GREEN LAST MILE LOGISTICS SOLUTIONS IN FINNISH CITIES

A study on last mile logistics solutions and related initiatives in Finnish cities.

Lappeenranta–Lahti University of Technology LUT

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Examiners: Professor Jukka Hallikas and Professor Katrina Lintukangas

ABSTRACT

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Green last mile logistics solutions in Finnish Cities

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Keywords: Logistics, green logistics, last mile logistics, city logistics, supply chain, delivery

The study examines green last mile logistics solutions used in the Finnish cities of Tampere, Turku, and Helsinki while aiming to identify the main drivers for increasing the adoption of new solutions. The solutions are identified and examined through the lens of city logistics literature, case studies and combined with information from interviews with city logistics stakeholders.

Predominant technologies used in Finland are alternative delivery vehicles, such as electric vans and electrically assisted cargo bicycles, as well as alternative fuels such as biogas. Infrastructure-related solutions such as city hubs have also been successfully piloted in some of the case cities. Wider city logistics improvement plans which contain some green last mile logistics elements have also been put forward.

The study identifies that while the development of technology itself acts as a driver for the adoption of greener last mile logistics solutions, stakeholder communication, infrastructure development, municipality driven governance and city logistics initiatives are also factors which positively impact the adoption of new solutions.

TIIVISTELMÄ

Lappeenrannan–Lahden teknillinen yliopisto LUT

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Supply Management

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Ympäristöystävälliset viimeisen kilometrin jakeluratkaisut Suomessa

Kauppatieteiden pro gradu -tutkielma

69 sivua, 11 kuvaa, 4 taulukkoa ja 2 liitettä

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Työ tarkastelee suomessa käytössä olevia ympäristöystävällisiä viimeisen kilometrin logistiikkaratkaisuja. Tarkastelun kohdekaupungit ovat Tampere, Turku ja Helsinki. Tavoitteena on tunnistaa uusien logistiikkaratkaisujen käyttöönoton mahdollistajat. Tunnistettuja ratkaisuja tarkastellaan hyödyntämällä kaupunkilogistiikkaa käsittelevää kirjallisuutta, tapaustutkimuksia ja tulokset yhdistetään sidosryhmähaastatteluista saadun tiedon kanssa.

Merkittävimmät Suomessa käytössä olevat teknologiat ovat vaihtoehtoiset kuljetusajoneuvot, kuten sähkökäyttöiset pakettiautot, sähköavusteiset tavarapyörät ja käyttövoimien osalta biokaasut. Infrastruktuuriin liittyvistä ratkaisuista erilaisia cityhubeja on onnistuneesti pilotoitu osassa käsiteltävistä kaupungeista. Laajempia kaupunkilogistiikan kehityssuunnitelmia, jotka sisältävät ympäristöystävällisten viimeisen kilometrin jakeluratkaisujen hyödyntämisen on myös otettu käyttöön.

Tutkimus tunnistaa, että teknologioiden kehitys toimii yhtenä ympäristöystävällisten jakeluratkaisujen käytön mahdollistajana, mutta sidosryhmien välinen viestintä, infrastruktuurin kehitystoimet, kaupunkien säädösympäristö ja hallinto sekä kaupunkilogistiikan kehityshankkeet ovat myös uusien ratkaisujen käyttöönottoon vaikuttavia seikkoja.

SYMBOLS AND ABBREVIATIONS

Abbreviations

AI	Artificial Intelligence
CCC	City Consolidation Centre
CH	City Hub
CL	City Logistics
CSCMP	The Council of Supply Chain Management Professionals
EV	Electric Vehicle
FQP	Freight Quality Partnership
LM	Last Mile
UCC	Urban Consolidation Centre

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1. Introduction

City logistics is undergoing changes and challenges related to increasing population size, urbanization, and growing transportation volumes. In the EU, the share of inhabitants between the ages of 16-74 years who have ordered goods online reached 74 percent in 2021, an increase of 11 percent from 2016 (Eurostat, 2022). In Finland, the growth of online shopping participants increased by 4-5 percent yearly between 2007 and 2017, after which the growth rate has slowed down due to younger age groups reaching a very high level of online shopping adoption with little room to grow. More rapid growth can still be seen in older demographics, online shopping representation within the ages of 65–74 has doubled in the last eight years (SVT, 2021).

The need for transporting goods in cities is increasing in both volume and complexity, while environmental concerns are causing increasing scrutiny on what companies are doing to mitigate the negative effects of deliveries (Savelsbergh and Van Woensel, 2016). Meanwhile, the logistics industry is facing challenges such as increasing costs, especially due to increasing fuel prices, as well as workforce availability concerns and a changing regulatory environment (IRU, 2022). This study provides a general overview of how green last mile solutions in the form of electric vehicles and cargo bicycles combined with city hubs and parcel lockers have been tested and used in Finland through research based on literature analysis and stakeholder interviews. The study also combines the viewpoints of the private and public sector, on how the use of innovative last mile logistics solutions can be encouraged and expanded through stakeholder collaboration, pilot projects and policy making.

1.1 Background

Current examples of widely used last mile logistics solutions include delivery vans and cargo bicycles as forms of attended delivery, as well as deliveries to self-service facilities such as decentralized parcel lockers. In the future, last mile deliveries could also be performed using

drones and autonomous delivery robots (Boysen et. al., 2020). New last mile technologies have also been trialled in conjunction with third-party operated logistics consolidation centres, which combine the transport flows of several operators and distribute the last mile deliveries using electric vehicles (Gammelgaard, 2015). In addition to physical distribution solutions, public-private partnerships have been developed in order to facilitate communication and collaboration between city logistics stakeholders (Lindholm, 2014). Initiatives related to the combination of physical infrastructure such as city hubs, urban consolidation centres and road infrastructure development plans have been implemented with varying levels of success (Quak, 2008).

City logistics and last mile logistics in Finland is a relatively specialized topic and not extensively covered in literature, providing an opportunity for establishing an updated understanding of current and potential solutions in Finnish cities. Furthermore, as Morganti and Dablanc (2014) suggest, city logistics and last mile research and resulting policies tend to be centred around technological innovation and solutions, meaning that there could be a research gap for studies incorporating less technical aspects such as stakeholder communication and collaboration, as well as the use of different forms of regulatory measures by municipalities and the government.

1.2 Aim of the study and research questions

The study explores which green last mile logistics solutions, such as electric vehicles, cargo bicycles and city logistics hubs are used in the largest Finnish cities. The aim of the study is to understand how green last mile logistics solutions have been implemented by providing practical examples from Finland and abroad while combining this research with interviews with key city logistics stakeholders. This approach is used to form a general overview of green last mile logistics solutions from different points of view, while highlighting experiences and lessons learned from different pilot projects and identifying future development potential. Additionally, the study aims to outline some of the challenges and limitations involved with the examined solutions as well as suggesting what kinds of actions companies and municipalities could take to facilitate the adoption of environmentally friendly last mile logistics solutions.

The study aims to answer the following questions:

a) What green last mile transportation solutions are currently utilized in the largest Finnish cities?

b) How can further adoption of green last mile logistics solutions be facilitated?

The novelty of the study comes from considering a range of technological, regulatory, and societal factors involved with city logistics development from different stakeholder perspectives, using current literature and interviews specifically focused on the adoption of new transportation technologies and initiatives. While it is acknowledged that it is potentially challenging to acquire detailed information related to the financial and operational feasibility of logistics pilots, the stakeholder interviews provide useful and up-to date information on the state of the art in Finland.

1.3 Research method and scope

The research consists of a qualitative case study method incorporating a review of existing literature and semi-structured interviews of stakeholders representing both the private and public sectors. The information gathered from interviews is combined and compared with literature and information collected during this study to identify potential solutions and to highlight differences and similarities between the examined cities. The literature used in the study was primarily found in online logistics-related journals, eBooks, and web-publications. Online press releases and articles were used as sources for examples of last mile solutions in Finland.

The study is centred on the implementation of existing green last mile solutions and initiatives in Finland. The geographical focus is on the Finnish cities of Helsinki, Turku, and Tampere, although the findings could also be related to slightly smaller cities with similar urban features on a general level. The geographical focus of the study has been identified as a potential limitation for available data, as even though considered major on a national scale, Finnish cities are relatively small compared to their Nordic and European counterparts. This means that there could be fewer city logistics pilot projects or operating models to examine

compared to larger European cities. Detailed information on the financial feasibility of logistics development projects may also be considered confidential, restricting the availability of detailed operational and financial data. The study does not aim to provide an exhaustive review of logistics literature or technologies and practises but focuses primarily on themes related to the examples found within Finland.

1.4 Structure of the study

The study is divided into three main segments: theoretical background, research and interviews, analysis of the results and conclusion. Each segment has subsections which aim to provide relevant background information on the study, describe the research process and findings, and finally to create, combine and summarize collected information.

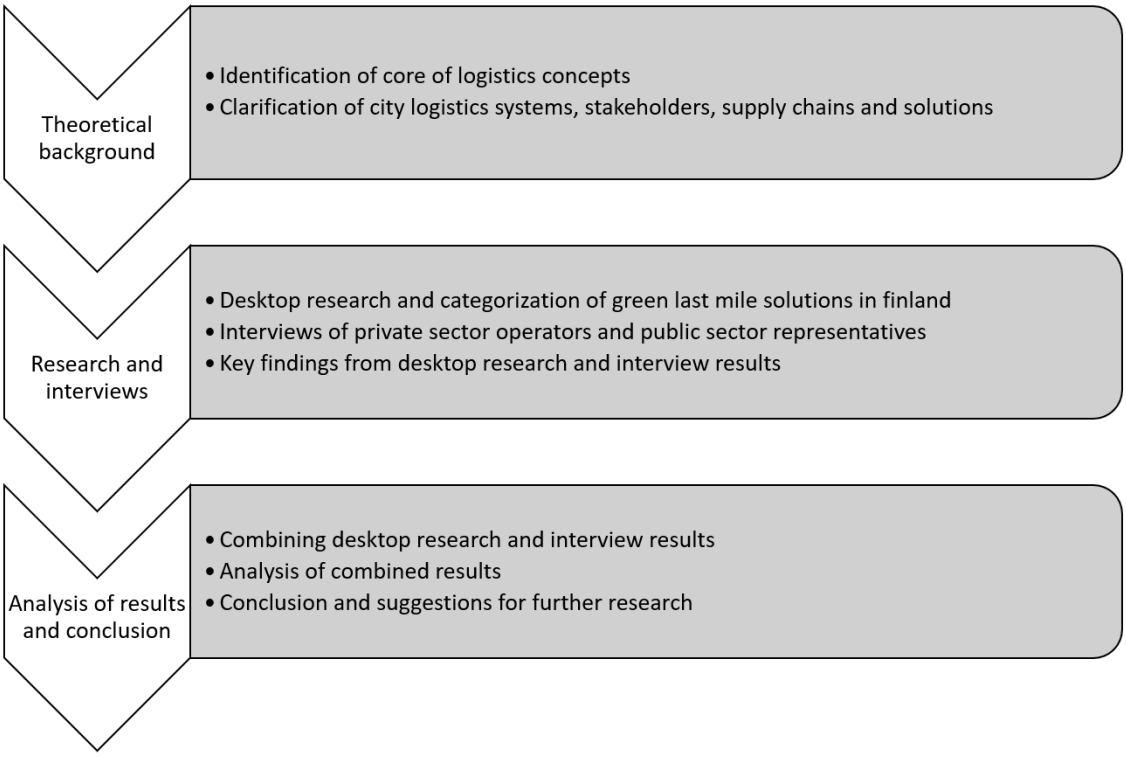

Figure 1. Structure of the study

The first chapters aim to provide a theoretical background for the topic covering core logistics concepts. Chapter 3 goes into more depth regarding green last mile solutions, which are key concepts in this study. Chapter 4 provides examples of green last mile solutions used in Finland which have been collected through desktop research and some had been mentioned during the interview process. Chapter 5 covers the interview process and findings, comparing the interview results with benchmarking results in the end. Finally, chapter 6 concludes the study, pointing out the key findings of the study and suggests future research topics.

