for scaling delivery models, offering a potential pathway toward more sustainable practices. This factor was emphasized by nearly all interviewees as central to the scaling discussion.

In contrast, the most prominent **barriers** identified include a **lack of governmental insight, ineffective policy design**, and **operational costs and challenges.** These barriers were consistently and strongly emphasized across most interviews. While **ineffective policy design** was recognized as a key barrier, it was highlighted to a somewhat lesser extent.

Additionally, the data suggest that certain elements discussed during the interviews may function as **both opportunities and barriers**, depending on the specific context and application. This duality applies particularly to **the introduction of parcel lockers** and **the implementation of zero- and low-emission zones**.

These seven identified barriers and opportunities are primarily associated with *municipal* actors, and secondarily with *logistics service providers* on the supply side (see Figure 2.1), from an opportunity as well as a barrier perspective.

In the following subsections these barriers and opportunities are elaborated.

4.1.1 Barriers: Lack of governmental insight and ineffective policy design

A recurring theme across the interviews was the perceived disconnection between industry expertise and governmental decision making in the context of sustainable delivery models. Several participants (interviewees D, F, G, H, I and O) clearly expressed their concerns that policymakers often lack a nuanced understanding of the operational realities of urban logistics, as noted by Interviewee B highlighting a sense of exclusion from strategic planning processes.

> *"For some reason, policymakers don't take us into the equation when doing all these big and brilliant things"*

This sentiment was reinforced by Interviewee O through the argument that modern logistics companies possess advanced data handling capabilities, enabling them to make informed decisions about transitioning to sustainable delivery models without significantly disrupting operations, calling for more consideration of the sectors knowledge when designing policy regulation.

Similarly, Interviewee F emphasized the importance of administrative awareness of logistics processes when developing policy decisions, remarking that:

> *"It's also important that, for example, administrations understand which type of vehicle is useful to be used in which way and for delivering what type of product."*

This observation points to a broader issue: local governments often lack understanding of the differentiated roles and applications of various vehicle types, which can lead to ineffective or misaligned policy interventions, especially when push for the use of a specific vehicle type.

This lack of insight and miscommunication goes hand in hand with the barrier of ineffective policy design, as this often leads to misalignment between implemented policies and the practical needs and constraints of the urban logistics sector. The policy frequently discussed in the interviews in relation to this was the introduction of access restrictions for traditional diesel vehicles in urban areas. While some cities have begun to implement such restrictions (e.g. Milan (IT), Utrecht (NL)), their limited scope have led to scepticism among logistics service providers regarding their impact on furthering the development of sustainable delivery models.

Furthermore, the absence of a coherent national strategy was also criticized, with Interviewee H from the Netherlands stating:

> *"What's also not helping is that the national government is not having any long-term strategy."*

Interviewee F echoed this concern about Italy, observing that there are very fragmented efforts across municipalities, requiring a more centralized push towards implementing policy.

4.1.2 Barrier: Operational costs and challenges

Operational cost emerged as another significant barrier to scaling up sustainable delivery models. Interviewees A, B, E, F, H, J and L emphasized that the logistics sector typically operates on very small profit margins, making any increase in delivery cost a crucial operational concern. In the case of upscaling delivery models towards electrification, the cost issue is not limited to solely the purchase price of vehicles but encompasses the broader conversion of logistics infrastructure, including charging facilities. Additionally, the longer charging times will have to be considered, causing a potential shift in operations.

Interviewees H and G further highlighted that if sustainable delivery options were to become the cheaper alternative, adoption would likely accelerate. As Interviewee F explained:

> *"All that helps is to increase the cost of gasoline, decrease the cost of electrification, which will help the electrification roadmap in the Netherlands."*

This point is further emphasized by interviewees A and F, stating that the setting up of charging stations is an additional large financial burden, which is not present when looking at purchasing diesel vehicles, extending the period to scale up electrification efforts both in Italy and Belgium.

4.1.3 Barrier: Availability of energy and charging

An additional barrier frequently mentioned in interviews A, B, C, F, H, I, J, K and L concerns the availability of electricity and the associated challenges in establishing private charging infrastructure. As companies transition toward electric delivery fleets, the ability to install cost-effective charging solutions becomes critical. Public charging stations, while more widely available, are significantly more expensive, making private infrastructure a more viable long-term solution. Interviewee F emphasized this point and pointed out that public chargers would only be a reasonable alternative if long-term contracts could be secured to match the electricity prices typically paid at private warehouse-based chargers. However, the setting up of charging

infrastructure at existing warehouses is often met with grid capacity constraints, preventing the installation of such facilities. This constraint has, in turn, forced some companies to consider relocating to new business sites with better grid access and higher potential for charging infrastructure development, as further noted by Interviewees F and H.

4.1.4 Opportunity and barrier: Introduction of parcel lockers

The implementation of parcel lockers in urban logistics represents a nuanced opportunity for upscaling sustainable delivery models, though it does not come without its challenges. Firstly, parcel lockers are seen as a promising solution to reduce the frequency of failed home deliveries. As Interviewee A notes:

> *"a high percentage of missed delivery currently occurs"*

and their strategy involves encouraging customers to change their preference of delivery and opt for parcel lockers instead. This shift could reduce the number of repeated delivery attempts, thereby lowering the overall number of trips required.

However, two major barriers complicate the scalability of parcel lockers as a sustainable solution. Firstly, the lack of interoperability between companies' IT systems hinders the development of a decentralized, shared locker infrastructure. As Interviewee E explains:

> *"We are working in that direction, but we are still not ready because of barriers in the technical integration"*

highlighting the costly nature of implementing white-label lockers. Secondly, there is concern about the unintended consequences on consumer behaviour. While lockers may reduce delivery trips and stops, they could simultaneously increase customers' travel, especially if consumers end up driving to parcel lockers. Interviewee I cautions that:

> *"If we deliver to a service point (or parcel locker) and the consumer has to go there to pick it up, you actually create more movements".*

4.1.5 Opportunity and barrier: Zero- and low-emission zones

The introduction of zero- and low-emission zones emerged as one of the most promising policy mechanisms driving the adoption of sustainable delivery models, particularly the uptake of zero-emission vehicles.

In the interviews, several variations of such policies that restrict access for diesel-powered vehicles to urban areas, thereby incentivizing companies to transition toward cleaner alternatives, were discussed. Interviewee E emphasized the importance of such zones, arguing that they are often

"the only way that large companies will be forced to adopt their current delivery practices."

In Belgium, a more collaborative approach was taken, where low-emission zones were designed in consultation with the logistics service provider, allowing for tailored adjustments that ensured essential addresses remained accessible while still promoting zero-emission delivery. In contrast, Norway has yet to implement such zones, but Interviewee L expressed readiness and support for their introduction, stating:

"So basically, we are very pro that, but it has not materialized in Norway yet. If it would come, we would be ready to operate within those frameworks."

In Italy, Interviewees D, E, and G view zones as a potentially valuable mechanism to increase the cost of diesel van usage or phase them out entirely, yet confidence in this approach remains low without broader implementation. Interviewee O noted that after the sudden introduction of access restrictions to a city:

"Something like 30% of orders could not be picked up"

illustrating the operational challenges posed by the introduction of these policies.

This problem is further emphasized by Interviewee E, by stating that the introduction of a large Zona a Traffico Limitato (ZTL; Limited Traffic Area) in certain Italian cities makes it impossible to complete all deliveries utilizing only one vehicle, pushing companies to send more than one vehicle into these zones to complete delivery activities, causing the policy to have an unintended consequence. This was further emphasized by Interviewee I in the context of the Netherlands, stating that the push towards tighter access restrictions.

"Makes your route very inefficient, … we go in with more vans than required, because of the time windows."

Interviewee F further emphasizes this point by stressing that the simple banning of diesel vehicles is no longer the most efficient way to get companies to become more sustainable stating:

"It's now all dependent on how you sustainably organize your activities. How sustainable can you be in organizing and optimizing your transport and logistic activity, which is very different from just stating how green your entire fleet is."

4.1.6 Opportunity: Governmental support and collaboration

Interviewees A, C, D, G, H, J, K, L, M, N and O emphasized the importance of governmental support and collaboration in driving the further upscaling of sustainable delivery models. It was argued that market-driven solutions alone are insufficient to shift the behaviour of larger logistics companies, necessitating active governmental intervention. As firms become increasingly data-driven, they possess valuable insights into which innovations and policy mechanisms can effectively foster sustainability within supply chains (Interviewee O, F). Consequently, many participants called for more structured public-private dialogues, where delivery companies are actively involved in shaping policies that promote sustainability without compromising operational efficiency.

