HOW ARE SHIPPERS AND CARRIERS PREPARING FOR THE ARRIVAL OF ZE ZONES?

Zero Emission Zone Genesis: Getting Acquainted With Possible Solutions for SME's

Hans Quak	Breda University of Applied Sciences and TNO
Thato Motloung	Breda University of Applied Sciences
Angel Stoyanov	Breda University of Applied Sciences

Summary

Zero emission zones (ZEZ) are getting closer and closer. And with that, it is also increasingly important for carriers and shippers to know how they can go about their business within the rules that municipalities will set. As a result, we see more and more students working on assignments with especially smaller shippers and carriers, to examine the options these companies have to meet the stated ZEZ-requirements. Many companies and students are examining the options to use ZE, in current practice this means battery-electric, trucks and vans in the existing city logistics activities. Except from what it operationally means, often the possible (purchase) subsidies, the difference in total cost of ownership between diesel and ZE vehicles, and the issues in charging the vehicles and especially larger fleets given the congestion on the electricity network are examined. And after these technical possibilities – which is already quite some work for companies or students that are new in this field – the explorative studies are considered to be completed.

However, the initial focus on how to deal with ZEZ from a vehicle-technological point of view, causes limited (if any) consideration of the possibilities of supplying ZEZ by organising logistics differently. This paper serves as an introductory guide for topics related to the sustainable execution of logistics in the last mile and the zero emission zone transition period in the Netherlands; for companies and students doing assignments for these companies, who are faced with research questions in this area. We structure the development and plans around ZEZ, after which we discuss the various directions that companies have to organise the last mile zero emission, from reducing the transported volume, to changing the existing flows and modalities, to changing the fleet.

The motivation behind paper is that many of the companies and students often have to start from scratch in their quest for background information before they can undertake the relevant research, which is a time-consuming exercise. At times, the results of these assignments are nothing more than a summary of information that is already available, with a particular focus on fleet electrification which is seen as a low hanging fruit. This limits the foray into other solutions which may be more beneficial and/or innovative. With this paper's overview, companies and students can access foundational knowledge onto which they are able to build further insights on, providing value and allowing them to use their time more effectively.

1. Introduction: zero emission zones – now what?

In recent years, there have been concerted efforts by private and public interest groups to determine how city logistics would function within zero emission zones. In addition to the focus on zero emission zones, cities and businesses alike are looking to become increasingly more sustainable in light of climate goals. This has led to questions being raised, some of which end up on the desks of students in higher education either as challenges or internship assignments. This article serves as an introductory guide for topics related to the sustainable execution of logistics in the last mile and the zero emission zone transition period in the Netherlands; for companies and students who are faced with research questions in this area.

1.1. Motivation

The motivation behind this guide is that many of these students often have to start from scratch in their quest for background information before they can undertake the relevant research, which is often a time consuming exercise. At times, the results of these assignments are nothing more than a summary of information that is already available, with a particular focus on fleet electrification which is seen as a low hanging fruit, this often limits the foray into other solutions which may be more beneficial and/or innovative. With a guide as such, the students can access foundational knowledge onto which they are able to build further insights on, providing value and allowing them to use their time more effectively.

One collaboration that seeks out these answers is between the Breda University of Applied Sciences (BUas) and the Rijkswaterstaat (RWS). The Rijkswaterstaat is a Dutch government agency that is responsible for primary infrastructure in the Netherlands, this includes the design, construction and maintenance of road and water infrastructure. The RWS has approached the BUas with a question (as a part of challenge based education) to how the impending ZEZ rollout will impact road infrastructure design in the coming years, looking into the plans of shippers and carriers to see what trends may be on the horizon according to the planned adoption of solutions.

This article delves into basics of the zero emission logistics solutions that are currently available to shippers and carriers. This list is not exhaustive, however, it serves as a starting point for further research on topics linked to zero emission city logistics.

1.2. Zero Emission Zones

From 2025, the Netherlands will be rolling out a series of zero emission zones in 29 municipalities across the country, this is in a bid to ignite a series of actions focusing on curbing the emissions emitted from

commercial transport starting from the last mile. This initiative was set out in Dutch Climate Agreement and detailed in the Uitvoerings Agenda (Rijksoverheid, 2020) which declares that zero-emission zones will be implemented in 30-40 Dutch municipalities between 2025 and 2030, the agenda details that fossil fuelled commercial vehicles are banned from entering zero emission zones by 2030 with the transition beginning with the phasing out of Euro 5 and below vehicle classes from 2025 and euro 6 commercial vehicles following in the subsequent years as per figure 1 below.