2. Theoretical background of green last mile logistics

This chapter provides the theoretical concepts and framework which is required to analyse green last mile solutions in more detail from various viewpoints. The chapter defines the core concepts of logistics, green logistics and city logistics (CL), all of which are higher level concepts closely related to the subject matter. The structure of the framework is illustrated below.

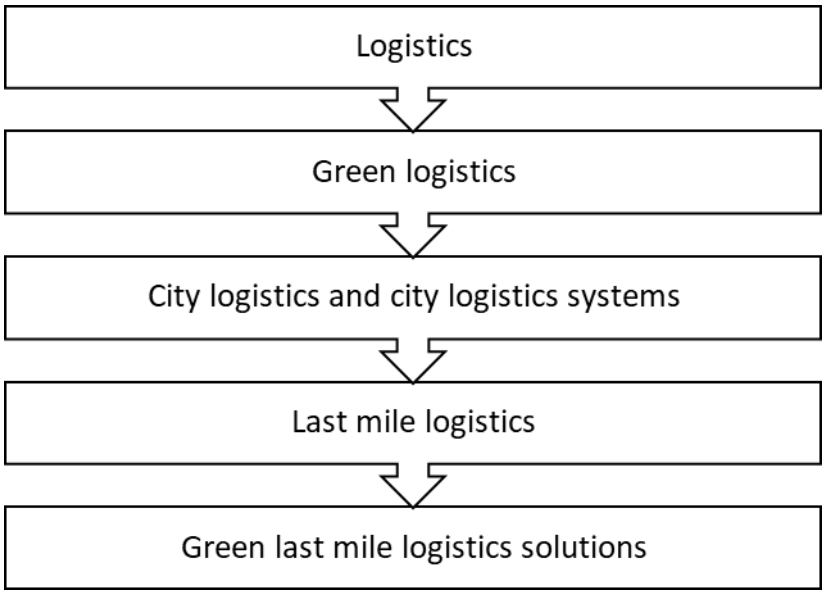

Figure 2. Structure of the theoretical framework

For the purposes of readability and clarity, a separate chapter is dedicated to "the green last mile" which is a lower level, detail-oriented and practical component of this theoretical framework.

2.1 Logistics

Throughout the years, logistics has been defined and expanded on in several ways. The Council of Supply Chain Management Professionals (CSCMP) (2013) and Georgia Tech

Supply Chain and Logistics Institute define logistics as a process which aims to achieve efficient and effective transportation of goods or services and related information from their point of origin to the point of consumption in a way which befits the customer's needs through planning, implementation and controlling procedures. Zijm et. al. (2019, pp. 33-34) state that in addition to the transportation of goods or providing a service within a supply chain, logistics includes inbound and outbound processes such as transportation to, within and from locations such as warehouses, where the processes within warehouses include processes such as materials handling. More recently, logistics definitions which include the transformation of goods or information involving the variables of space and time are described as being being flow oriented by Pfohl (2022). Logistics is also no longer considered to be a simple process of moving items from point A to B, as it has grown to involve goals where the costs of processes are minimized, the robustness and adaptability of the logistics system is increased, and value is added to goods throughout the logistics chain (Gleissner and Femerling, 2012, pp. 4). Expanding on the aforementioned definitions, Logistiikan maailma (2022) citing Karrus (1998) state that logistics includes maintenance and support functions, value adding services and customer service management as parts of the umbrella term in addition to basic features such as material, information, and capital flows. Furthermore, in addition to the technical and financial management of supply chain functions, logistics can include a holistic management and development approach of aspects such as production, services, and customer relations. (Karjalainen, 2008 cited in Logistiikan maailma, 2022).

2.2 Green logistics

Green logistics has been described as a study of methods that aim to reduce the environmental impact of logistics activities related to the transportation, handling, and storage of goods in both forward and reverse directions of the supply chain, with touchpoints that are relevant to both businesses and public policy makers alike (McKinnon, 2015, pp. 4-5). According to Blanco (2017, pp. 147-148) green logistics is an approach where the environmental effects of logistics operations are systematically measured, analysed, and mitigated, where the mitigation of environmental effects can be achieved through the reduction of non-renewable energy consumption, various emissions (e.g., greenhouse gases)

and by the reduction of produced waste. Some of the methods aiming to achieve the reduction of environmental effects can take the form of using more environmentally friendly technologies or designing operations in a way which improve their efficiency e.g., optimizing deliveries to decrease their total mileage and improve transport capacity utilization, leading to less emissions. Green logistics can also be incorporated on a more strategic level, in the form of company-wide environmental goals that affect a wide range of operations, for example through the implementation of large-scale reverse logistics activities. Gruchmann (2019, pp. 664-665) states that green logistics has moved on from being a simple collection of emission reduction methods to being a strategic element for entire industries, since the advantages of transportation efficiency can be twofold: carbon dioxide emissions are reduced while achieving cost savings.

2.3 City logistics

For the purposes of this study, the term city logistics has been used to describe logistics operations within cities, especially in the most central and built-up areas. It should be noted that several terms with a similar or even identical meaning are used within the logistics research field, for example the term urban logistics is often used synonymously with city logistics. (Rose et al., 2016, pp. 362). To provide an initial definition, Dablanc (2006, pp. 284) condenses city logistics (in this case urban logistics) to mean the following: "*Urban logistics can be defined as any service provision contributing to an optimised management of the movement of goods in cities*". Expanding on this definition, the common factor shared by various definitions of city logistics can be considered to be the aim to find efficient and effective ways to transport goods to customers in urban areas. City logistics also acknowledges that there are positive as well as negative environmental and social effects related to logistics operations within urban areas, negatives being issues such as congestion, safety issues and emissions (Savelsbergh and Van Woensel, 2016, pp. 579). In addition to the encompassing the aforementioned features, Aifandopoulou and Xenou (2019, pp. 9) describe city logistics as a for-profit activity largely driven by private sector interests, which contains last mile (LM) transportation, the storage of goods, inventory management, waste and returns management and home deliveries.

Savelsbergh and Van Woensel (2016, pp. 579) expand the list of interconnected terminology by identifying the terms urban freight, urban freight distribution, last mile logistics, urban logistics and city distribution as terms that are used in contexts that are very similar to each other. However, more recently Preindl (2022) suggests that as research has advanced, a distinction can be made that urban logistics encompasses entire urban environments, whereas city logistics is more focused on city centres and the transport solutions featured within. Hence, for the purposes of this study, city logistics is considered more suitable, while still falling within the umbrella of other similar terms used in the field.

Some unique characteristics of city logistics stem from the nature of operating in an urban area. The flow of flow of goods into a city is usually much larger in volume compared to the flow out from the city. There is usually relatively little space to store inventory in stores due to changing operational principles, meaning that stocks need to be replenished more often, leading to more frequent deliveries. There are also challenges related to delivery times which are pre-determined by the opening hours of businesses, as well as potential constraints set by pedestrian-only zones etc. (Gleissner and Femerling, 2012). Companies within the city logistics field will be faced with sustainability driven operational challenges in the future due to shifting public attitudes towards carbon dioxide emissions and other negative externalities related to city logistics. As urban populations and demand for deliveries grow, companies will be faced with potentially conflicting objectives where increasing service (i.e., transportation) demand will need to be met while also mitigating the resulting negative environmental effects (Savelsbergh and Van Woensel 2016, pp. 582).

City logistics supply chains are also extremely diverse and fragmented, and there are multiple stakeholders in the form of end users, carriers, producers, and retailers, all of whom operate within a city governed by local authorities. There are also indirect stakeholders, such as vehicle drivers, trade associations, public transport operators, landowners and other citizens or visitors to consider. The interactions between these stakeholders are also diverse, as some supply chains are extremely complex and the products can originate from a distant location, or the exchange in question can be a local one where all parties are located within, or close to the city (Dablanc, 2009; Ballantyne and Lindholm, 2012, cited in Lindholm, 2014 p. 129). Due to the diverse nature of the operating environment, developing sustainable city logistics schemes which are aligned with the interests of different stakeholders can prove to be a challenge (Quak and Nesterova, 2014, pp. 266).

The table below illustrates the primary logistics chains involved in city logistics, briefly describing the involved operators and the nature of the transportation methods used.

Table 1:" A city's main logistics chains" adapted from Dablanc (2009, pp. 10-11).

Name	Description
Independent retail	• Local stores and convenience stores. • This category represents 30-40% of daily deliveries within a city. • Range of suppliers is diverse, and stores are supplied approximately 3-10 times a week, predominantly via delivery vans (or small trucks).
Retail chains and commercial centres	• Less frequent, more consolidated shipments of goods with better transport capacity utilization compared to independent retail.
Food markets	• Food markets are more relevant in developing countries, but they share similar characteristics elsewhere. • Transport modes from suppliers are very diverse and sources are fragmented. • Accurate data on volumes is difficult to obtain.
Parcel transport and express deliveries	• Quickly growing transport category, consisting mainly of large vans or small to medium sized trucks. • Deliveries originate from terminals located at the perimeter of cities and form routes throughout urban areas. • Leading express delivery companies have global coverage.
Home deliveries	• Can be considered a subsection of parcel transport, operated especially by local postal providers, as well as express delivery companies. • A new emerging segment could be home food delivery, which has become more prevalent due to the popularization of food and item delivery companies such as Uber Eats, Postmates and Wolt.
Construction sites	• Building materials account for up to 30% of total tonnage transported in cities. • Mode of transportation is primarily heavy vehicles. • Complex supplier networks and frequent deliveries place a strain on infrastructure and can cause congestion in cities.

The majority of freight transportation in cities is done using vans and small trucks, while lorries are mostly only present in urban areas during the mornings and nights, when supermarkets are resupplied. Manufacturing facilities and logistics warehouses to which

goods are transported by lorries are usually located on the outskirts of urban areas, along access points to highways. The access points in question can become congested during heavy traffic (Dablanc, 2009, pp. 11).

2.4 Basic structure of city logistics systems

Pfohl (2022) provides an illustration of basic logistics systems, which can also be applied to a city logistics setting in the context of this study, as a combination of single-stage systems, combined systems and multi-stage systems are used by different operators.

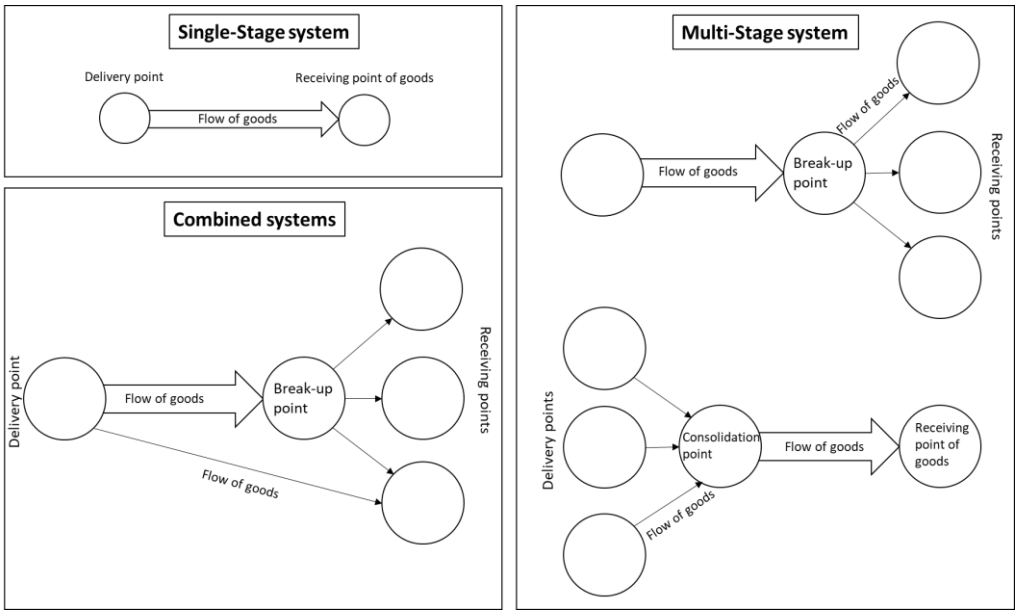

Figure 3. Basic structure of logistics systems based on Cf. Bowersox et al. (1968, pp. 120; Brauer and Krieger, 1982, p. 34; Bowersox and Closs, 1996, pp. 90, adapted by Pfohl, 2022).