In Belgium, interviewee A elaborated that such collaborative efforts are already underway and were cited as a promising example of effective strategy, as it ensures that policy moves at a pace that is appropriate for the upscaling of the logistics sector. Interviewee A highlights that their strategy to introduce company specific low-emission zones for various cities was planned with:

> *"a distribution of different cities, not the federal government, but more local political actors"*

and has led to great success in aligning political and company strategic outlook.

Interviewee O further stressed this need for flexibility and dialogue, stating, that:

> *"We really need to get the conversation simply going with policy makers,"*

as they see that upscaling sustainable delivery solutions should not be forced by policy but rather encouraged and then designed and executed by the companies themselves.

Interviewee F further emphasized this point, stating that additionally to collaboration, in the Italian context, there needs to be an increase in the trust that city councils have in the logistics operators to effectively design policy and ensure that policy can be implemented operationally efficient.

4.2 Emerged key barriers and opportunities for scaling delivery model, in specific for active modes

Next to the findings in general, this section provides a nuanced understanding of systemic factors influencing the scalability of sustainable delivery models and the specific challenges and opportunities associated with active transportation modes, thereby enabling more targeted and context-sensitive recommendations for CodeZERO.

Analysing the contextual data, this clearly indicated that specific considerations for scaling delivery models rely on active transportation modes, such as cargo bikes, cargo trailers, and walking, typically in conjunction with micro-hubs. These insights of key barriers and opportunities go beyond general opportunities and barriers in urban logistics, offering a more targeted perspective on the transition toward sustainable last-mile delivery (see Figure 4.1).

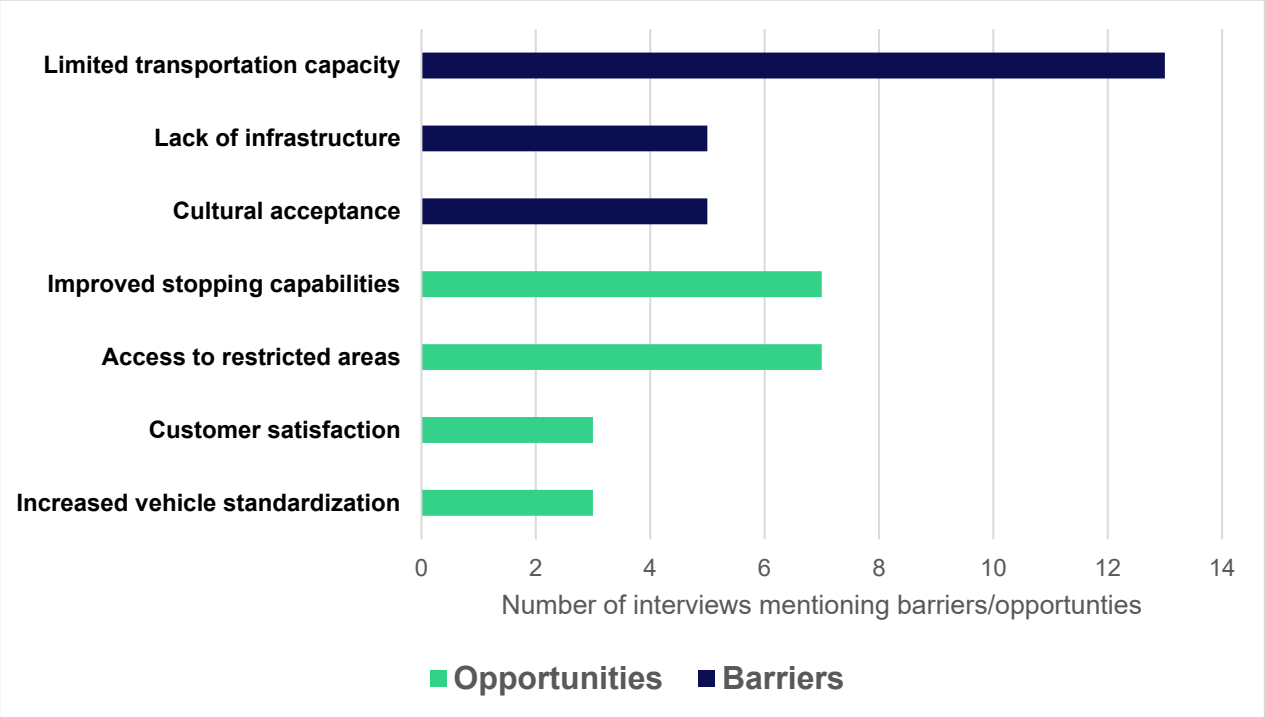

Figure 4.1: Key barriers and opportunities for scaling delivery models, in specific for active modes

These seven identified key barriers and opportunities, for scaling delivery model, in specific for active modes, show a primary association with *municipal* actors, and secondarily with logistics service providers on the supply side, and thirdly with the *customers*, on the demand side (see Figure 2.1). Barriers and opportunities are further elaborated on in the following subsections.

4.2.1 Barrier: Limited transportation capacity

One of the most frequently cited limitations in scaling delivery operations using active transportation modes - such as cargo bikes and trailers - is their restricted carrying capacity. This concern was raised in thirteen out of fifteen interviews, particularly in the context of high-volume e-commerce logistics or in relation to delivery of large-scale products. Unlike vans, which can accommodate

large quantities of parcels in a single trip, cargo bikes are significantly constrained in terms of volume and weight.

Interviewee I emphasized this point, stating:

> *"we have bikes … But with the type of work that we do and very high density of parcels within locations, for our type of work it's better to have a van and go into the area where you deliver once, be there the whole day and go out once".*

This highlights the operational efficiency vans offer in dense delivery zones. Furthermore, not all e-commerce flows involve small packages; larger items such as furniture or B2B shipments often exceed the capacity of cargo bikes. Interviewee F noted that

> *"B2B parcels were simply too big"*

underscoring the mismatch between cargo bike capabilities and certain logistical demands.

A key disadvantage identified is that a full transition to cargo bikes would necessitate a substantial increase in the number of vehicles and trips to match the delivery volume of a single van, potentially undermining the environmental and logistical benefits of active transport modes.

4.2.2 Barrier: Lack of infrastructure

Another significant barrier is the lack of appropriate cycling infrastructure, as emphasized across multiple interviews. Interviewee O stated:

> *"we don't have a proper infrastructure for cycling"*

pointing to this being the foundational limitations that hinder the scalability of cargo-bike logistics, particularly in the Italian context. They further argued that improved infrastructure could serve as a catalyst, initiating a chain reaction that would enable the upscaling of cargo-bike deliveries.

While some cities have implemented dedicated cycle paths separated from vehicular traffic, these are often inefficiently designed and fail to connect frequently travelled routes. Interviewee G highlighted this issue, noting

> *"Because it's not the fastest way to get from point A to point B"*

which undermines the operational efficiency of cargo bikes. As a result, delivery bikes are frequently forced to use regular roads, exposing them to the same traffic conditions as motor vehicles. This negates one of the key advantages of cargo bikes - namely, their ability to bypass

congestion - and poses a challenge even when larger-capacity bikes are introduced to address volume limitations discussed in Section 4.2.1.

Interviewee G further explained that under such conditions,

> *"there is no longer a traffic advantage for these bicycles"*

making them equally vulnerable to delays and inefficiencies. Thus, without strategic investment in cycling infrastructure, the potential of cargo bikes as a sustainable delivery alternative remains constrained.

4.2.3 Barrier: Cultural acceptance

Another critical factor influencing the adoption of active transport modes for urban delivery is the acceptance of these modes by delivery personnel.

Resistance often stems from the discomfort associated with transitioning from vans or trucks to cargo bikes, which offer fewer physical protections and amenities. Interviewee A highlighted this challenge, stating,

> *"But it depends on the postman because it's a mindset that they must change switching between a van and a bike"*

underscoring the psychological and habitual barriers to change.

This issue is compounded by environmental conditions and urban topology. Vans provide shelter from adverse weather, making them more universally applicable across varying climates. In regions with extreme heat, such as Italy, or cold and wet conditions, such as the Netherlands or Norway, drivers using cargo bikes are directly exposed to these elements, which can deter adoption. Several interviewees suggested that the most effective strategy for integrating cargo bikes into delivery operations is to recruit new drivers who are not yet accustomed to the expectations and routines associated with van-based delivery. These individuals may be more open to alternative transport modes and better suited to the operational demands of active mobility. Thus, workforce adaptation emerges as a key consideration in the successful scaling of cargo-bike logistics.

4.2.4 Opportunity: Improved stopping capabilities

An important operational advantage of cargo bikes, as emphasized by Interviewees A, C, D, E, G, M and N is their enhanced manoeuvrability and minimal spatial footprint in dense urban environments.