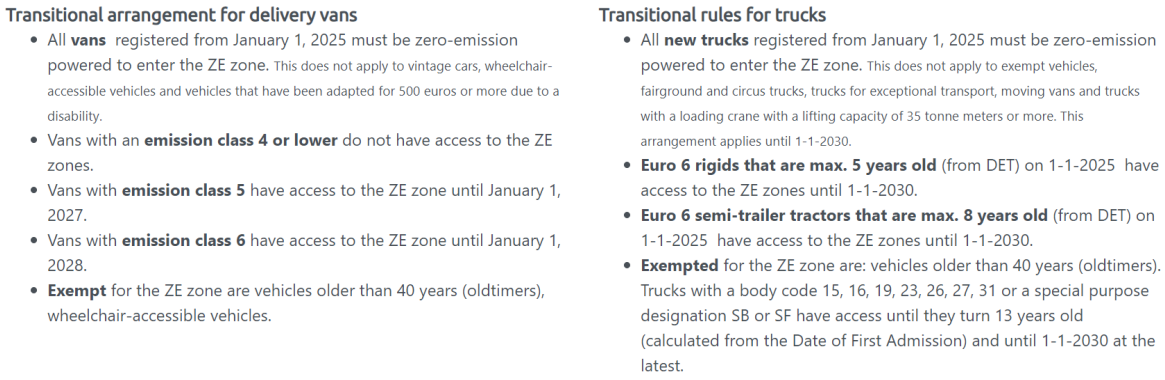

Figure 1: ZEZ transition 2025-2030 (Opwegnaarzes, 2024)

Zero emission zones comprise of city centres which are often central business districts with numerous retailers, offices and residential apartments all of which are dependent on logistics activities. The plight for more sustainable city logistics bears a direct impact on the economy of the region which beckons to the importance of researching feasible solutions for how city logistics can be carried out in a sustainable manner.

1.3. Driving Awareness

Various initiatives have been undertaken in the Netherlands to drive awareness regarding the Zero Emission Zone rollouts, the main channel used being digital media by the way of online articles, radio, TV, but also the use of logistics brokers and sending direct mail to companies that are located within zones is used by local authorities to reach these companies. However, since this communication has not been very effective in the past, evidenced by a little over 30% of 210 surveyed businesses in the inner cities of Noord Brabant's Big 4 municipalities indicating that they were not aware of the zero emission zones in 2021 (Motloung et al., 2022). These businesses were surveyed via QuickScans which were executed at small to medium retailers within the city centres by students. Out of the four, Breda is yet to announce a zero emission zone, however, Den Bosch, Tilburg and Eindhoven were already working towards it.

The municipalities with a higher ZE awareness among businesses can attribute this to operating within low emission zones which has offered a buffer between using traditionally fuelled and fully zero emission vehicles. The proportion of informed businesses has since grown, due to concerted efforts to broadcast this information. It was also established within this study that although some businesses had not heard about the zero emission zone rollouts, they were already seeking carbon neutral alternatives due to their own initiative to prioritise more sustainable operations.

Seeing that communication was not being effectively disseminated, municipalities have allocated logistics brokers (logistiekmakelaars) to bridge the gap and give tailored advice to businesses that are aware of the zero emission zones but don't know how to make the cross over to more sustainable means of commercial transport. In conjunction with this effort websites such as OpwegNaarZes.nl and DoeHetZero.nl also offer transitional guidelines, advice and businesses cases thus leading to quality references in peer to peer communication, enabling residents and business owners alike to have access to basic knowledge about the impending ZEZ rollouts.

Overall the most notable communication channel thus far within the logistics industry has been issued by sector organisations such as the EU wide ALICE and POLIS, and even local initiatives such as the TopSector Logistiek as well as government agencies. The disadvantage being that this information is disseminated through the sector but barely filters through to the transporters engaging in the day to day business of city logistics, particularly, ZZPers and MKBers (micro to medium enterprises and freelancers) and retailers who often don't consider news relating to logistics.

1.4. Key Trends Impacting Logistics within zero emission zones

The future of logistics within zero emission zones requires one to look at the logistics ecosystem with binoculars, looking far beyond the trends of today and borrowing insights from the future to investigate the suitability of zero emission solutions for long term use. Some of the trends that are currently at play or the horizon are:

a. E-Commerce

The ease of access to international e-commerce sites, an improving fintech industry as well as a 34% rise in social commerce between 2021 and 2025 (Bruijn et al., 2023) is set to impact e-commerce even greater than before. With economic trends such as the recent recessions tamping frivolous spending and de-influencing (consuminderen) trends among awareness of ethical and environmental issues surrounding manufacturing, consumers are more conscious of their spending habits, however, the projected GDP growth as well as deflation (European Commission, 2023) is set to offset this as purchasing power increases thus directly impaction e-commerce positively and the resulting logistics.