Many smaller scale localized interactions can fall under the single-stage system category, for example a small store delivering their goods directly to their customer. On the other hand, a single-stage system can also exist within a larger entity as long as the flow of goods is uninterrupted, for example in the form of long-haul truck transport from a port directly to a large retail outlet or production facility. An example of a multi-stage system with a break-up point could be a terminal situated on the outskirts of a city, which is owned by a single carrier. Items such as parcels arrive at the break-up point, where they are handled and sorted

into separate batches, after which they delivered to the end customers (receiving points) using delivery vans or small trucks. A multi-stage system with a consolidation point functions in a manner where goods are received from multiple operators and sources (delivery points). The goods are processed at the terminal (consolidation point) and then combined into a single flow leading to the end customer (receiving point of goods). Combined systems have the functionality to deliver smaller flows directly to receiving points, as well as directing flows of goods to a break-up point, from which the majority of goods is distributed onwards to the receiving points.

Allen et al. (2018, pp.185) propose that delivery companies adopt different operating models and strategies based on their location and the needs of their customers. Smaller, local companies will most likely utilize a single depot, from which they perform delivery routes from in the local area. In the case of national or even international carriers, the system will be based on large regional hubs which are supported by more localized depots located in or around major cities. The transportation between major hubs and depots is done with heavier vehicles such as trucks, whereas the routed deliveries from the local depots are handled by smaller, lighter vehicles such as vans or electric vans.

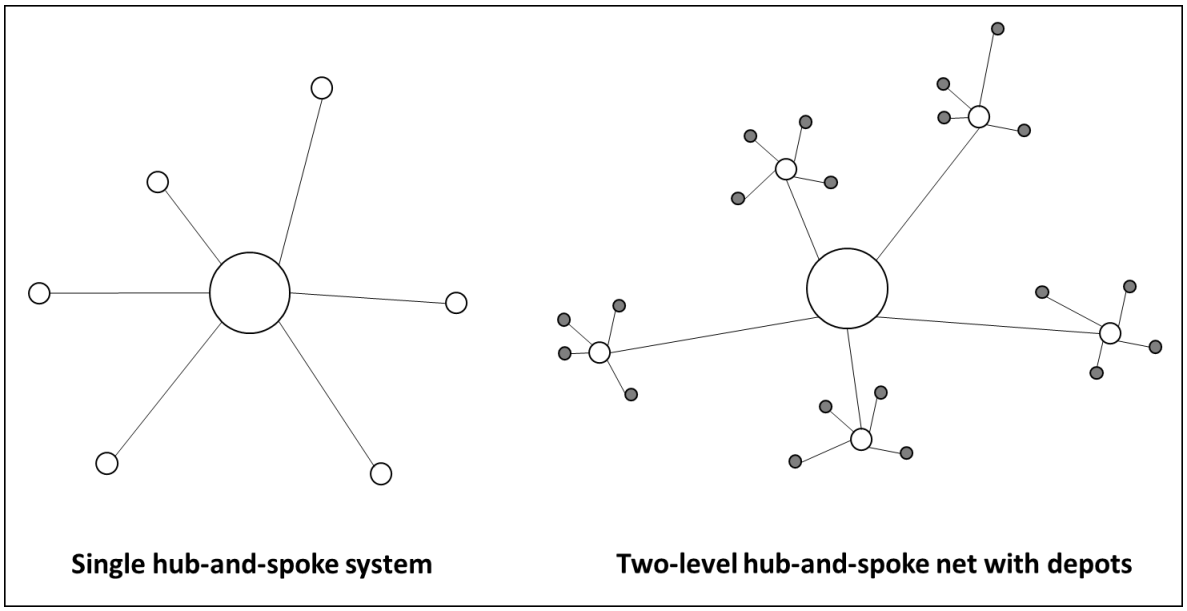

Figure 4. Different hub-and-spoke variations based on Gleissner and Femerling (2012, p. 173).

The figure above shows Gleissner and Femerling's (2012, p. 174) description of hub-and-spoke systems. All traffic passes through the central hub, and there is no connection between regional hubs or depots. The use of a central hub enables bundling of shipments, which creates more efficient utilization of cargo density and larger volumes, in addition to less time spent waiting for suitable goods to fill up capacity on a specific route. After hubs, the function of the depots is to serve as a distribution point in local areas. Allen et al. (2018, pp.185) also word the operations of a large carriers in a large city in a similar way; trucks transport parcels from a regional distribution centre to local depots located on the outskirts of the city, from which smaller vehicles drop off deliveries along the routes which have been assigned to their local depot.

2.5 Last mile logistics

Last mile logistics as a term covers all movements of goods involved with the business operations of companies operating within a city, such as the transportation of goods, raw materials, and waste. Home deliveries to private customers are also included under last-mile logistics (Morganti and Dablanc, 2014). Last mile can be considered to be a logistics collection problem that deals with distribution and collection in urban areas and is closely linked to the term "first mile", which is also used when discussing collections or returns, which is essentially the same process as last mile, but in reverse (Souza *et al*., 2014, pp. 423).

Last mile deliveries are characterized by the fragmented nature, time sensitivity, and small average size of items to be delivered, which creates a challenge in utilizing the full cargo capacity of the delivering vehicle. These challenges are in part due to the ever-increasing popularity of ecommerce and competition within the logistics service space (Iwan et al., 2015). Preindl (2022) notes that last mile logistics can also deal with logistics challenges outside of urban areas, such as in rural locations where a different set of problems, such as achieving critical mass of transported goods is emphasized. Therefore, it is important to note that this study in particular focuses on the last mile segment of logistics which occurs centrally in an urban area. Since the term is interlinked with green last mile solutions, the topic, including key issues and related solutions will be discussed in more detail in the following chapter.

3. The green last mile

This chapter discusses last mile logistics in more detail through the lens of green logistics and serves as an introduction to the subject matter before analysing the examples provided by research on Finnish cities and the interview results in the following chapters. Green last mile can be considered to be a combination of green logistics and last mile innovations which aim to mitigate the effects of deliveries on the urban environment. Quak and Nesterova (2014) attribute problematic sustainability issues such as traffic hazards, noise pollution, carbon emissions, congestion and overall logistics inefficiencies to last mile and city logistics. Faced with increasing volumes of goods moving inside cities, the stakeholders of city logistics have come together to combat the inefficiencies and negative effects of urban freight by various means including stakeholder collaboration and consultation, piloting new operating models and technologies, as well as exploring various forms of regulation on traffic and parking (Morganti and Dablanc, 2014).

Below is a classification table with modifications to fit the scope of this study, adapted from Boysen, Fedtke and Schwerdfeger (2020, p.7), which outlines the green last mile solutions covered in this study, apart from wider city logistics plans and initiatives which are described separately due to their general relevance to the topic, as they often contain last mile solutions.

Table 2: Green last mile delivery concepts, adapted from Boysen, Fedtke and Schwerdfeger (2020, p.7).

Logistics concept	**Transport mode(s)**	**Handover method(s)**
Consolidation centre	Truck, E-Truck, E-Van	Direct delivery
City hub	Truck, E-truck, E-Van, cargo bicycle	Direct delivery, Self-service
Parcel locker	Van, E-Van, cargo bicycle	Self-service

Logistics concept indicates the method where goods are handled and stored when using the LM solution, transport mode indicates the mode of transport used in conjunction with the solution such as electric vehicle (EV) or cargo bicycle, and handover method states if the

handover of goods is done through human interaction (handed by courier to recipient) or as self-service, such as picking up a parcel from a parcel point.

3.1 Alternative delivery vehicles

In the context of the study, alternative delivery vehicles refer to non-standard modes of transportation, e.g., EVs such as electric vans and trucks, electrically assisted cargo bikes and autonomous vehicles (Quak and Nesterova, 2014; Morganti and Dablanc, 2014). Last mile deliveries in an urban environment are particularly suitable for electric vehicles as delivery distances are generally short and involve repeated stops and starts. A further advantage of electric vehicles is their low level of emissions and capability to operate silently, reducing the level of disruption caused to inhabitants and people working in urban areas (Morganti and Dablanc, 2014, pp. 33-34).

Some of the main obstacles facing alternative delivery vehicles and especially EVs is that current logistics concepts are designed for traditional vehicles, meaning that for example operating ranges are too long to cover in a cost-effective manner due to current range limitations of EVs, potentially making it difficult to achieve an effective business case. Logistics operating and service concepts could be modified to compensate EVs weaknesses, at least for the time being while technology develops (Quak and Nesterova, 2014). Along with EVs, some additional technological developments and relevant innovations include autonomous driving, drones, and delivery robots, which have potential to see further use in the future (Boysen et al., 2020).

3.2 Parcel lockers

Parcel lockers, or parcel pickup points are self-service, unattended delivery machines that enable the sending and receiving of parcels or packages that usually related to e-commerce. The machines are usually located in easy to reach, public spaces or within stores and customers access their deliveries by identifying themselves with a unique pin code which is inputted into a keypad attached to the pickup point. (Iwan et al., 2016; Boysen et al., 2020).

Parcel pickup points help to avoid delivery failure as they remove the scenario where the customer is not at home during an attempted delivery. Furthermore, multiple deliveries can be fulfilled when filling a parcel pickup point with goods, making it more efficient than driving from customer to customer (Allen et al., 2018). Morganti and Dablanc (2014) also describe parcel pickup points as a method for combating the increasing amount of parcel home deliveries, in turn decreasing the amount of driving involved, reducing emissions and pollution, as well as cutting down on delivery costs for the operator. In a similar context goods reception via parcel lockers, a simulation-based study conducted by Punakivi, Yrjölä and Holmström (2001) concluded that unattended reception boxes used for home delivery of groceries yielded significant cost reductions compared to models requiring attendance.

In spite of the operational cost advantages, while more efficient for the operating company, the self-service model means that the customer is giving up some of the service level that is related to home delivery. It is also possible that the reduced emissions from the delivery process are at least partially transferred to the customer's side if they use a vehicle to get to a pickup point (Boysen et al., 2020, pp.18).

3.3 City hubs and consolidation centres for last mile delivery

City hubs (CH) allow for a multi-modal approach to LM deliveries, where the hubs act as a point of transfer between transport modes. City hubs are viable in densely populated urban areas, where a small CH can be located close to areas where enough demand for small package deliveries exists to achieve cost effective operations using more environmentally friendly delivery vehicles such as electric vans or cargo bicycles to deliver straight to the customer or to parcel lockers (Bayliss et al. 2022). On a larger scale, city consolidation centres (CCC) can be used to combine flows of goods from outside the city at a warehouse usually located at the perimeter of the city with the aim of reducing heavy traffic in the city centre. Large shipments arrive at the consolidation centre and the cargo is then loaded into smaller, more environmentally friendly vehicles such as EV vans for the final leg of the journey. Consolidation centres can either exist within the ecosystem (and be operated by) the delivery company themselves, or the CCC can be operated by a third party, which takes over responsibility for the goods once they arrive in the CCC. The benefits of using

consolidation centres include less emissions and negative environmental effects resulting from the lighter vehicles used, as well as a potentially higher utilization rate of vehicle capacity due to their smaller size. However, it is possible that the total number of vehicles operating within the city could increase if the volume of goods is high enough. There are also other considerations involving the feasibility of consolidation centres, such as willingness within the transport industry to utilize said solutions due to cost and liability issues, service guarantees and not enough volume to effectively combine deliveries in a short enough time window (Quak, 2007).