Unlike vans, cargo bikes can stop and park with ease in city centres without obstructing traffic flow, a feature that becomes increasingly valuable as urban access for larger vehicles becomes more restricted. This logistical flexibility allows for more efficient deliveries in congested areas and reduces the need for designated loading and unloading zones. Interviewee G highlighted this benefit in the context of urban accessibility, noting that cargo bikes can reach consumer residences more directly, thereby streamlining the delivery process.

Furthermore, the reduced spatial impact of cargo bikes contributes to a lower overall delivery footprint, both in terms of physical space and environmental disruption. This positions cargo bikes as a viable and efficient alternative for last-mile delivery in cities facing growing pressure to reduce traffic congestion and improve urban mobility.

4.2.5 Opportunity: Access to restricted areas

The ability of cargo bikes to access restricted urban areas presents a distinct logistical advantage in last-mile delivery, particularly in city centres where motorized vehicles are increasingly prohibited. This capability complements the benefits discussed in Section 4.2.4 regarding spatial efficiency and manoeuvrability. In many European cities, pedestrian zones and traffic-restricted areas pose challenges for conventional delivery vans, yet companies still require reliable access to these locations. Interviewee E illustrated this point, stating:

> *"What we do when there are very big pedestrian areas such as in Florence for example, then in those cases the only way is to deliver with the cargo bike."*

This highlights the strategic role cargo bikes can play in maintaining service continuity in areas inaccessible to larger vehicles.

Furthermore, this operational niche allows companies to optimize their delivery routes by matching specific conditions, such as distance, parcel volume, and weight, to cargo bike capabilities. Interviewee A explained:

> *"If the round is about 25 kilometres in length that can be done in with a bike and if the number of parcels on the round is not too high"*

indicating a targeted approach to route planning that leverages the strengths of cargo bikes. As such, cargo bikes not only offer a sustainable alternative but also fill a critical gap in urban logistics by enabling access to otherwise unreachable delivery zones.

4.2.6 Opportunity: Customer satisfaction

Another opportunity highlighted by interviewees D, G and L is the notably high level of customer satisfaction associated with deliveries made via cargo bikes.

This was particularly emphasized by couriers operating in Italy, where both interviewee G and interviewee D reported that customers consistently express greater satisfaction when receiving packages by bike compared to traditional delivery vans. Interviewee G noted:

> *"we have very good… commercial feedback"*

and further shared that customers often inquire why bike deliveries have ceased when operations revert to van-based methods, indicating a clear preference for the more sustainable and personable delivery approach.

Interviewee D reinforced this observation through their customer base, stating:

> *"People that choose our service are very, very happy,"*

with additional survey results from their contracting company confirming that bike-based deliveries yield higher satisfaction scores.

These findings suggest that beyond environmental and logistical benefits, active delivery modes such as cargo bikes can enhance the customer experience, offering a compelling incentive for companies to invest in and scale such solutions.

4.2.7 Opportunity: Increased vehicle standardization

An additional opportunity identified by Interviewees G and O is the need for greater standardization within the last-mile delivery sector, particularly concerning emerging vehicle types such as cargo bikes and light electric vehicles (LEVs).

Standardization at a European-wide level was seen as a critical enabler for scaling sustainable delivery operations, as it would reduce the complexity and cost associated with adapting logistics strategies to diverse national and municipal contexts. Interviewee G noted that:

> *"Big companies are looking for standards. This is another limitation of cargo bikes,"*

while Interviewee O emphasized the challenge of scaling across borders due to limited manufacturer availability:

> *"Those (cargo-bike) manufacturers are few and far between and so it's very hard for companies like us to help those organizations scale across borders."*

4.3 Analysis from geographical context perspective

4.3.1 In general

Although the interview sample size was limited, the findings reveal notable geographical differences in the transition toward sustainable delivery models across Europe. Interestingly, the interviews reveal that one important factor to scaling-up sustainable delivery models is the cultural acceptance of receivers, noting that the transition towards sustainable delivery models isn't purely based on decisions made in the logistics market or by governmental organisations.

In the Netherlands and Belgium, the transition is currently centred on the adoption of electric vehicles (EVs). However, this shift is primarily constrained by limitations in grid capacity and charging infrastructure, despite the early implementation of access restrictions such as zero-emission zones. These infrastructural challenges were consistently highlighted as key barriers in both national contexts.

In Italy, access restriction zones are also being introduced, albeit in a less centralized and coordinated manner. This decentralization necessitates context-specific operational adjustments by individual logistics companies. The Italian case reflects a broader lack of collaboration between governmental bodies and logistics operators, a theme that was also emphasized in the Dutch context.

Conversely, the Belgian interview revealed a more successful model of collaboration between industry stakeholders and government authorities. This partnership has facilitated the establishment of designated low-emission zones without compromising operational efficiency.

In Norway, no formal zonal restrictions are currently in place. In the case of the interviewee, the transition toward zero-emission mobility was driven entirely by internal company policy, rather than external regulatory pressures.

In Norway, no formal zonal restrictions are currently in place. In the case of the interviewees, the transition toward zero-emission mobility was driven entirely by internal company policy, rather than external regulatory pressures. Additionally, the parcel locker adoption in Norway is largely driven through cultural acceptance of out-of-home deliveries. Since Norway has long had a culture of individuals picking-up parcels at local post offices and more recently dedicated pick-up points, parcel lockers are quick to pick-up higher volumes of packages.

4.3.2 Adoption of active modes

The contextual data further indicate that the adoption of active transportation modes varies significantly across the countries analysed. In Italy, *cultural attitudes* present a substantial barrier to the uptake of active transportation, a challenge compounded by *policy frameworks* that lack a strong emphasis on developing supportive infrastructure.

In contrast, the Netherlands and Belgium benefit from well-established *infrastructure* that enables the integration of active transportation into logistics operations. This existing foundation not only facilitates the adoption of active modes but also enhances their efficiency for specific delivery routes within the supply chains of the logistics service providers studied.

Therefore, to effectively scale sustainable delivery models across Europe, it is essential to address and account for the key barriers and opportunities identified in the various geographical contexts.

5 Conclusions

This study provides a comprehensive exploration of the barriers and opportunities associated with scaling zero-emission delivery models for e-commerce in urban contexts across Europe in general and for active transportation modes in specific. Through an exploratory qualitative approach, drawing on semi-structured interviews with logistics service providers and e-tailers, the research has illuminated both systemic and context-specific factors that influence the feasibility and effectiveness of sustainable delivery innovations.

The findings underscore the pivotal role of governmental support and collaboration in enabling the transition to zero-emission logistics, as further outlined by Aifandopoulou & Xenou (2019), Castillo et al. (2024) and Timms (2014). While policy interventions such as zero-emission zones and parcel lockers present promising avenues for change, their success is contingent upon coherent design, stakeholder engagement, and operational alignment (Motloung et al., 2024; Schnieder et al., 2021). Conversely, persistent barriers including grid constraints, ineffective policy frameworks, and high operational costs, highlight the need for more integrated and informed policymaking that reflects the realities of urban logistics.

Focusing specifically on the upscaling of active modes of transportation, several limitations were identified in the interviews, including restricted transport capacity and insufficient infrastructure, which are further highlighted by Colonna et al. (2025), Melo et al. (2014) and Verlinghieri et al. (2021). Nevertheless, active modes were further discussed to have distinct advantages over conventional delivery methods. These include improved stopping capabilities in urban areas, easier access to restricted zones and enhanced customer satisfaction, which align with findings by Browne et al. (2011) and Colonna et al. (2025). These benefits position active transport as a viable complement to broader zero-emission logistics strategies, provided that infrastructural and societal barriers are adequately addressed.

The study also reveals significant geographical variation in the adoption and scalability of sustainable delivery models. Differences in infrastructure readiness, regulatory environments, and cultural attitudes necessitate tailored strategies that are sensitive to local conditions. Active transportation modes, while offering environmental and operational benefits, face limitations in capacity, infrastructure, and workforce acceptance, further reinforcing the importance of context-aware planning.

Importantly, the research demonstrates that a universal delivery model is neither feasible nor desirable. Instead, diversification based on delivery area, freight type, and regulatory context is essential. Replication of successful models requires not only technical and economic viability but also alignment with local governance structures and stakeholder priorities.