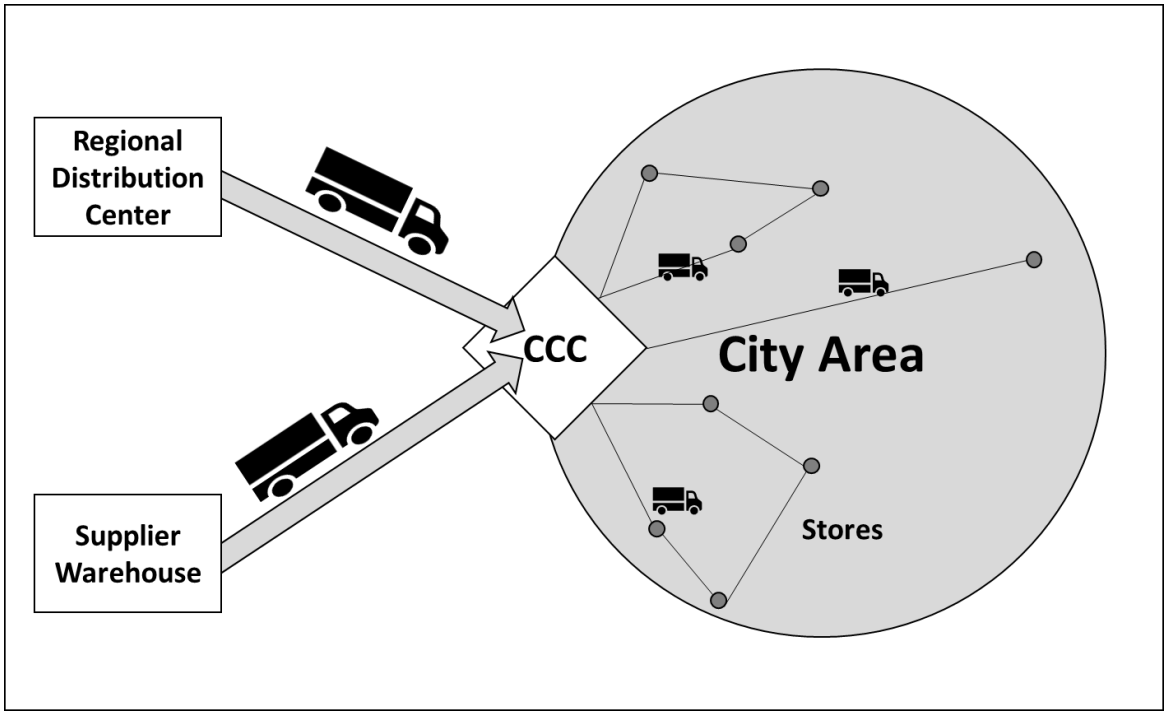

Figure 5. City consolidation centre operating model, adapted from Quak (2007, p. 67).

Goods arrive at the CCC from retail warehouses or suppliers using large lorries, which can transport high volumes. The lorries are unloaded in the consolidation centre which is ideally located on the outskirts of the city, along key routes such as a highway intersection. The goods are then handled and sorted in the CCC, after which they are loaded into smaller vehicles such as electric delivery vans, which navigate a route around the city centre delivering the goods to their recipients along the way.

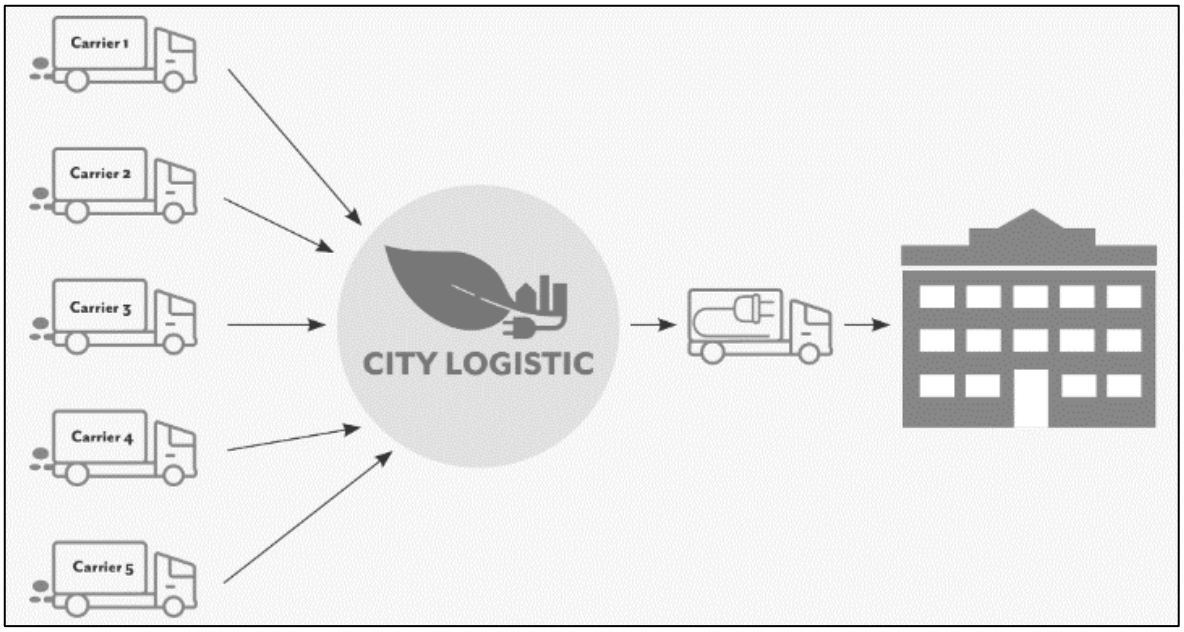

Figure 6. Image of the City Logistic operating model. Image from the City Logistic Website (City Logistic, 2022).

A practical example of a third-party city hub/CCC service is City Logistic in Denmark, which operates a logistics service which consolidates deliveries in their hub and transports them to central areas of the city in the cities of Roskilde and Lyngby (City Logistic, 2022).

3.4 City logistics policies and development initiatives

City logistics policies and development initiatives aim to improve the efficiency of city logistics while reducing its negative effects by considering economic, social, and environmental viewpoints. Policies and initiatives can often contain a selection of different last mile delivery solutions, such as the use of alternative delivery vehicles, parcel pickup points, as well as city hubs and consolidation centres. Despite their often-technological focus, initiatives can also contain elements of governance and legislation which affect last mile operations. (Aifandopoulou, and Xenou, 2019). Morganti and Dablanc (2014) conclude that city logistics development research and implementation is often very focused on finding technological solutions, suggesting that this is also reflected in development policies driven by the public sector.

According to Dablanc (2007) policy can affect city logistics on multiple levels. The public sector can influence the planning of road infrastructure, land use and economic development and facilitation of local business is in the interests of the public sector and finally, smaller level regulation involving matters such as parking restrictions and traffic time windows also falls under the jurisdiction of the municipality in question. Municipalities can also subsidize smaller operators, who may otherwise lack the means to invest in new technology, such as EVs. Oexler (2002); Gammelgaard (2015) cited in Preindl (2022, 36) emphasize the importance of involving stakeholders when implementing policies or initiatives aiming to develop CL. The attitudes of private sector are especially relevant, towards whom the value added by new initiatives must be clearly demonstrated and contextualized in a meaningful way to secure acceptance. In order to set up effective city logistics policies, cities must be aware of the economic needs of the companies operating in the city, this can be achieved through data collection in the form of surveys, as well as consultation with stakeholders (Dablanc, 2007).

Lindholm (2014, pp. 133) studied the Freight Quality Partnership (FQP) in Gothenburg, which aimed to improve city logistics through collaboration and information exchange between CL stakeholders. The study indicated that initiatives such as FQPs can run the risk of not leading to concrete actions on improving city logistics due to becoming more akin to discussion forums with little influence on decision making, while also not reaching important stakeholders such as retailers. However, they can raise awareness and knowledge among stakeholders and political decision making, leading to influence in long term city planning if the goals of the FQP are clearly defined and information flow to decision makers is ensured. Scandinavia has several examples of broad city logistics plans, namely from Sweden and Denmark. The Stockholm freight plan (2014) aims to improve city logistics using regulation, increasing freight transport expertise within the city's technical administration, employing strategic land use, testing efficient urban logistics and last mile practises as well as innovating with new technology. Some of the activities from the categories are listed below:

- **Regulation**: Test projects involving freight transport at night, with special focus on monitoring noise levels. Designing and implementation regulations based on collected data to facilitate freight transport at night.
- **Freight transport expertise**: Ensuring that the technical administration of the city is aware of current issues within city logistics while raising the overall level of knowledge.
- **Strategic land use**: Ensuring that key industrial areas and freight hubs have good connections. Creating a freight plan for the better management of excavation materials from construction projects in the city.
- **Urban logistics**: Promoting the use of light electric vehicles for last mile deliveries. Further piloting electric trailer last mile deliveries, which have been tested under the "Älskade Stad" project.
- **Innovation and technology**: Accelerating the use of digitalization and the automation of traffic to move towards a fossil-fuel free transport system, for example through the development of geofencing in urban environments. Geofencing can be used to control vehicle's speed and drivetrain based on its geographical location.

The city also strives to further utilize its rail and water connections by promoting the use of said transport modes and by piloting parcel deliveries involving local shipping. The city of Malmö (2018) also has a sustainable urban mobility plan, which includes sustainable freight traffic and city logistics. Some of the aims and points of the plan are:

- Achieving a denser, greener, more integrated city with shorter distances.
- City planning: establishing a new logistical centre in Norra hamnen for the receiving and distribution of goods.
- Road infrastructure planning: opening street areas for the picking up and unloading of cargo and waste by placing embarkation/disembarkation points between trees by sidewalks.
- Changing modal shares of traffic, reducing the overall amount of traffic in areas, leaving room for logistics operators.

Finally, the Copenhagen green mobility plan (date unknown) also combines similar methods mentioned in the other Scandinavian freight plans. The plan aims to have a system for optimized goods delivery tested and developed before 2015, but the results were not verified at this time. Some other features of the plan were changes to infrastructure, where the high street Nørrebrogade was reconstructed with less capacity for cars and a decreased speed limit, without affecting delivery vehicles. There are also plans of potentially extending an environmental zone which restricts vehicles based on their emission classes to cover cars and delivery vans, but at the time of writing of the plan, this was not possible due to legislation, although this may have changed later.

3.5 Evaluating green last mile solutions and initiatives

While not directly applying their theory to last mile solutions, Morganti and Dablanc (2014, pp. 14) suggest that a framework which considers the economic feasibility and effects, fairness, or equity of measures and general acceptability among stakeholders could be used to evaluate city logistics initiatives containing policies such as environmental zones or other regulatory measures aiming to mitigate the environmental effects of city logistics. Economic feasibility refers to the financial implications of a policy, for example a potential increase or decrease in operating costs in the form of an additional toll or tax. The fairness of a measure means how different stakeholders are affected by a specific measure or policy, for example how companies of different sizes, or industry sectors are affected by said policy. Acceptability encompasses issues such as general attitudes towards a certain policy, which is an essential requirement for wider acceptance and implementation. Aifandopoulou and Xenou (2019) indicate that prerequisites of effective urban mobility plans include the establishment of goals and implementing metrics to track the plan’s performance. Regarding data collection, accurate and up-to-date information on city logistics solutions can be hard to come by. Information on technologies, infrastructure related solutions and city driven initiatives is sparse, fragmented and often limited, partly due to the fact that data collected by private operators can be restricted in order to protect competitive advantages (Aifandopoulou and Xenou, 2019; Benjelloun et al., 2010).

4. Green last mile logistics in Finland

This chapter provides examples of categorized last mile logistics solutions and initiatives involving city logistics from Tampere, Turku, and Helsinki. The availability of detailed and recent financial and operation data regarding LM solutions is scarce, making it difficult to collect from literature or public sources. Hence, research is mainly reliant on press releases and other news publications, but an aggregation of information should still provide an updated overview on what kinds of technologies and initiatives have been applied in Finland.