The findings of this study also align with previous results from CodeZERO T3.2 and other relevant sources in literature, such as Klein & Popp (2022), and Beck, Esquillor, Zarei, Froes, Hauswald, Giannakopoulou & Flämig (2025), as they underscore the critical role of consumer behaviour and cultural acceptance in facilitating the successful transition and upscaling of zero-emission delivery models. Our findings indicate that regions where consumer behaviour is strongly tied to home delivery or individual convenience often encounter slower adoption rates, even when technological and regulatory frameworks are supportive. This relationship underscores the importance of aligning technological innovation with cultural norms. In Norway, the normalization of locker use has reduced last-mile emissions and improved delivery efficiency, illustrating how cultural readiness can accelerate systemic change. Comparative analysis across countries indicates that cultural acceptance is not merely a passive backdrop but an active driver of transition success. Nations

that integrate behavioural insights into policy and business strategies are better positioned to overcome barriers and capitalize on opportunities for scaling zero-emission delivery models.

The insights generated through this study will inform the continued development and refinement of CodeZERO solutions, particularly in the context of pilot evaluations and broader replication efforts. While the limited sample size and scope of interviews present constraints, the findings offer a valuable foundation for future research. Subsequent studies should expand stakeholder engagement, apply structured methodologies such as Q-analysis, and explore underexamined strategies including asset sharing, behavioural nudging, and the integration of logistics into urban planning frameworks.

In conclusion, scaling zero-emission delivery models demands a multifaceted approach that balances technological innovation, policy coherence, and stakeholder collaboration. Only through such an integrated strategy sustainable urban logistics can be realised at scale across diverse European contexts.

5.1 Limitations

This study provides valuable insights into the conditions necessary for scaling innovative delivery models for e-commerce in urban environments. However, some limitations must be acknowledged.

First, the research is based on a limited number of interviews, both in terms of geographical coverage and supply chain positions. As such, the findings should be interpreted as exploratory rather than representative. The restricted sample size may have constrained the diversity of perspectives, particularly from small and medium-sized enterprises (SMEs) and varied freight flows.

Second, the geographical distribution of interviewees was uneven, which may have influenced the comparative analysis across national contexts. While the study highlights important regional differences, these insights would benefit from further validation through a broader and more balanced sample.

Third, the exploratory nature of the research limits the generalizability of the findings. Future studies should adopt more systematic methodologies and include a wider range of stakeholders to deepen understanding of the barriers and opportunities for scaling sustainable delivery models. Q-methodology presents a promising avenue for follow-up research. This approach enables the identification of subjective viewpoints and the mapping of dominant perspectives among stakeholders through structured statements (see, for example, van Duin et al., 2018). Two themes emerged prominently from the findings: the prevailing focus on zero-emission vehicle technologies and the pivotal role of government in shaping logistics policy. Future research should also investigate alternative strategies such as asset sharing, consumer behaviour nudging, and the integration of logistics into urban planning—areas that remain underexplored but are critical for long-term sustainability.

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7 Annex

7.1 Statements

Statement	**Category**
Pricing is the most effective tool for prompting customers reconsider their ordering behaviour.	Demand
Most customers are expected to use a car to collect orders from the pick-up point.	Demand
If competitors do not impose charges for less sustainable delivery options, I am unlikely to do so either.	Demand
Delivery time slots are determined by service level considerations rather than route optimization.	Demand
My delivery model prioritizes service, emphasizing speed and value-added services.	Demand
I offer customers flexibility in the mode of transport used for goods.	Demand
Customers who are difficult to access - due to e.g. low-emission zones- are currently excluded from my service area.	Demand
The default delivery option is linked to the preferred customer's choice.	Demand
The location and accessibility is key for success of a pick-up location.	Demand
When recipients are not at home, redirecting deliveries to neighbors enhances distribution efficiency and reduces delivery-related disturbances.	Demand
Educating and incentivizing consumers to select sustainable delivery options is key in contributing to the development of more efficient delivery models.	Demand
Incentivizing receivers to select eco-friendly delivery options is essential for promoting sustainable last-mile logistics.	Demand
Receivers must be incentivized to opt for environmentally sustainable delivery alternatives.	Demand
A more efficient delivery model can be established by educating and incentivizing customers (receivers) to choose sustainable delivery options.	Demand
If access restrictions are tightened for certain urban areas, customers in those zones are subject to higher delivery charges.	Product
I support municipal policies that grant access to designated areas for preferred suppliers operating zero-emission vehicles.	Product
Dynamic reservation of unloading zones enhances delivery efficiency.	Product
In car-free neighborhoods, logistics vehicles must be granted exemptions for access.	Product
Municipalities should support parcel lockers in public spaces.	Product
Municipalities should establish regulatory frameworks enabling them to mandate large companies to outsource last-mile delivery to a designated sustainable, socially responsible, and locally rooted provider.	Product
Access restrictions serve as a more effective catalyst for transforming delivery models than emission-based regulations such as zero-emission zones.	Product
The uptake of electric vehicles is expected to occur autonomously due to EU vehicle production regulations; therefore, no local regulation is required.	Product
In order to stimulate electric vehicles, they should receive exemptions compared to conventional vehicles such as wider time windows and access to bus lanes.	Product

A shift in delivery models is only contingent upon increasing the cost of existing practices, either through direct pricing mechanisms or indirect regulatory measures.	Product
Restricting car access to urban pick-up points incentivizes last-mile collection by foot or bicycle, promoting more sustainable mobility patterns.	Product
To promote fair competition, parcel delivery providers should be permitted to install their own lockers in public spaces.	Product
To reduce dwell times, municipalities should substantially expand the availability of unloading zones, in specific within residential areas.	Product
The only way to scale investment in electric vehicle fleets is by implementing a zero-emission zone.	Supply
Cargobikes and light electric freight vehicles present a viable alternative to conventional (electric)vans.	Supply
Logistics service providers need to be incentivized to choose eco-friendly delivery options.	Supply
Assigning a designated delivery provider per neighbourhood enhances significantly logistical efficiency and reduces the negative externalities of home deliveries.	Supply
Integrating pick-up points into the delivery model offers greater efficiency compared to home delivery.	Supply
Social responsibility is incentivized by granting operational privileges, such as extended delivery time windows, to companies demonstrating socially responsible practices.	Supply
Brand visibility in the city center is a key argument for the continued operation of in-house logistics.	Supply
Technology and data integration, such as real-time tracking and AI-driven demand forecasting, underpin the development of a sustainable last-mile delivery system.	Supply
E-commerce can be more successfully enrolled when the density of pick-up points is increased.	Supply
Delivery pricing is differentiated based on the customer's geographic location.	Supply
Improvements in delivery efficiency are primarily driven by advancements in route optimization algorithms.	Supply
Crowdsourcing facilitates efficient last-mile delivery by leveraging distributed local resources.	Supply
Consolidating return collections from customers, including those for third-party suppliers, enhances delivery model efficiency.	Supply

7.2 Interview outline

Overarching main questions:

- What are the main external barriers that are currently hindering your transition towards more sustainable delivery models?
- What do you see as the biggest opportunities driving the adoption of sustainable delivery models?

1. **Current practices and challenges:**
    - What are your current delivery models and practices?
        i. Delivery model completely based on consumer preferences?
        ii. Encouraged sustainable practices (i.e. pick-up points, pricing strategies?)
        iii. What determines time-slots or pricing? (efficiency, customer service)
        iv. What are current market dynamics with competition? (large vs. small companies, adoption of sustainable practices, price driven strategies)

	Barriers + External influences	*Drivers + motivations*
Finance	Are you willing to impose costs on your customers for less sustainable alternatives? Are sustainable options more costly for you?	What type of financial incentives would help you to transition towards more sustainable delivery options?
Customers	Are customers interested in being able to utilize more sustainable options? Even at the cost of service level (i.e. slower delivery speed)?	Do customer preferences or behavior influence the ability to offer sustainable options (i.e. pricing)? Is pricing, education or incentivizing the customer an effective strategy? Or is education needed?
Regulation	What is the current impact of regulations, municipal policies or access restrictions? If restriction were/are too high, would you charge these customers more or not deliver to them anymore?	What regulatory support or limitations (i.e. zero-emission zones, access restrictions, extended time-windows) would help you to transition towards more sustainable delivery options? Should ZE vehicles receive more exemptions?
Infrastructure	Is infrastructure facilitated? Or is additional facilitation required? i. (dynamic) unloading zones ii. Charging stations iii. Pick-up points (in public space?)	What type of infrastructure facilities would you require to become more sustainable?

2. **Future outlook**
    - What could ideally be done to facilitate further adoption and up-scaling of sustainable delivery models?
    - Do you see the transition more as market- or policy driven?
    - Will the uptake of electric vehicles happen automatically, due to EU regulations?
    - Additional possible suggestions to overcoming barriers

7.3 Anonymized interviews

Due to privacy concerns, the interview summaries presented here are anonymized minutes of each of the interviews. For information about accessing the full transcripts of the interviews, please contact the authors of this deliverable.