When examining the case examples in question, factors based on CL and LM solution evaluations by Quak (2008) and Preindl (2020) will be considered within the limits of available information along with a simplified version of (Benjelloun et al., 2010, pp. 6224) taxonomy components for some of the examples. This analysis includes the *description of the solution, the business model, functionality, scope, and technology used*. Since city-wide initiatives can incorporate several practical LM solutions and are broader in scope in general, they are left out from the comparison and addressed separately. The full list is shown below and applied in the chapter where the information is available.

- Description of solution
- Business model (also including cost and profitability factors when possible)
- Functionality
- Scope (how widely has be solution been applied)
- Environmental impact
- Societal influence (impact on public perception, marketing, etc.)
- Regulatory considerations

The aim of the list above is to provide a concise summary of the selected solution and to provide a uniform description on its features when relevant data has been available.

4.1 Introduction and previous studies

Some literature regarding city logistics solutions in Finland exists, mainly in the form of studies which propose various solutions to existing CL issues identified through stakeholder interviews and surveys. Kiiskinen et al. (2013) and Nykänen, Kallionpää and Liimatainen (2015) have studied city logistics in Tampere, suggesting city logistics could be developed using means such as technological innovations, infrastructure development, regulation, and the optimization of business operations. These studies have focused mainly on gathering information and proposing solutions to local issues in Tampere, but they could potentially be applied to similar cities. Korhonen (2019) has examined city logistics in Finland from the perspective of improving the quality of pedestrian zones using city logistics solutions such as regulation regarding delivery time windows and dedicated loading zones. The study also explored various other solutions identified from Scandinavian cities such as city hubs and alternative delivery vehicles, which had not yet been implemented in Helsinki at scale outside of select pilots. A report for the Confederation of Finnish Industries (2022) provides information on the needs of companies operating in urban areas, researched through stakeholder interviews. In the interviews, companies indicated that attention should be directed towards methods such as ensuring the availability of loading and unloading locations, expanding EV charging infrastructure, efficient utilization of vehicle cargo capacity, coordination of road works and building construction as well as exploring centralized last mile delivery options such as city hubs and parcel lockers.

4.2 Alternative delivery vehicles and technology

The subchapter includes alternative delivery vehicles such as autonomous robots, electric vans and trucks, cargo bicycles and other technical solutions such as fuels, related directly to the transportation of goods.

4.2.1 Autonomous robots

The 6Aika: Citylogistiikan uudet ratkaisut -project [Six City Strategy - New city logistics solutions] (2020) has piloted the use of a messenger robot in Helsinki in a trial called “Home-on Demand”, which delivered grocery orders from the REDI shopping centre to inhabitants of a nearby building. The autonomous robot completed all 86 of the deliveries tasked to it. While the trial itself was small scale, it did create media visibility, collected operating data, and provided initial indications of economic viability (Forum Virium, 2020).

HOK-Elanto (2022), in partnership with Starship Technologies, executed a pilot project which utilized autonomous robots to deliver online grocery orders in Espoo. The delivery robots have a capacity of 2-3 shopping bags and are loaded top-down by the store staff. The route of the robot is calculated by AI, and it navigates along sidewalks and pedestrian walkways while using sensors to avoid obstacles. During an approximately six-month period, the project collected data on the technical feasibility of the solution as well as consumer attitudes and demand towards robot deliveries. Exact details of the pilot are not available, but during the busiest times, the robots delivered thousands of shopping bags in a week. The project also received a lot of media attention, images and videos were also circulated in social media. Now that the project has concluded, talks are underway to determine any continuation of robot deliveries in the coming years (HOK-Elanto, 2022).

Figure 7. A Starship Technologies delivery robot. (HOK-Elanto, 2022).

- Description of solution: Autonomous delivery robots used by HOK-Elanto/Alepa to deliver groceries.
- Business model: Used as a part of a grocery chain's logistics process. Financial data unknown/unavailable.
- Functionality: Last mile autonomous delivery of online grocery orders.
- Scope: Total number of 60 robots trialled for 6 months in Espoo, in an area with a population of around 8000 people.
- Environmental impact: The robots are electric and exhaustless.
- Societal influence: Media coverage and increased awareness of green last mile solutions.
- Regulatory considerations: Road safety concerns related to autonomous navigation. The robots have a remote override.

The project demonstrated the use case of autonomous robots as a last-mile logistics solution, while collecting data for future development. The project also served as a way to introducing autonomous vehicles to the public, increasing awareness and potential interest in alternative logistics solutions.

4.2.2 Electric vans and trucks

Electric vans are the most predominant example of green logistics solutions which aim to replace or supplement traditional diesel-powered vans and small trucks. In 2020, DHL Express began deliveries in Turku using StreetScooter EVs, which have an operating range of approximately 200km in European conditions. The aim of the trial was to test the feasibility of the solution during Finnish winters, as a replacement for cargo bikes which were used to distribute parcels from a hub located at a marketplace in Turku. Although very low temperatures could cause a reduction in operating range, mild early winter conditions had not proven to be an issue at the time when the article was published in 2020. Whereas EVs have not seen mainstream adoption in Finland yet, DHL operates 11 000 EVs in Germany which have driven a total of 120 million kilometres (DHL, 2020). A more recent use case of EVs is the adoption of the Mercedes eSprinter electric van by DHL Express, which was encouraged by the success of the 2020 trial in Turku. These EVs are used in the

capital region in Finland for use with parcel and document deliveries, with the aim of expanding to larger express deliveries (DHL, 2021).

Larger electric commercial vehicles such as trucks have taken longer to develop, recently DB Schenker has trialled the Fuso eCanter truck manufactured by Daimler in Europe and at least two trucks have been deployed to Tampere as of 2021. The eCanter trucks have a cargo capacity of 2,8 tonnes and an operating range of over 100km, which fulfils the needs of most usual city distribution tasks. The trucks batteries can be charged to 80% capacity in 60 minutes (DB Schenker, 2021). Other companies operating electric trucks in Finnish cities include DHL and Niinivirta European Cargo. Niinivirta operates 3 electric trucks in Finland, and 15 trucks across Europe (Niinivirta, 2022).

The SeCLog-project webinar (2022) included presentations which contained companies' experiences and opinions related to the use of EVs in Tampere, for example a presentation by Ylinen (2022) pointed out that legal environmental requirements in vehicle and traffic service purchasing for the public sector is driving the adoption of green logistics solutions, although the effect has been relatively small so far. For example, Tuomi Logistics operates one electric van for deliveries. Despite this, the amount of EVs in operation is expected to grow, as is the offering of different EV options, making it easier for companies to find suitable vehicles. The findings of Kallionpää, Nair and Liimatainen (2020) indicate that companies are closely monitoring the development of EVs but are somewhat reluctant to be the first ones to adopt new technology due to the costs and risks involved. Technology is also a limiting factor, as current models become outdated quickly and are generally only suited for last mile deliveries, and not long distances such as trips between cities, especially in a country with long travel distances such as Finland.

Figure 8. Photo of DB Schenker's Fuso eCanter vehicles (DB Schenker, 2021).

- Description of solution: Electric delivery vans (and trucks) used by delivery companies in the capital region, Turku, and Tampere.
- Business model: Used to support current logistics operations, initially on a trial basis.
- Functionality: Last mile delivery of parcels and other small goods.
- Scope: Small amounts of vehicles per operator (2-5) although number is expected to grow.
- Environmental impact: Reduction of emissions and noise pollution.
- Societal influence: Media coverage and increased awareness of green last mile solutions.
- Regulatory considerations: Potential benefits when dealing with environmental requirements in tender processes, ease of meeting public sector environmental goals.

The capabilities of electric delivery vans have developed rapidly and demonstrate the potential for replacing a share of traditional combustion engine vehicles with greener alternatives for last mile deliveries, especially as battery technology develops and initial investment costs become more manageable.

4.2.3 Cargo bicycles

While a fundamentally a traditional concept regarding technology, electric cargo bicycles have been described as a modern solution for LM deliveries. The addition of electric assistance means that cargo bicycles are fast and well suited to the urban environment and can deliver relatively large amounts of packages. The Helsinki City innovation company Forum Virium has trialled cargo bicycles operated by logistics company A2B for grocery and restaurant food deliveries in Helsinki, with the aim of minimizing the congestion and environmental effects of last mile deliveries (Kuljetusnet, 2019). DB Schenker has also experimented with using cargo bicycles to deliver parcels from a mobile urban depot, which consists of a movable truck trailer. Parcels are delivered to the mobile depot from a central warehouse located in the nearby city of Vantaa, and the last mile delivery is carried out using a cargo bicycle. The cargo bicycles can also operate during the winter, the same solution is also in use in Bergen, Norway, which has similar weather conditions as Helsinki. As the cargo compartment of the electric bicycle is limited, it is not intended to fully replace other forms of parcel transport such as vans or EVs, but to supplement them in a sustainable manner (DB Schenker, 2020).

Figure 9. Photo of the DB Schenker cargo bicycle and mobile hub. DB Schenker (2020).

- Description of solution: Cargo bicycle operating from a mobile cargo hub.

- Business model: Used as a part of a parcel carrier's urban logistics chain. Financial data unknown/unavailable.
- Functionality: Last mile delivery of parcels and documents.
- Scope: Small scale trial in Helsinki, small amount of cargo bicycles and one hub trailer which doubles as cargo bike storage.
- Environmental impact: Aims to reduce overall emissions, the solution itself has no negative environmental impacts such as emissions or noise pollution. Potential to decrease the number of heavy vehicles operating in the inner city, improving pedestrian and road safety.
- Societal influence: Media coverage and increased awareness of green last mile solutions.
- Regulatory considerations: No negative considerations, potentially an advantage in tenders which favour carbon neutral solutions.

Cargo bicycles and electrically assisted cargo bicycles offer an affordable and environmentally friendly alternative for last mile deliveries in densely built urban areas. The solutions also generate positive visibility for logistics companies and demonstrate the possibility of using green last mile solutions to consumers.

4.2.4 Alternative fuels

In 2019 the delivery company A2B had 34 biogas-fuelled delivery trucks. A barrier to entry for biogas fuelled trucks has been their relatively high cost when compared to traditional diesel trucks. The company has pursued a strategy of increasing the share of ecological transportation solutions and were able to achieve profitability in 2017 despite the investments in green solutions (Raskas sarja, 2019). In a similar vein, moving and logistics service company Niemi Solutions has used biogas since 2016. 25% of Niemi's fleet uses biogas and the remainder is shifting to using Neste MY Renewable Diesel in order to cut greenhouse gas emissions. The company carries out approximately 35 000 moves per year, which equals around 3 million kilometres driven by their fleet. By switching to renewable fuels, the company will be able to reduce emissions by a number equivalent to the yearly emissions of 700 passenger cars (Niemi Services, 2022).

- Description of solution: Adoption of alternative fuels, such as biogas and biodiesel.
- Business model: Used as a part of logistics processes to achieve sustainability goals and reduce greenhouse gas emissions. Accurate financial information unavailable.
- Functionality: Alternative fuel used in transportation.
- Scope: In use throughout Finland.
- Environmental impact: Reduction of greenhouse gas emissions.
- Societal influence: Media coverage and increased awareness of renewable fuels.
- Regulatory considerations: A growing advantage in tenders which favour carbon neutral solutions.

The use of alternative fuels has seen several successful implementations in Finland, providing evidence for it's potential as a viable alternative for traditional fuels, despite the cost-related hurdles involved.

4.3 Infrastructure

Infrastructure solutions contain city logistics and last mile solutions which involve physical infrastructure, for example parcel pickup points or larger city hubs.