7.3.1 Interviewee A

Green Delivery Initiatives and Eco Zones

The interviewee outlined the structure of delivery operations in Belgium, emphasizing the implementation of eco zones designed for emission-free deliveries. The discussion covered the current proportion of green deliveries, challenges in scaling electrification, and strategies for sustainable logistics expansion.

Cargo Bike vs. Van Delivery Operations

The conversation explored decision-making processes between using cargo bikes and vans. Factors influencing these choices included cultural attitudes, geographic conditions, urban infrastructure, and weather-related constraints.

Parcel Lockers and Pick-Up Point Network Expansion

The interviewee described the rapid growth of the parcel locker and pick-up point network. Motivations included improving accessibility and sustainability. The discussion also touched on partnerships with private actors and the financial and operational impacts of this expansion.

Customer Mindset and Promotional Campaigns

The interview addressed the prevailing customer preference for home delivery in Belgium. Efforts to shift this mindset were discussed, including pricing strategies and promotional campaigns that highlight environmental benefits.

Parking and Urban Delivery Challenges

The interviewee explained the difficulties in securing parking for delivery vans in city centers, noting competition with other delivery services. These challenges were presented as further incentives for adopting cargo bikes.

Technical and Infrastructure Barriers to Electrification

The conversation included an overview of technical limitations of electric vehicles, such as range and charging infrastructure. The operational model for van usage was also discussed in the context of these constraints.

Open Locker Network and Interoperability Challenges

The issue of closed locker networks was discussed, along with government interest in creating open networks. Technical and organizational barriers to interoperability between different operators were highlighted.

7.3.2 Interviewee B

A logistics expert provided a comprehensive overview of parcel and freight operations in Belgium, highlighting the dual-network structure, the introduction of a value-added service offering in-home delivery and installation, and the company's evolving focus on both B2B and B2C markets.

- Network Structure: The organization operates separate freight and parcel networks with distinct vehicles, depots, and management, while sharing corporate services. The freight network also serves the broader Benelux region.
- Market Focus: Originally B2B-oriented, the company has shifted toward B2C, especially following the COVID-19 pandemic, with growing volumes from e-commerce and larger online purchases.

Challenges and Adoption of Out-of-Home Deliveries

The slow adoption of out-of-home delivery models in Belgium was discussed, including cultural factors, market dynamics, and environmental implications.

- Customer Mindset and Market Leadership: Belgian consumers have been slow to adopt parcel shops and lockers, influenced by dominant market players and limited promotion.
- International Comparison: Belgium lags behind neighboring countries in out-of-home delivery adoption but may follow broader European trends over time.
- Environmental Impact: Consolidated deliveries to lockers or shops can reduce emissions and congestion, though benefits depend on how customers travel to collect parcels.

Electrification and Regulatory Environment

The conversation addressed fleet electrification goals, infrastructure investments, and the impact of low-emission zones.

- Electrification Targets: The organization aims to electrify 50% of its fleet by 2030, focusing on light commercial vehicles.
- Charging Infrastructure: All depots are being equipped with charging stations to support transport partners, with lessons drawn from neighboring countries.
- Scalability Challenges: A gradual transition is feasible, but a rapid shift to full electrification would pose significant logistical and financial challenges.
- Regulatory Landscape: Cities such as Ghent, Antwerp, and Brussels have implemented low-emission zones, with increasing restrictions on diesel vehicles.

Urban Delivery Model Adaptations

Operational adjustments in urban areas were discussed, including depot placement, alternative transport modes, and regulatory constraints.

- City Depots: Urban depots have been established to reduce driver travel time and support electric vehicle use.

- Active Transport Trials: Bike delivery trials received positive feedback but were financially inefficient due to parcel size and handling costs.
- Delivery Windows and Congestion: Restricted delivery times in pedestrian zones increase costs and reduce efficiency.

Engagement with Public Authorities

The logistics provider regularly engages with city governments to discuss urban delivery models and policy proposals.

- Consolidated Delivery Proposals: Municipal suggestions to consolidate deliveries and use a single carrier for last-mile logistics are viewed as commercially and operationally unrealistic.
- Cost Implications: Additional handling and infrastructure costs would likely be passed on to consumers, a concern shared by other industry stakeholders.

7.3.3 Interviewee C

Operational Focus and Regional Differences
The logistics provider is currently focused primarily on transportation, with varying challenges and opportunities across Europe.

- Regional Variation**:** Strategies differ significantly between western/northern and eastern/southern Europe due to cultural attitudes and approaches to sustainability.
- Emission Reduction as a KPI**:** Emission reduction is used as a key performance indicator to evaluate the cost-effectiveness of sustainability strategies, such as calculating the cost per metric ton of CO_2 reduced.

Energy Infrastructure and Electrification
Energy grid capacity and electrification challenges vary widely across countries.

- Grid Capacity**:** Some countries, like Norway, have robust energy grids, while others, such as Belgium or the Netherlands, face limitations.
- Warehouse Location and Energy Access: Grid availability influences warehouse placement. Local energy storage systems are being considered but require significant investment and are not yet cost-effective.
- Electric Vehicles**:** Range is no longer a major concern with modern models. While initial investment is high, maintenance costs are lower. Vehicles are charged exclusively on company premises due to the impracticality of public charging.

Urban Access and Delivery Innovation
Urban accessibility is increasingly constrained by pedestrianization and regulatory changes.

- Access Limitations**:** Traditional delivery vehicles face growing restrictions in city centers. Bikes and micro-hubs are being piloted to reach these areas.
- Scalability of Innovations**:** A network of planners and engineers facilitates knowledge sharing across regions and functions to scale successful innovations.

Weather Resilience and Year-Round Operations
Delivery operations are maintained throughout the year, requiring solutions that perform reliably in all weather conditions.

Drivers of Sustainability Transition
Three primary motivators are driving the shift toward sustainable delivery models:

1. Customer Demand**:** Some clients require sustainable delivery of their products and are willing to pay extra for it.
2. Legislation**:** Regulatory frameworks such as CSRD and EU Commission standards mandate sustainability adoption.
3. Economic Viability**:** In certain cases, alternative fuels are more cost-effective, accelerating adoption.

- End-Customer Influence**:** Final consumers are generally less concerned with the delivery method and more focused on receiving their goods.

7.3.4 Interviewee D

Consumer Choice Factors for Cargo Bike Delivery

The interviewee described key factors influencing customer preference for cargo bike delivery in Italy, including high satisfaction scores, reliable four-hour delivery windows, and competitive pricing for smaller orders.

- *Customer Satisfaction Metrics:* Survey scores for cargo bike deliveries consistently exceed 90 out of 100, well above the company's target of 76–77. The damage rate for packages is notably low at 0.08%.
- *Delivery Time Windows:* Customers benefit from guaranteed four-hour delivery slots (morning or afternoon), offering more convenience than traditional services requiring full-day availability.
- *Lead Time and Capacity:* Cargo bike deliveries typically have a longer lead time (around three days) compared to vans (one to two days), but allow for more precise scheduling.
- *Pricing Structure:* For orders under 10 kg, cargo bike delivery costs a flat rate of €3, while van delivery costs €5 for orders up to €60, making bikes more economical for small orders.

Barriers and Policy Challenges in Milan

The interviewee outlined the main obstacles to expanding cargo bike delivery in Milan, focusing on infrastructure and regulatory issues.

- *Infrastructure Limitations:* The lack of adequate cycling infrastructure restricts the efficiency and reach of cargo bike operations.
- *Policy and Regulation:* City policies limiting van and truck access are being implemented slowly and inconsistently, with many exceptions.
- *Lobbying Efforts:* Collaborative lobbying with courier companies, NGOs, and clients aims to push for stricter van regulations, though major players are not actively supporting these efforts.

- *Current Regulatory Environment:* Vans generally have access to all areas of Milan, with only minor restrictions or fees, offering little incentive to switch to cargo bikes.

Customer Education and Marketing

The potential of marketing and education to promote green delivery options was discussed.

- *Role of Education and Campaigns:* While education and campaigns are part of the strategy, current research indicates that cost remains the dominant factor in customer decision-making.

Operational Details of Cargo Bike Deliveries

The interview covered the logistics and limitations of cargo bike operations.

- *Vehicle Types and Pilots:* Traditional two-wheel cargo bikes are used, with pilot programs testing larger quadricycles for city center deliveries.
- *Delivery Destinations:* Most deliveries are to homes, with occasional drop-offs at urban collection points.
- *Load and Route Optimization:* Routes are optimized for efficiency, typically handling 10–12 orders per bike over one to two hours.

Cargo Bike Courier Market in Milan

The interviewee provided an overview of the local market.

- *Market Size and Structure:* Approximately 80 cargo bike couriers operate in Milan across six companies, some of which act as subcontractors for larger clients.

7.3.5 Interviewee E

Urban Delivery Regulation Challenges in Italy

The interviewee described the regulatory complexities affecting urban delivery operations in Italy, including restricted traffic zones (ZTLs) and pedestrian areas. The conversation focused on how these regulations impact e-commerce logistics and the strategies used to ensure compliance.

Vehicle Choice and Electrification Strategies

The interviewee outlined the approach to vehicle selection, including the use of electric vans, cargo mopeds, and cargo bikes. These choices are primarily influenced by regulatory requirements and operational needs. Broader electrification goals at the European level were also discussed.

Parking and Infrastructure Barriers

Challenges related to parking and loading zones were highlighted, including illegal occupation of designated areas and insufficient support from local governments to improve infrastructure for urban deliveries.

Lockers and Alternative Delivery Solutions

The role of parcel lockers as an alternative delivery method was explored. The interviewee discussed limitations in locker deployment, integration challenges, and the need for collaboration between public and private stakeholders to expand locker networks effectively.

Standardization and Data Challenges in Urban Logistics

The interviewee emphasized the importance of standardized and digitized access regulation data across cities to improve compliance and operational efficiency. Current inconsistencies were noted, along with the role of European initiatives aimed at addressing these issues.

Market Versus Policy Drivers for Sustainable Delivery

The discussion addressed whether sustainable delivery should be driven by market forces or government policy. The interviewee concluded that regulation is the key driver for large operators, while incentives are more critical for smaller companies.

Collaborative and Exclusive Delivery Models

Examples of collaborative and exclusive delivery models in Italian cities were shared, including cases where only one company is permitted to operate within ZTLs. The interviewee discussed the operational challenges these models pose for large logistics providers.

7.3.6 Interviewee F

Sustainability Strategies and Challenges

The representative outlined the company's sustainability goals and the challenges they face, including a target of carbon neutrality by 2050, the use of sustainable aviation fuel (SAF), and difficulties in transitioning ground fleets to greener alternatives.

- Carbon Neutrality by 2050: Achieving full carbon neutrality is a major challenge due to the diversity of delivery methods and aviation-related emissions.
- Sustainable Aviation Fuel: SAF is the primary strategy for reducing aviation emissions, but supply limitations have led the company to support book-and-claim systems at the European level.
- Ground Fleet Transition: Long-haul trucks are being converted to natural gas and biogas, but full electrification is hindered by operational needs and reliance on third-party service providers.
- Third-Party Delivery Constraints: Most last-mile deliveries are outsourced, limiting the company's control over vehicle types and requiring incentives to encourage electric vehicle adoption.

Urban Delivery and Last-Mile Logistics

The discussion covered the realities of last-mile delivery in Italian cities, including the use of access points, route optimization, and the impact of urban infrastructure and regulations.

- Access Points and Route Efficiency: Deliveries are consolidated at access points like stores and kiosks to reduce stops and emissions.
- Limited Control Over External Drivers: The company can only suggest route optimizations and vehicle types to contracted drivers, making sustainability enforcement difficult.
- Urban Space Constraints: City authorities focus more on congestion and space than emissions. Small, crowded city centers limit the feasibility of micro-hubs and bicycle deliveries.
- EV Infrastructure Challenges: Older facilities lack charging infrastructure, prompting the company to plan for EV support in new locations.

Bicycle and Micro-Hub Delivery Solutions

The use of bicycles and micro-hubs was discussed as a potential solution for urban deliveries, with effectiveness varying by city infrastructure and parcel characteristics.

- Bicycle Delivery Limitations: Professional bikers are used for small parcels in select cities, but limitations include parcel size, delivery range, and lack of space for micro-hubs.
- Micro-Hub Feasibility: While effective in cities with wider streets, micro-hubs are difficult to implement in dense urban areas with limited space.

Policy, Regulation, and City Collaboration

The representative described the evolving regulatory landscape and the need for better collaboration between logistics providers and city councils.

- Pedestrianization Trends: Increasing pedestrian zones, especially in tourist areas, create hybrid zones that challenge both logistics operations and resident satisfaction.
- Post-Pandemic Urban Dynamics: The pandemic altered city center dynamics, raising concerns about safety and livability alongside delivery efficiency.
- Need for Collaboration: Greater trust and cooperation between city councils and logistics providers is essential for realistic and mutually beneficial solutions.
- Regulatory Impact: Frequent changes in access and electrification requirements disrupt operations and complicate cost-effective service delivery.

Shifting Priorities in Urban Logistics Sustainability

The conversation concluded with a reflection on how sustainability priorities have evolved.

- Focus on Operational Optimization: The main challenge is now optimizing logistics operations rather than simply increasing the number of green vehicles.
- Changing Expectations: Post-pandemic policies and consumer expectations emphasize livability, congestion reduction, and efficient space use over emissions alone.

7.3.7 Interviewee G

Overview of Cycle Logistics Operations

The interviewee provided an overview of their company's activities in Italy, including client types, operational regions, and involvement in European sustainability projects.

- Company Activities and Clients: The company primarily uses cargo bikes for deliveries, with trucks only used to transport goods from client warehouses to city depots. Clients include major parcel couriers, B2B distributors (e.g., wine and spirits), and small local businesses.

Challenges in Scaling Cargo Bike Logistics

The discussion covered barriers to expanding cargo bike logistics in Italy.

- Market Fragmentation: The logistics market is highly fragmented, with many small firms working for large couriers, making it difficult for alternative models to scale.
- Regulatory and Political Barriers: There is a lack of supportive regulation and political vision. Initial engagement with national authorities showed promise but stalled due to shifting priorities.
- Infrastructure and Vehicle Suitability: Cargo bikes designed for northern European cities struggle with Italian city infrastructure, such as cobblestones, leading to frequent breakdowns.
- Standardization Issues: The absence of standardized cargo bike platforms complicates integration with large logistics providers, who prefer truck-like standardization.
- Supplier Conflicts of Interest: Some suppliers to large couriers also rent vans, creating a disincentive to adopt cargo bikes.

Benefits and Feedback of Cargo Bike Deliveries

The operator highlighted the advantages of cargo bike logistics and the challenges of changing established practices.

- Productivity and Cost Efficiency: Despite high upfront costs (€18,000–20,000 per bike), cargo bikes are more cost-effective than vans in the long run due to lower operational expenses.
- Customer and Public Perception: Public perception has improved, with recipients appreciating bike deliveries, contributing to a cultural shift in cities served.
- Traffic and Congestion Advantages: Bikes are more efficient in narrow streets, reduce congestion, and occupy less public space than vans.
- Resistance to Change: Larger logistics firms and their suppliers are often resistant to adopting cargo bikes due to entrenched business models.

Workforce Recruitment and Motivation

Recruitment and retention of motivated riders is a strength for the company.

- Recruitment and Retention: The company receives many applications from individuals drawn to the ethical appeal of bike logistics, resulting in low turnover and a stable workforce.

Urban Planning, Infrastructure, and Policy Recommendations

The conversation addressed infrastructure limitations and policy needs.

- Cycling Infrastructure Limitations: Existing cycle paths are often unsuitable for cargo bikes due to size constraints and indirect routing, leading riders to seek more efficient alternatives.
- Impact of Low-Emission Zones: Traffic-restricted zones have increased demand for bike logistics, as bikes can access areas vans cannot.
- Need for Urban Logistics Planning: Comprehensive planning is needed to address parcel volume growth and its impact on public space, health, and city budgets.
- Standardization and Policy: National and European-level frameworks are needed to support sustainable logistics, though past efforts have struggled to maintain momentum.

Parcel Lockers and Alternative Delivery Solutions

The operator shared insights on parcel locker use and its implications.

- Locker Use Cases: The company has participated in projects using refrigerated lockers for grocery distribution, allowing customers to collect purchases after shopping.
- Limitations and Impact: Lockers help with failed deliveries and cash payments but may increase congestion if consumers drive to access them.

Political and Market Dynamics in Sustainable Logistics

The discussion concluded with reflections on the role of political support in driving change.

- Political Will and Industry Change: Without political facilitation, the logistics industry is unlikely to shift toward sustainability on its own, as market forces are insufficient to drive transformation.

7.3.8 Interviewee H

Impact of Local Government Regulations on Logistics Operations

The interviewee discussed how sustainability-focused decisions by local governments in Dutch cities, such as Amsterdam and Utrecht, often create operational challenges for retailers.