4.3.1 City hubs

City hubs are a relatively recent phenomenon in Finland, with a handful of pilot projects springing up between 2018 and 2021 based on online research and interviews. DB Schenker piloted the use of a city hub called the "Baana CityHUB" combined with cargo bicycles in central Helsinki in 2020 as a part of an initiative funded by the European Institute of Innovation & Technology (DB Schenker 2020). Another trial, the Turku CityHUB was put in place as a part of the Citylogistiikan uudet ratkaisut [New city logistics solutions] project, which aimed to further the implementation of green city logistics solutions in Turku. The project was conducted as a partnership between the City of Turku and DHL Express as operator. The city hub was resupplied using delivery vans while functioning as an operating

base for cargo bicycles, which conducted the last mile deliveries inside the city, with the goal of improving liveability and safety by reducing the amount of heavy traffic and its associated side-effects (6aika; Citylogistiikka; City of Turku, 2022).

Figure 10. Photo of the Puutori CityHUB in Turku. Citylogistiikka.fi/6Aika: Citylogistiikan uudet ratkaisut (2022).

Useful information was collected regarding best practises for establishing city hubs; finding a suitable location can be a challenge, as the hub needs sufficient space while still being located centrally enough to enable the use of last mile solutions such as EVs and cargo bikes, which have limited range and work best in a compact urban environment. EVs also require charging stations, so this infrastructure needs to be in place beforehand. The permit process for constructing a hub can also be relatively time consuming and complex. This could be mitigated by using existing stakeholder facilities such as the parking building of a supermarket, which may also already have EV charging capabilities (6aika; Citylogistiikka; City of Turku, 2022).

- Description of solution: Utilization of an urban logistics hub combined with green last mile delivery solutions.

- Business model: Used as a part of logistics processes to achieve sustainability goals and reduce greenhouse gas emissions. Accurate financial information unavailable.
- Functionality: Alternative city logistics/last mile distribution solution.
- Scope: Trialled in the city of Turku for 12 months.
- Environmental impact: Reduction of greenhouse gas emissions, improved safety due to reduction in heavy vehicle volumes, reduced noise pollution and congestion.
- Societal influence: Media coverage and increased awareness of green last mile solutions.
- Regulatory considerations: Potential challenges in securing planning permission. Helpful when operating with time-window restrictions or environmental zone restrictions.

City hubs have been used as a successful method of combining traditional transportation methods with new last mile logistics technologies and new operating models, providing use cases for justifying further pilot projects and continued use of the concept.

4.3.2 Parcel lockers

Parcel lockers are widespread in the country, with most major parcel distributors offering self-service pickup model. An example of the most widespread model of parcel lockers is the concept offered by Posti Group, one of the leading delivery and logistics companies in Finland. In 2011 Posti Group launched their first parcel pickup point, and by 2021 the number of lockers had grown to almost 2200. In 2020, the number of parcels which passed through Posti Group's parcel lockers grew by 76%. The company aims to increase the number of parcel lockers to 4 000 by the end of 2022 (Posti Group, 2022).

A slightly different concept is the Lähiboksi parcel locker service operated by PostNord. The parcel lockers are located outdoors and opened using a mobile app. Since the parcel lockers are located outdoors in public areas, they are accessible around the clock. The first lockers have become available in Tampere and Turku, but the company aims to expand the network to 300 parcel lockers in southern Finland by the end of 2022. The solutions are also already in use in Sweden, Denmark, and Norway (PostNord, 2022).

Figure 11. PostNord "Lähiboksi" parcel locker. PostNord (2022).

- Description of solution: Mobile-app controlled self-service parcel pickup locker, located outdoors.
- Business model: Used as a part of PostNords logistics chain.
- Functionality: Last mile logistics solution, centralized self-service delivery point for parcels.
- Scope: Used in Turku and Tampere, planned expansion across southern Finland.
- Environmental impact: Reduction of greenhouse gas emissions from last mile deliveries, improved safety due to reduction in heavy vehicle volumes, reduced noise pollution and congestion.
- Societal influence: Media coverage and increased awareness of green last mile solutions.
- Regulatory considerations: Potential challenges in securing permissions from landowners for the placement of parcel lockers.

Parcel lockers have seen the most adoption compared to the other solutions examined in the study, with their adoption being driven by online shopping and developments in customer preferences. They provide benefits for the operator involving the consolidation of deliveries while allowing for flexible pickup times for the consumer.

4.4 City logistics plans and initiatives

Governance and city initiatives include municipality driven projects such as stakeholder involvement, city logistics plans and policy initiatives aimed at developing city logistics. In 2014, the city of Helsinki published a city logistics plan, which outlined methods of developing city logistics in the central areas of the city. The city logistics plan was updated in 2020 to include newer technologies, updated measures based on previous experiences and new interview and survey results. The action plan contained research on existing city logistics solutions used in Scandinavia and Europe as well as stakeholder interviews used for identifying current challenges facing companies operating in the city, which were used to establish a selection of actions and initiatives for developing city logistics in Helsinki.

The action plan contained 11 measures, 4 of which were direct measures and 7 development projects, which served as an umbrella for a selection of related actions. Each measure or collection of measures was assigned a responsible party, for example the city planning bureau, and a timeframe for implementation. The practical measures included the development of parking arrangements in the city and collaboration with property owners during urban planning, as well as development of pedestrian zones. The city also plans to implement a parking badge or identifier for use by delivery companies, which would allow the user to conduct deliveries in the city during the authorized time window of 7 AM to 10 PM. The identifier also permits the use of designated unloading spots by the roadside, as well as removing the need for paying for parking in certain areas in order to avoid parking tickets while unloading.

The implementation of the aforementioned measures were the responsibility of the municipality. Other measures were designed to function as projects, which would yield possible solutions for future use, such as piloting different last mile solutions and technologies, developing waste and sanitation transportation, improving stakeholder collaboration and training, as well as increasing the utilization of underground maintenance tunnels for city logistics (City of Helsinki, 2015). The city logistics plan was revised in 2020 with minor updates to development solutions based on previous experiences, along with suggestions for the establishing of KPI’s which could be used to measure the effectiveness of the proposed measures and solutions (City of Helsinki, 2020).

5. Interviews

The interviews conducted for this study were semi-structured interviews in Finnish over Microsoft Teams video/audio calls during November 2022, which were recorded to aid the reviewing of discussions. The interview questions were designed to fill the gaps in previous research as well as this study, to form an understanding of current state of green city logistics solutions, challenges, and future prospects. The interviews placed further emphasis on green last mile logistics solutions, regulation, city initiatives, and infrastructure development, which all play a role in furthering the adoption of green last mile logistics solutions. Five people with a connection to city logistics through their current or earlier positions were interviewed.

Table 3: Description of interviewee's organization and their roles.

Organization/company	**Role in organization**
DHL Express Ltd.	Operations manager
Matkahuolto Ltd.	Development manager
Niemi Services Ltd.	Fleet and sustainability manager
City of Tampere	Traffic engineer
City of Turku	Project manager (previously PM for city logistics pilots)

The interviewee selection contains various stakeholders, municipal and private sector, as the development of city logistics requires the involvement of as many stakeholders as possible to be successful. For these purposes, the selection was largely successful, even though retail business or other similar parties are not represented. The interview answers were combined to represent general observations on city logistics and green last mile solutions in Finland, and not necessarily specific companies' points of view, unless it is directly specified.

The interviews were conducted as theme-based interviews, which was tied to a thematic structure which enabled the discussion to flow relatively freely, while still focusing on and returning to key topics when necessary. Furthermore, due to the different roles and expertise of interviewees, some areas were not covered in detail in each session. The interview questions are provided as an appendix at the end of this study. The interview results have

been divided into subchapters to group findings into thematic categories in the following order:

- 5.1 Alternative delivery vehicles and technologies
- 5.2 Infrastructure, city hubs and consolidation centres
- 5.3 Methods for facilitating the adoption of green last mile solutions
- 5.4 General observations on city logistics which do not fit under other categories

The first subchapter establishes what kinds of last mile solutions have recently been piloted or are currently in use in Finland, specifically in Helsinki, Turku, and Tampere. The interviews also covered what results these pilots have yielded and what could be expected in the future. The second subchapter focuses on collecting answers based on questions about infrastructure-related solutions, such as city hubs, parcel lockers and urban planning considerations. The third subchapter contains results which are related to the second research question of this study, which aims to answer how the use of green last mile solutions could be facilitated in the future. Finally, the last subchapter includes observations and discussion recorded during the interviews, which does not directly fall under a specific category, but was considered relevant to include in this study.

5.1 Alternative delivery vehicles and technologies

This subchapter contains the interview results regarding alternative delivery vehicles and other technologies such as autonomous robots. The questions aimed to simply establish what solutions the interviewees were aware of, either through their own organization and work, or from other sources. After the solutions were identified and located, the discussion moved on to establish how these solutions were being utilized and if possible, what kind of experiences have been had from their use. The advantages and disadvantages of solutions, as well as their requirements from the operating environment were discussed.

5.1.1 Electric vans and trucks

Electric vans are in use in DHL is currently using electric delivery vans (Mercedes eSprinter) in Helsinki and Tampere, with plans to expand their operations to Turku, where electric vans have also been trialled earlier. The expansion of DHL's EV fleet is a continuous process; when current diesel vehicles are decommissioned, they will be replaced with EVs such as the eSprinter. The overall experience regarding EVs has been positive, and the technical capabilities of EVs such as their operating range is improving over time.

From the perspective of the private sector interviewees, the first electric vehicles on the market were not ideally suited for winter use in Finland, but most of the issues have been ironed out as technology has developed. However, the operating range and charging time can always be improved. Sometimes managing longer charging periods have been a challenge, as drivers change shifts etc. With effective route planning, the effects of EVs' diminished operating range can be used efficiently even during winter.

The interviewee group's shared experience regarding heavy EVs such as trucks was more limited, as only a handful of fully electric trucks are in operation and data is still being collected. In the case of Niemi Services, electric trucks operate in a similar fashion to their other fleet vehicles, the only exception being charging timetables and the availability of charging stations. In general, while electric trucks have longer operating ranges than electric vans for the most part due to larger batteries, delivery distances outside city centres in Finland are often long, and thus not ideal for current EVs. For shorter distances within the city, in cases where larger goods need to be moved, electric trucks have a use case. However, the overall experience with electric vans has been quite positive according to the interviewees.

Regarding electric trucks, the initial investments are high, and the charging infrastructure is more limiting. The trucks are charged during night-time and are ready for the next day. It was also mentioned that acquiring new vehicles will create the need for more charging stations at depots, leading to further investment requirements. Hence, a major drawback related to EVs is the initial cost of acquiring vehicles and adapting facilities to accommodate them (charging, warm storage etc.) making adoption difficult for small companies, who represent a significant share of the traffic in urban areas.

From a public sector perspective, the city of Tampere has its own fleet of traditional vehicles, but EVs have not yet seen widespread use, although there have been some limited trials. It was noted that eventually nationwide guidelines for reducing emissions may be implemented which could act as a driver for the adoption of greener vehicles in the future. Municipalities in general can't always maintain comprehensive awareness regarding the types of vehicles and trials in use by the private sector, but participation in pilot projects in collaboration with other stakeholders involving EVs and other environmentally friendly solutions help to raise awareness of current trends within municipalities. Regarding collaboration and initiatives, major logistics companies operating in Finland have suggested the use of cargo bikes in Tampere based on experiences from other cities. In general, there have been some small-scale trials in the city, and there is potential for further pilots or longer-term initiatives in the future.

5.1.2 Cargo bikes

According to the feedback from logistics operators, cargo bikes are considered to be a form of supplementing the other last mile solutions such as electric vans in dense urban areas. This use case is mainly due to their physical dimensions and limitations; for example, the cargo bikes used by DHL and others have an approximately 1x1 meter cargo compartment, meaning that their volume is relatively limited and there can be cases where an extra electric van must assist with completing the leftover deliveries on busy days. The main purpose of bringing in various green solutions is to replace traditional diesel vehicles with EVs and to an extent, cargo bikes. However, as far as efficiency, electric (assisted) cargo bikes have been very successful especially in the central Helsinki area. The electric bikes can potentially surpass the efficiency of electric vans in areas with good cycling infrastructure; the bicycles are electrically assisted so they are not overly heavy to operate, and they are convenient to manoeuvre in congested central areas. Other comments made by the interviewees relating to the use of cargo bikes pointed out their limited capacity and range, which was considered a potential drawback. Despite their drawbacks, the marginal environmental impact of cargo bikes was thought of as very positive, and the solution was considered beneficial if it could be executed in a feasible manner from a business perspective e.g., when combined with a city hub.