- Changing Exemption Policies: In Amsterdam, exemptions for heavyweight delivery vehicles previously renewed automatically, but now require annual renewal. This change has led to unexpected fines when exemptions lapse unnoticed.
- Vehicle Weight and Electrification Conflicts: Electrification efforts are complicated by weight restrictions, as electric trucks are heavier due to battery systems, making it difficult to comply with both sustainability and weight regulations.
- Time Window Restrictions: Delivery time regulations, such as APFA, limit access to city centers. Exceptions are needed for night deliveries, while wider time windows are now used as incentives for electric vehicle adoption.
- Standardization and Cost Implications: Non-uniform vehicle requirements across cities increase costs, as maintaining specialized fleets for each city undermines standardization and raises investment needs.

Business Case and Infrastructure for Electrification

The conversation explored the economic and infrastructural factors influencing the transition to electric vehicles.

- Electricity Pricing and Contracts: Retailers prefers charging vehicles at its own facilities to benefit from lower electricity rates. Public chargers are only used if contractually guaranteed similar pricing, as high costs undermine the business case.
- Charging Infrastructure Limitations: Limited truck charging infrastructure and the need for fair electricity contracts with loading bay vendors are major barriers to electrification.
- Battery and Range Developments: Current electric trucks offer 200–300 km per charge, sufficient for most routes. However, fast charging remains a challenge due to battery size and speed limitations.
- Creative Solutions for Energy Bottlenecks: Innovative approaches include mobile battery packs, shared infrastructure with neighboring sites, and transporting charged batteries between locations using conventional vehicles.

Policy Alignment and Industry Collaboration

The discussion highlighted the need for better coordination between local and national policies and described collaborative efforts among retailers.

- Local vs. National Policy Discrepancies: Local governments often implement stricter sustainability measures than national authorities, prompting retailers to develop independent long-term strategies.
- Joint Advocacy and Lobbying: Retailers coordinate responses to local proposals and escalate concerns through national industry organizations to influence broader policy.
- Negotiating Exemptions: Ongoing efforts aim to secure exemptions from municipalities to avoid store closures, with collective action emphasizing the urgency of regulatory flexibility.

Inefficiency of Alternative Delivery Models

Alternative delivery models using city hubs and smaller vehicles are seen as inefficient for grocery logistics.

- Full Truckload Efficiency: Direct store deliveries using full truckloads minimize vehicle numbers and energy use. Transferring goods to smaller vehicles at city hubs would require significantly more vehicles and energy, making it impractical.

7.3.9 Interviewee I

Last Mile Sustainability Transition

The interviewee discussed the progress of a major parcel delivery company in electrifying last-mile delivery in the Netherlands, including market share, fleet composition, and the operational rationale behind vehicle choices.

- Electrification Progress: Electrification efforts began about a decade ago. Currently, 90–95% of deliveries are performed using electric vehicles or HVO, with over half being fully electric, supported by a fleet of around 3,000 electric vehicles.
- Vehicle Choice Rationale: While alternative methods like bikes and small vehicles are tested, vans remain the most efficient for high-density parcel deliveries. Smaller vehicles often lead to more traffic and inefficiencies.

- Operational Challenges with Alternative Vehicles: Deliveries to businesses with large parcels (e.g., shoe stores) are impractical by bike due to limited capacity. Vans allow for mixed deliveries and pickups in a single route.

Parcel Lockers and Service Points: Trends and Municipal Relations

The conversation explored the role of parcel lockers and service points, regional differences, and efforts to standardize approaches through collaboration with municipalities and national authorities.

- Regional Differences and Municipal Hesitancy: Locker adoption varies by region. Some municipalities support them for mobility reasons, while others hesitate due to aesthetic concerns and increased consumer movements.
- Challenges in Service Point Siting: Finding suitable locations is increasingly difficult, especially outside shopping areas, as shop-based service points face growing workloads.
- Standardization Efforts: Discussions with major cities and the national government aim to create a uniform process for locker placement, reducing policy variability.
- Impact on Mobility: Delivering to service points can increase traffic if consumers drive to pick up parcels, sometimes resulting in more movements than direct home deliveries.

Municipal Regulations and Their Impact on Operations

The interviewee described how municipal regulations affect delivery operations, including time windows, weight limits, and zero-emission requirements.

- Time Window Restrictions: Shrinking delivery windows and late store openings force multiple trips to the same street and require more vans, reducing efficiency.
- Weight Limitations: Restrictions like Utrecht's two-ton axle limit necessitate smaller vehicles, and electric vans are sometimes excluded due to their weight, undermining zero-emission goals.
- Municipal Collaboration: While regulations are often set unilaterally, the company is increasingly engaging with cities to advocate for practical solutions.
- Balancing Zero Emission and Operational Needs: Zero-emission requirements are manageable, but time window restrictions remain the most challenging, especially when misaligned with store operations.

Drivers of Electrification and Remaining Challenges

The motivations behind electrification and current limitations were discussed.

Motivations for Electrification: The transition began as an internal innovation project, later driven by regulatory pressures and customer expectations, with expansion enabled by vehicle availability.

- Charging Infrastructure Limitations: Barriers include limited charging infrastructure and parking space, which are difficult for the company to influence.
- Operational Advantages: A city hub structure with 130 small locations enables short delivery routes (20–25 km/day), making electrification more feasible.
- Vehicle Range and Rural Deliveries: Electric vans with 150–200 km range are sufficient for urban and rural deliveries, supported by nearby hubs.

Active Transportation and Delivery Bikes

The adoption of delivery bikes and related regulatory issues were explored.

- Driver Acceptance and Vehicle Suitability: Different drivers are recruited for vans and bikes. Larger, covered bikes are preferred for comfort and capacity, while smaller bikes are unsuitable for parcel sizes.
- Regulatory Challenges: Regulations vary, with some municipalities restricting bikes due to safety concerns. National authorities are considering moving delivery bikes onto roads, which may reduce practicality.

Ideal Scenario for Sustainable Urban Logistics

The expert shared a vision for efficient and sustainable urban logistics.

- Recognition of Logistics' Role: Cities should view logistics as essential, recognizing its role in delivery, food supply, and waste management.
- Public-Private Collaboration: Closer collaboration between cities and logistics providers is needed to develop balanced regulations that support both sustainability and operational efficiency.

7.3.10 Interviewee J

Delivery Model Overview

The logistics provider operates a modernized "milkman" model, where customers place orders via an app or website before a clear cutoff time. Delivery routes are planned with the principle of "never visit the same street twice," optimizing efficiency and minimizing travel.

- Time Slot Management: Customers receive time slots for delivery, which are shorter if deliveries are already scheduled in the area. A typical delivery occurs within a 20-minute window inside a 70-minute slot. A visual indicator highlights when the provider is already active in the area.
- Tour-Based Routing: The model is based on round-trip planning rather than on-demand service, resembling tour logistics rather than taxi-style delivery.

Fleet and Vehicle Strategy

Deliveries are performed using highly customized small electric vans (LEVs), optimized for urban logistics.

- Vehicle Characteristics: LEVs are charged at centralized hubs. Their range depends on battery age, with an ideal range of 60 km, though often less in practice.
- Routing and Vehicle Assignment: Each delivery tour is assigned a specific LEV based on battery status, age, range, and payload capacity. Charging strategies are individualized per vehicle.
- Vehicle Models: Two LEV types are used—one with a top speed of 45 km/h and another at 70 km/h. Payload affects range and performance.

Hub Location and Infrastructure

Hub placement is critical to operational success.

- Hub Radius and Customer Reach: The number of reachable customers within a hub's radius determines delivery efficiency. Families are the primary customer base.
- Charging Infrastructure: Charging capacity at hubs is constrained by electricity availability, requiring government support for higher grid connections.
- Urban Real Estate Challenges: High commercial property prices often push distribution centers to city outskirts, affecting delivery dynamics.

Urban Accessibility and Delivery Challenges

Urban environments present logistical challenges.

- Address Accessibility: In large cities, locating addresses can be time-consuming, increasing drop times.
- Traffic and Pedestrianization: Efforts to reduce car traffic and expand pedestrian zones limit vehicle access, making some addresses unreachable.
- Cargo Bike Consideration: Cargo bikes are being considered as an alternative for hard-to-reach areas, though no pilots are currently underway.

Operational Efficiency and Social Impact

The delivery model supports accessibility and sustainability.

- Village Penetration: High service penetration in villages without supermarkets improves accessibility for underserved populations.
- Parking and Drop Time: LEVs require minimal parking space, reducing drop times and minimizing urban disruption.
- Government Support: The current fleet benefits from public subsidies supporting sustainable transport.