5.1.3 Drones and autonomous vehicles

According to the interviewees, autonomous vehicles could be feasible in the future, as some projects have demonstrated, (such as HOK-Elanto in Espoo mentioned in the previous chapter) but the technology is still limited and not ready for full-scale adoption. Autonomous delivery robots would most likely be intended to supplement other means of transport in the future. However, technology develops rapidly, and the adoption and use cases can change relatively quickly. Infrastructure can pose a challenge to autonomous solutions, some areas of the city will always be a challenge for delivery robots due to their dated layouts, cobbled streets, and high kerbsides. As new areas are designed, upcoming technology and operating models should considered so that they are more accommodating for new solutions in the future. New city logistics models are already integrated during the design phase, such as more innovative parking and unloading locations, as well as bicycle- and robot-friendly lanes. Additionally, it was mentioned that delivery drones have been widely tested in Europe. However, a case for large scale use does not yet exist in Finland partially due to technological limitations, although some limited trials have also been conducted.

5.1.4 Alternative fuels

In an interview, Niemi Services' utilization of alternative fuels was raised as a talking point; biogas-fuelled vehicles make up for approximately 25 % of the company's fleet. The use of electric vehicles is also underway, but at a relatively small scale at the time of writing. The percentage share of these solutions is expected to grow in the future. Supply shortages also limit the utilization of EVs, which Niemi operates in Helsinki. It was pointed out that lifecycle costs of biogas moving trucks have even been lower than traditional diesel trucks. In the case of biogas, currently the biggest challenge is the physical refuelling network, which is a lot sparser than traditional fuels, meaning that routes have to be planned carefully in order to guarantee operational efficiency.

The use of greener alternatives generates positive visibility in the media and while operating in the cities. At times customers request the use of green solutions for their deliveries or moves - in some public sector tenders the use of alternative fuels can create an advantage if

environmental requirements are present. The parameters of the environmental requirements in public tenders are likely to become more significant in the future, meaning that it would be beneficial for companies to position themselves in a way that makes them ready to meet stricter requirements.

The municipalities covered in the interview also have emission reduction targets as a part of their environmental strategies, which is in line with companies' strategies of shifting towards greener fuels and vehicles. Combined with public image factors and meeting tender requirements, the widespread adoption of alternative fuels can be a future competitive advantage for the companies that are first to successfully incorporate them to their daily operations.

5.2 Infrastructure, city hubs and consolidation centres

Infrastructure and different cargo consolidation methods are covered in this subchapter. The interviewees were asked if they were aware of city or consolidation centres being used in Finland, as well as what the requirements for their successful implementation would be. Parcel lockers were also included in this segment, as they are often grouped into the infrastructure category of last mile solutions, even though they are a much lighter alternative to actual hubs or consolidation centres.

5.2.1 City hubs

All of the interviewees were aware of the major last mile -related pilot projects which had taken place in the capital region and Turku, either through a professional capacity or through the media, as the initiatives by DB Schenker and DHL have been widely featured in logistics media publications. More specific information on their respective trials was provided from the perspective of DHL, based on which city hubs have been found to be a feasible solution when piloted in Turku and Vantaa. City hubs reduce last mile delivery distances by bringing the distribution point closer to the customer in central urban areas. Pilot results suggest that city hub similar to the ones used in Helsinki and Turku could be possible in Tampere as well,

possibly operating throughout the year. In order to be as efficient as possible, the location and connected infrastructure of the city hub is important; the hub needs to be located in a central area surrounded by a dense population, preferably along an extensive network of streets which are accessible by vans and cargo bikes. The city hub should also be reachable with small trucks so that it's capacity can be filled effectively before distribution with light vehicles.

So far, the pilot projects such as the one in Turku have been quite short, but they have provided some supportive data suggesting that that EV deliveries can be cost effective, especially once the charging network and battery capacities improve, allowing for longer operating range for the vehicles. Currently the initial investments regarding EVs are high, which is especially problematic for small businesses. The situation is somewhat different for global operators, who have the resources to invest in technology and they have ambitious environmental goals as a part of their long-term strategies. Regarding other operating models similar to city hubs, an interviewee pointed out that during traditionally busy periods, Posti Group has used temporary depots as points for consolidating deliveries, where customers can pick up their mail and packages instead of finding a parcel locker or service point inside a store.

5.2.2 Consolidation centres

According to one of the private sector interviewees, a logistics hub on the outskirts reduces the number of heavy vehicles heading into the city, especially if the last mile segment of the delivery is carried out using an alternative form of transportation. The logistics centre could also be shared by multiple companies, and the operations of the facility could be taken care of by the city. The centre could also provide services such as charging opportunities for EVs.

In the case of city hubs and shared consolidation centres operated by a third party, it was pointed out that companies can be quite protective about their brand representation, logos etc. The general preference is that branding is visible to the end customer, which in turn, makes the involvement of third parties more challenging since there is a concern that the customer will not distinguish which entity is responsible for different stages of the delivery process, potentially leading to misunderstandings. More importantly, companies have

service agreements with customers which they are responsible for, so they are relatively unwilling to hand stages of their logistics chain over without strict guarantees of service level and communication to the end customer in order to avoid misrepresentation. Furthermore, the integration of information systems is challenging and costly if there is a need to transfer delivery and handling data to a third party, creating a barrier for entry regarding collaboration.

Outside of physical consolidation centres, the industry has some additional historical examples of collaboration. An earlier case of delivery consolidation comes from the combination of newspaper deliveries by logistics companies; operators realized that they had very similar delivery routes with their competitors who were delivering other newspapers, so multiple deliveries from different newspapers were merged onto routes which had excess cargo capacity instead of two separate companies operating half-empty trucks. This way the utilization of truck capacity was improved, cutting operating costs by removing excess vehicles from the roads.

5.2.3 Parcel lockers

A view shared by the private and public sector alike was that parcel lockers and self-service pickup points are already widespread and function well when combined with green last mile solutions. According to the logistics company interviewees, the number of parcel lockers is expected to keep growing at a steady rate in the future, following the trend of online shopping and urban population growth.

Parcel pickup points have also been placed in apartment buildings, where they are conveniently located in built up areas near inhabitants. These locations also improve delivery conditions from the perspective of the delivery company, as drivers do not need to spend time walking up flights of stairs or waiting for elevators in case the customer is not at home, also meaning that delivery vehicles are not parked on sidewalks for long periods of time. Parcel pickup points are also considered to be very flexible, as customers can choose from a large selection of locations and timeframes, making the solution both cost-effective and more environmentally friendly than home delivery from the operator’s perspectives. In the future parcel pickup points are something that will be developed even further. Centralizing the

delivery locations could offer many benefits regarding volume of deliveries and total delivery distances. In a way, reverting to the old model of having to pick up a package from the post office could be worth revisiting.

5.3 Methods for facilitating the adoption of green last mile solutions

This subchapter covers interview answers and observations regarding the prerequisites and methods for supporting the adoption of green last mile solutions from the perspective of private companies and the public sector. The discussed methods have been divided into categories involving city infrastructure, governance and legislation and initiatives, which can contain a combination of the aforementioned categories.

5.3.1 Infrastructure development

Charging stations would help adoption and improve operating efficiency in urban areas especially during winter, where battery capacity is diminished. Location is the most critical for feasible operations. Offering a permanent central location with good connections (also heavier vehicles for feeder traffic) would help significantly aid adoption. There could also be other companies operating in the location to help share the costs. The Turku city hub was partially funded by the city and EU funding is also a possibility.

When planning urban areas, setting up parking spots and unloading points on the street would cut down on the time that drivers spend looking for a location to unload their cargo, lowering emissions and improving safety when vehicles are not parked on the pavement etc. A lot of the most practical solutions for the city involve parking spots, unloading locations etc. which aim to reduce the time spent idling or driving around looking for a parking spot, which directly decreases pollution levels and improves the quality of life in those locations. Parking permits for logistics is another solution which can assist logistics companies.

5.3.2 Governance and legislation

From the interviews with a private sector angle, the cities are viewed as potential enablers, but this does not rule out the possibility of being able to require changes to company operating methods. For example, by requiring that deliveries fulfil certain criteria such as fuels and vehicles used. Controlling timeframes for driving in the city is considered restrictive, as the delivery industry operates around the clock and customers want their deliveries as fast as possible, so meeting additional time-frame limits would be challenging. Another possibility mentioned was the use of delivery time windows, or the restriction of heavy vehicles in central areas. This could be somewhat challenging to implement, as there are different service guarantees for different sectors, so deliveries are required at different times of the day and organizing efficient routes can be difficult.

There can also be some incentives granted to companies for using green logistics solutions, perhaps parking permits, grants etc. Cities could assign and make locations available for companies to use, making sure that the handling of permissions etc. is as straightforward as possible. Municipalities' perspective is that the city must treat operators equally, so it can be challenging to find solutions that don't favour specific operators, e.g., providing a location to the first company that contacts the municipality. Instead, there could be an open call for tenders for locations.

The city can also offer an open bidding process for logistics initiatives and pilots, where they can find logistics partners in an unbiased manner. It may even be possible to provide companies with a vacant location, where the city could buy a service from a logistics company with requirements of using green logistics solutions. This could be explored further, to see what kind of costs are related and if it would be beneficial and low cost for the city. Transport unions and associations could function as a partner for the cities when looking for an operator for a logistics service.

It is also still uncertain how the city can encourage or enforce the use of greener fuels and motive forces, other than by implementing regulations which limit the use of certain fuels in the city centre. According to some of the interviewees representing the private sector, carbon free and controlled zones could serve as a tool for driving adoption, even though "forcing" the issue can be perceived negatively. However, if problems are allowed to manifest for too

long, the transition process could become even more difficult. There could be some higher-level authority driven standards and regulations which will drive adoption in a way that treats all participants equally. Government level guidance can also help cities create their own guidelines for companies.

5.3.3 Initiatives

Communication was considered to be important, as all different operators and inhabitants of the space have their interests so improving communication and awareness is mutually beneficial. Communication also enables collaboration and better, more inclusive infrastructure planning. It's important to hear the needs of transport companies since deliveries still need to be made, especially as online orders and shopping volumes are increasing yearly. Communication in the form of public forums was raised several times as being very significant. With forums, the municipality decision makers, as well as inhabitants could be made more aware of the practical challenges involving last mile deliveries. Local inhabitants can also raise their own concerns through the forums. Sometimes compromises are required in order for stakeholders to work together, making clear communication even more significant. The ability to influence planning and operations could also lead to more commitment by each party.

A logistics company employee described some issues related to the success factors of city logistics forums based on experiences from current and previous iterations; the experiences have been somewhat modest regarding practical outcomes, as the forums are not mandatory or at least strongly encouraged by the city or some other part, leading to lack of commitment and stakeholders not actively engaging in discussions. From a municipality perspective, resources to organize initiatives are often limited, and the necessary knowhow or industry experience is not always available to facilitate effective collaboration. Some communication from a government ministry level or from municipalities stating if they will support initiatives in a specific manner, would provide more confidence in private companies to invest if support can be expected. However, the style of forum-like discussive communication between stakeholders is preferred to simply making announcements, as more nuance and planning is involved.

5.4 General observations on city logistics in Finland

This subchapter contains some observations related to the nature of city logistics, which were made during the interviews. The concept of city logistics is largely considered to be delivery directly to the end customer, usually local businesses, or private citizens. There are a lot of variances in deliveries, as volumes and delivery frequencies have increased while delivery end points are at located all over the city.

Heavier diesel vehicles will still be present in the future, especially for longer distances until there are more breakthroughs in alternative fuels or improvements in battery technology and EV affordability. The change towards greener logistics will most likely stem from changes in operating models in urban centres, driven by the requirements and limitations set by cities. Before new technologies and ways of operating can become mainstream, viability from a business perspective is always being considered. An investment will not be made if it does not address a clear business need while meeting the financial criteria set for it. Customers will also drive adoption of greener logistics solutions through their own preferences and requirements. From the perspective of municipalities, it is important to reduce the effects that heavy vehicles have on the operating environment regarding safety, quality of life and comfortability etc. Many companies operate on the principle of delivering as fast as possible to the end customer, which poses challenges to the city and makes it harder to influence city logistics.

The public sector also takes some time to react to market developments due to the need for internal discussion and decision making, so private companies are often acting first regarding the implementation of green logistics solutions. However, private operators are sometimes unwilling to bear the risk themselves due to business concerns. In a sense, each stakeholder group is waiting and observing the industry for signs of development and change. The public sector is monitoring EV use before committing to infrastructure plans, and in turn, the private sector is waiting for public initiatives which would support their adoption.

5.5 Overview and comparison of research and interview results

The last mile solutions highlighted in interviews were almost completely featured in the initial research for LM solutions used in Finland, this could suggest that the selection of different technology options and initiatives is generally narrow. Due to the small number of initiatives and the representation of the interviewees, the solutions described in the interviews are largely based on the few major delivery companies that are driving the use of green last mile logistics in Finland. The interviewees were not directly asked about any projects or initiatives outside of the three cities covered in this study, but it seems unlikely that other smaller cities would be the targets for any significant LM projects or solutions. The representation of solutions and their presence in case cities is summarized below.

Table 4. Overview of green last mile solutions used in Finland based on literature and interviews.

	Helsinki	**Turku**	**Tampere**
Electric vans	• In use as part of transport fleets • Previously used as part of city hub trials	• In limited use as part of transport fleets • Previously used as part of city hub trials	• In limited use as part of transport fleets
Electric trucks	• In limited use as part of transport fleets	• Data unavailable, potentially in limited use	• In limited use as part of transport fleets
Cargo bikes	• In use as part of transport fleets • Previously used as part of city hub trials	• In use as part of transport fleets • Previously used as part of city hub trials	• In limited use as part of transport fleets
Drones and autonomous robots	• Previously used as part of trials	• Data unavailable	• Previously used as part of trials
Biofuels	• In use by some operators	• In use by some operators	• In use by some operators
City hubs	• Not currently used • Previously used as part of pilot projects • Future potential	• Not currently used • Previously used as part of pilot projects • Future potential	• Not currently used • No previous uses • Future potential
Consolidation centres	• Not in use	• Not in use	• Not in use
Parcel lockers	• Widely used	• Widely used	• Widely used

Similarities between literature research and interview results

- The interviewees were generally aware of all of the various green last mile solutions which were feature in the online research.
- Stakeholder involvement and communication was raised in each interview as an important driver for the adoption of new technologies and broader development initiatives.
- Infrastructure development, such as the improvement of charging infrastructure for EVs was considered to be beneficial for increasing the utilization of EVs. The expansion of charging networks could be driven by both private and public sectors, or as a combination of both.
- The trials were all considered relatively small-scale, and there was no further information of larger scale pilot projects in progress at the time of writing. However, the use of green last mile solutions such as EVs is expanding and is expected to become more widespread in the future.

Differences and new observations

- There were some differing opinions on the viability of cargo bicycles during the winter, as well as their capacity. The consensus was that when combined with other solutions such as delivery vans, the cargo bicycles can supplement other forms of city logistics deliveries efficiently.
- Alternative fuels were not represented in depth within literature, but the interviews provided information on their feasibility after substantial initial investments.
- Consolidation centres operated by a third party were mentioned in some of the interviews, but their implementation was considered challenging due to economic viability issues, closed systems and liability considerations.
- The use of drones and autonomous robots was not considered especially viable in Finland at the moment by the interviewees, their use was mainly related to marketing and raising awareness about new logistics solutions and collecting data using new technology.

Overall, the last mile solutions raised in the interviews were relatively similar to the trends that were raised in city logistics literature, only at a somewhat smaller scale as the pilot projects had been scaled down to adapt to the Finnish operating conditions. The key drivers for increasing the adoption of green last mile solutions also shared similarities with previous studies, where infrastructure development, financial support from the government and the formation of stakeholder forums had been raised. Policy-driven initiatives such as the use of stricter operating time windows and environmental zones were also discussed but were considered to be restrictive, although their ability to influence city logistics was acknowledged.

6. Conclusions

This chapter concludes the study by comparing the observations collected from literature and other sources with the interview results. As pointed out earlier by Benjelloun et al., (2010), acquiring detailed information on city logistics solutions and initiatives is a challenge, but when combined with interview data, a general overview on the current state of green last mile logistics solutions and methods for increasing their adoption was achieved.

6.1 Comparison with previous studies

Many of the solutions and measures identified in this study were already present in previous research on the subject area involving the cities of Tampere and Helsinki such as those by Kiiskinen et al. (2013) and the City of Helsinki (2014; 2020). This is relatively unsurprising, as these previous studies are still relatively recent and approached the subject from a similar perspective. There were some small differences related to the associated technologies and last mile solutions, which is most likely due to the development of technology and more information being available regarding the results of pilot projects, such as the city hub trials in Turku and Helsinki. Overall, alternative delivery vehicles such as EVs are used in all three of the examined cities on a limited scale. Currently, the level of adoption is highest in Helsinki. EVs have been used in conjunction with city hubs in Turku and Helsinki, but neither of the projects are currently in operation. However, the pilot projects have been enough to indicate the feasibility of city hubs combined with EVs and cargo bicycles, making it likely that they will see more utilization in the future, possibly on a larger scale if suitable locations can be found. An option for municipalities could be that they allocate competitive locations for use in future last mile logistics projects or even longer-term initiatives.

Regarding similarities compared to international literature on city logistics, the results were reminiscent of the observations made by Dablanc (2007) and Gammelgaard (2014), where stakeholders were considered to be waiting for each other to act due to the business risks involved, as well as being generally unsure of each other’s interests. According to these studies, stakeholders such as retail stores did not want to take the lead on initiatives, nor did delivery companies. Municipalities could not or lacked the willingness to enforce the use of

concepts such as consolidation centres or city hubs. In the context of this study, companies, especially smaller operators can be reluctant to take on the role of furthering the adoption of new last mile solutions requiring extensive investment and commitments before they receive acknowledgement and support on a government or municipal level.

6.2 Managerial implications of findings

The issue of the costs involved with some of the solutions and measures was present in most of the source literature and interviews; new technologies and infrastructure-related solutions require significant investments, which may not be feasible for the smaller stakeholders in city logistics, who still make up a large portion of deliveries conducted in urban areas. It is important not to forget the role of smaller businesses and to involve them in discussions revolving around the topic, as well as in wider stakeholder collaboration so that the adoption of greener last mile solutions can be facilitated through different means. Methods for financially supporting smaller companies in order to increase the use of relatively costly technologies such as EVs is something to be explored further. Not all initiatives need to be large-scale and costly, municipalities could also enact some lighter measures in the form of facilitating stakeholder involvement and implementing more minor infrastructure changes, such as improving the availability of parking spaces for loading and unloading cargo.

When exploring the possibility of developing city logistics through broader initiatives containing various improvement measures, municipalities should strive to enable effective communication between different city logistics stakeholders in order to form a mutual understanding of different goals, challenges, and criteria. Achieving commitment from a diverse range of stakeholders is challenging, but a proactive approach and demonstration of mutually beneficial initiatives could lead to improved commitment levels in a fair manner. Private sector operators should also evaluate the opportunities for collaboration with other companies, either through shared facilities or equipment in order to mitigate expenses and responsibilities. Active participation in public forums is also encouraged in order to ensure that logistics companies are adequately represented in communication and decision making.

6.3 Grounds for future research

A more complete understanding of the financial and operational aspects of green logistics solutions would require access to information which is often restricted due to confidentiality. However, it could be possible to form a deeper understanding by conducting more detailed interviews or comprehensive surveys. Despite these challenges, the study demonstrated that green last mile solutions such as electric vehicles, cargo bicycles and city hubs, along with parcel lockers all have a potential role to play in future city logistics in Finland. With the development of technology and adequate stakeholder involvement in the planning and execution of new pilots and initiatives, the role of green last mile solutions in Finnish cities can be expanded even further. As new initiatives and pilot projects take place, there will be grounds for further research on their implementation and results, and the adoption of emerging technologies such as autonomous delivery robots and drones will provide additional dimensions for this research.

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Appendix

Appendix 1 Interviewees

Harri Henriksson, Operations and Service Partner Manager, DHL Express Oy (Interviewed 14.11.2022, recording and notes available by request).

Janne Reiman, Manager - Control Tower, Matkahuolto Oy (Interviewed 14.11.2022, recording and notes available by request).

Jere Lumikko, Project Manager, City of Turku (Interviewed 9.11.2022, recording and notes available by request).

Pekka Stenman, Traffic Engineer, City of Tampere (Interviewed 10.11.2022, recording and notes available by request).

Ville Häyrynen, Fleet and Sustainability Manager, Niemi Services Ltd (Interviewed 9.11.2022, recording and notes available by request).

Appendix 2 Interview template

Teemahaastattelupohja

Läsnä:

Aika:

Paikka:

Haastattelun taustoittaminen

- Mitä organisaatiota edustatte?
- Mitä on organisaationne keskeinen liiketoiminta?
- Millaisessa roolissa toimitte organisaatiossanne ja mitkä ovat keskeiset vastuualueenne?

Vihreät logistiikkaratkaisut

Taustoitus: tarkastellaan Suomessa pääosin Tamperetta, Turkua ja Helsinkiä. Käydään läpi keskeisiä termejä.

- Onko organisaatiollanne/yrityksellänne käytössä vihreitä logistiikkaratkaisuja? Jos on, mitä ja missä?
- Onko suunnitelmissa ottaa käyttöön uudenlaisia ratkaisuja, tai selvittää uusien ratkaisujen mahdollisuuksia? Jos on, mitä?
- Millaisia kokemuksia edellä mainituista ratkaisuista on saatu? Jatkuuko ratkaisujen käyttö?

Logistiikkaratkaisujen tarkastelu

- Käytön helppous, ovatko ratkaisut käytännöllisiä käyttäjän näkökulmasta (jos kyseessä jakeluratkaisu)?
- Onko ratkaisuilla ollut päästöjä ja muita ”haittoja” vähentävä vaikutus?
- Muita etuja, kuten näkyvyys kaupunkialueilla?
- Etuja liittyen viranomaisvalvontaa ym.
- Ratkaisujen taloudellinen kannattavuus?
- Onko havaittu ongelmia/heikkouksia liittyen ratkaisuihin?
    - Toiminnalliset ongelmat, liittyen käytettävyyteen, kapasiteettiin, toimintaympäristön asettamiin vaatimuksiin jne.
    - Taloudelliseen kannattavuuteen liittyvät haasteet
- Mitkä ovat tärkeimmät edellytykset, että jakeluratkaisun tai teknologian käyttöönotto on mahdollista kohdekaupungeissa? (Volyymit, infra, sääntely ym.).

Vihreiden logistiikkaratkaisujen hyödyntämisen tukeminen

Millä keinoilla uusien logistiikkaratkaisujen hyödyntämistä voitaisiin edistää eri tahojen toimesta?

- Kaupunkien hankkeet
- Viranomaisohjaus ja säädösympäristö
- Kaupunkilogistiikan sidosryhmien välinen kommunikaatio
- Kaupungin infrastruktuuri ja suunnittelu

Vihreät logistiikkaratkaisut yleisesti (täydennys)

Onko teillä täydentäviä kommentteja muista logistiikkaratkaisuista, jotka eivät ole käytössä suoraan organisaatiossanne/yrityksessänne ja/tai ei aikaisemmin mainittu?

- Jakeluratkaisut, kuten tavarapyörät ja sähköpyörät
- Jakeluun liittyvä infra, kuten pakettiautomaatit ja lähijakeluasemat