7.3.11 Interviewee K

Supply Chain Strategy and Innovation

The logistics provider focuses on both sustainability and solutions for larger parcels, with an emphasis on innovation in delivery models.

Sustainability Transition and Electrification

The shift toward electric vehicles began in 2020–2021, largely driven by the introduction of zero-emission zones.

- Fleet Electrification: Around 20% of the van fleet is electric, with commitments to reach 100% by 2030 and achieve net zero by 2040 (aligned with SBTI targets).

- Cost and Maintenance: Electric vehicles are becoming more affordable and cheaper to maintain, making them increasingly attractive compared to diesel.
- Charging Infrastructure: Charging is primarily done at company sites. Public charging is not part of the current strategy yet. Range is no longer a major concern, but limited parking and space at distribution centers pose challenges.

Market Trends and Delivery Models

- C2C Growth: Significant growth in consumer-to-consumer deliveries, especially through platforms like Vinted.
- Parcel Lockers and Car-Free Zones: Parcel lockers and low-traffic areas are seen as opportunities to move away from traditional home delivery models. Municipalities require white-label locker solutions, prompting discussions about collaboration among major carriers.
- Commercial Viability: Locker locations need added value beyond parcel delivery to justify investment.

Collaboration and Customer Experience

- Home Delivery Collaboration: Joint delivery models are difficult because companies want direct customer interaction. Driver behavior and professionalism are considered key differentiators.
- Cargo Bikes: Limited application for cargo bikes, as small parcels handled by bikes still require vans for larger items, reducing overall efficiency gains.

7.3.12 Interview L

The interviewee provided an overview of three main delivery models used for their operations: parcel deliveries, store-based truck deliveries, and large order fulfillment via central distribution units. A recent expansion includes a new distribution unit located south of Oslo.

Use of Electric Vehicles and Sustainability Commitment

The representative clarified that last-mile deliveries in Norway are handled by third-party providers. Approximately 80% of dedicated trucks are electric, driven by the company's internal commitment to achieving zero-emission transport by 2025, rather than external regulations or customer demand.

Pilot Project for Alternative Delivery Methods in Oslo

A pilot initiative in Oslo aims to reduce delivery kilometers and environmental impact through the use of micro hubs and alternative delivery models. The project involves collaboration with local authorities and focuses on innovation in urban logistics.

Urban Parking and Delivery Logistics Challenges

The representative discussed challenges related to parking and unloading zones in Oslo. The city is working to design dedicated delivery spaces, with centralized delivery points offering benefits in terms of safety and operational efficiency, particularly for B2C deliveries.

Comparative Urban Delivery Policies in Europe

The conversation briefly compared Norway's position in sustainable urban logistics to other European countries. Norway is considered more advanced in some respects, facing fewer restrictions on diesel vehicles and trucks than countries like Italy.

7.3.13 Interviewee M

Parcel Locker Network Development and Strategy

A logistics expert described the development and management of a parcel locker network across Norway, Sweden, and Denmark, focusing on current utilization, expansion strategies, and operational challenges.

- Current Network Status: Norway has approximately 2,000 parcel lockers, with 500 over-utilized and 1,500 under-utilized. The goal is to double the share of parcels delivered via lockers from the current 12%.
- Utilization Strategies: Efforts include improving usage in underutilized areas, expanding lockers in high-demand zones, and connecting nearby lockers to balance capacity.
- Operational Adjustments: In busy areas, delivery frequency is increased, sometimes with two rounds per day. Pricing incentives encourage smaller parcel sizes to optimize locker space.
- Overflow Management: Overflow parcels are redirected to nearby lockers or returned to terminals. Drivers follow a fallback hierarchy, and SMS notifications prompt faster pickup, increasing capacity by up to 20%.

Urban Logistics and Delivery Methods

The conversation explored the evolution of urban delivery models and adaptations for different environments.

- Delivery Modal Split: The model has shifted from 98% pickup points to a mix of mailbox deliveries (over 50%), parcel lockers (12%), traditional home delivery (2%), and remaining pickups. Mailbox and locker deliveries are considered unattended.
- Vehicle Types: Electric mopeds and e-bikes are used for small parcels in urban areas, while vans handle larger items. In rural and winter conditions, electric carts and snow chains ensure service continuity.
- Winter Operations: Improved snow clearance in cities like Oslo supports continued use of small electric vehicles. Arctic regions rely more on cars, and delivery personnel are equipped for harsh conditions.
- Urban Planning Integration: Logistics considerations are integrated into urban development, including traffic limits, parking optimization, and safe delivery zones. Parcel lockers support car-free and low-traffic neighborhoods.

Locker Network Models and International Comparisons

Different locker deployment strategies and international practices were discussed.

- Three Strategies: These include replacing high-volume manned points with large lockers, deploying dispersed networks as home delivery backups, and extending manned networks with strategic locker placements.
- Shared Networks: Experiences with shared locker networks in Sweden and Denmark revealed inefficiencies due to diverse transporter needs, leading to withdrawal from such models.
- International Context: Countries like Poland rely heavily on home delivery, resulting in more dispersed locker networks. Norway balances consolidation and proximity.
- Private Locker Integration: There is potential for integrating lockers in apartment buildings, as seen in Switzerland, offering low-cost, resident-aligned solutions.

Optimizing Delivery Efficiency and Customer Experience
Strategies to improve delivery productivity and customer convenience were explored.

- Asynchronous Delivery: Unattended deliveries via lockers and mailboxes increase last-mile efficiency and reduce vehicle travel.
- Bundling and Vehicle Optimization: Smaller parcel sizes and consolidated deliveries reduce trips and improve vehicle fill rates.
- Customer Preferences: Customers favor unattended delivery for convenience and flexibility, reducing missed deliveries.
- Home Parcel Mailbox Trials: Trials with larger mailboxes have seen limited uptake due to cost. In Norway, leaving parcels in unlocked mailboxes or porches is generally accepted due to low theft rates.

Delivery Network Structure and Vehicle Allocation
The delivery network is segmented by vehicle type and adapted to urban and rural conditions.

- Stream Segmentation: Lorries serve manned pickup points, vans serve parcel lockers, and light electric vehicles serve mailbox deliveries. Routes are merged based on drop density and geographic context.

7.3.14 Interviewee N

Operations Overview

A logistics expert provided a comprehensive overview of parcel delivery operations in Norway, including the facility network, daily logistics processes, and the unique challenges posed by Norway's geography and customer expectations.

Transition to Electric Vehicles and Sustainability

The discussion covered the transition to electric vehicles, which is being driven by expectations from customers, employees, and stakeholders, as well as supportive government incentives and infrastructure availability.

Micro Depot and Urban Delivery Innovations

Efforts to implement micro depots and collaborate with municipal authorities were described, focusing on optimizing urban deliveries through the use of small electric vehicles and geofencing technologies.

Vehicle Routing and Cargo Allocation

The expert detailed the approach to route planning and vehicle selection, balancing shipment size, time efficiency, and regulatory constraints in urban environments.

Cargo Bikes Versus Small Electric Vehicles

A comparison was made between cargo bikes and small electric vehicles used in urban deliveries, highlighting operational challenges and the evolution of the delivery fleet.

Municipal Collaboration and Policy Influence

The conversation concluded with reflections on the evolving relationship between logistics providers and municipal authorities, noting increased openness to business input and the influence of political changes on urban logistics policy.

7.3.15 Interviewee O

Delivery Platform and Vehicle Mix

The discussion covered the company's three-sided delivery platform, its operational model, and the diverse mix of vehicles used by courier partners. Regional differences in vehicle usage were highlighted, along with ongoing efforts to promote clean vehicle adoption.

Sustainability Incentives and Courier Partner Support

The interviewees explained their approach to encouraging sustainable deliveries, focusing on incentive programs for courier partners. They addressed financial and practical barriers and described tailored initiatives to improve access to clean vehicles and financing options.

Collaboration with Cities and Policy Challenges

Challenges in working with city governments and policymakers were discussed, including the need for data-driven collaboration and better integration of last-mile delivery into urban policy. Limitations of low emission zones without industry input were also noted.

Public Incentives and Manufacturer Support

The conversation highlighted the need for public financing programs and government support for sustainable vehicle manufacturers. Gaps in eligibility for courier partners and the high costs of specialized delivery vehicles were identified as key issues.

Policy Recommendations and Future Collaboration

The meeting concluded with recommendations for more flexible, data-informed policy approaches. Emphasis was placed on setting emission reduction targets, improving infrastructure, and fostering collaboration between companies, governments, and researchers.