E-Commerce has a direct relationship with city logistics as a rise in e-commerce bears a brunt on unique parcel deliveries to residentials as opposed to bulk freight which is delivered to brick and mortar stores. Resulting in increased volumes, some coming from the same source with just a split in B2B and B2C channels.

b. Physical Internet and Industry 4.0

Logistics is not to be left behind when thinking about the internet of things (IoT) applications. Currently, large logistics companies are using truck telematics with a plethora of sensors to monitor driving behaviour, offer real time routing insights as well as monitor freight, this, combined with camera networks, smart containerization, parking sensors and urban design advances that cities offer are creating good groundwork for the physical internet which is essentially a network of networks where freight is moved around in a similar way to how the internet transmits data (see European Commission, 2024 and Montreuil, 2011). With these in tow, concepts like capacity and asset sharing for volume consolidation are enabled which further supports the move towards sustainable logistics. The physical internet will support the integration of logistics planning to a new level, inclusive of insights from municipalities, private companies as well as real time traffic and urban space use data. Although barriers such as cost allocation and the viability of an open system in a highly competitive market exist (see Van Duin et al., 2023 and Cimon, 2014), the potential of a collaborative network holds wins for sustainable transportation within zero emission zones.

c. Greening Urban Space

In efforts to improve the quality of life in cities, many councils have opted to green urban space and reclaiming what was initially streets and parking spaces to make way for gardens and more walkable cities. Amsterdam is one such city with a green space policy. This vision is squarely placed in the cities 2050 vision document (Gemeente Amsterdam, 2024). As other cities follow suit, there is a question as to how city logistics will look in the future with less urban roads apportioned to vehicles.

d. As a service platforms

Gone are the days where ownership was a prerequisite to using goods. product as a service systems are fast becoming a norm in different industries. Underpinned by 5G technologies and cloud computing, as a service platforms offer products on use based billing systems as opposed to a once off payment and a focus on ownership, this could have a tremendous impact on the running of the city logistics landscape in the coming years. In the freight delivery perspective, there are opportunities in various business models linked to the execution of logistics deliveries such as mobility as a service (which is addressed further down this article) and freight as a service which serve as booking platforms for freight and mobility assets which could possibly be privately owned or owned by the platform itself (Johnson, 2020), thus eliminating the need for businesses with minimal deliveries to the city centre to invest in

their own vehicles. Although not exhaustive, the above trends are contributing towards a change in the manner in which logistics has been conducted for the past century, perhaps indicating a shift from decentralised to more organised city logistics operations. Choices pertaining to solutions should always take the direction in which logistics is moving in mind, particularly for hauliers and shippers as their business operations will be directly impacted by the impending zero emission zones.

1.5. Setup of the paper

After this introduction, this paper presents the ASI-framework (avoid-shift-improve) to classify the various solutions that carriers and shippers can use to satisfy the ZEZ regulations that will be implemented. The presented trends in the previous section illustrate that even if there are no ZEZ regulations, the city logistics playing field is changing anyway. These trends also provide new directions for the logistics industry to develop logistics strategies that fit the future. The avoid-shift-improve solutions that will be presented in the following sections provide ideas for strategies to deal with the upcoming ZE zones.

2. Directions: what can shippers and carriers do?

2.1. A classification for solution directions

Very often, zero emission urban logistics is immediately assumed to be about replacing the existing diesel-powered vehicles with electric vehicles. This is not surprising, as the establishment of ZE zones is mainly about not allowing vehicles emitting CO_2 in certain areas (see Figure 1). So, then the most logical response is, there must be zero emission vehicles. An example of this initial reflex can be found at the information website on the plans for zero emission zones and in particular the section for businesses (see opwegnaarzes, 2023), where the following advice is provided: "a roadmap electric driving, in which companies can learn which vehicle to choose, how to charge the vehicles, what the transitional arrangements and possible vehicle purchase subsidies are". But there are other options and alternatives that companies could consider than replacing their polluting vehicle and continuing to do everything else the same.

In older work we already argued that a mix of technical, political and logistical solution directions is necessary to achieve a more sustainable city logistics system. This still holds for the current challenges, i.e. zero emission city logistics and the future challenge urban freight transport competes with other activities in the cities for the use of space, including greening urban space. Notice that the technical solution direction does not just applies to the vehicles, but also to the innovations in computing technology and the resulting physical-digital integration in the urban logistics system (see Tavasszy and Quak, 2023 for an exploration of three pathways, i.e. 1. the Physical internet, 2. Control in the smart

city, and 3. Digital Twins for Collaborative Innovation). Although, some of these technical innovations may seem like a far future, it is important to realize that the mix of feasible solutions is subject to change over time. This is also the case for the policy directions, where developments in for example enforcement options, allow for more customized policies in the future, as well as change in public opinion that may lead to different policy measures over time. The logistical solutions also interact with the changing possibilities due to for example possibilities to directly interact with receivers. Having said that, we focus in the remaining of this paper on solutions that are feasible or are expected to be feasible on the short term in daily urban logistics operations, as the main focus of this paper is to provide the main solution directions that current urban logistics professionals have to comply with upcoming ZE regulations.

The one-sided focus on the electrification of the urban freight delivery fleets, also ensures that the other solution direction, that of organising logistics differently, is sometimes completely out of sight. And the one-to-one replacement of the current diesel fleets with electric vehicles is not only very expensive in the short term, it also does not result in fewer vehicles in urban traffic or reduction of the space occupied by these vehicles in the already crowded cities while driving, loading and unloading or performing a service.

Therefore, we argue that to develop a sustainable urban freight transport system for the future, it is important to broaden the scope and consider non-technical solutions that focus on reducing the need for trucks or vans – and truck- and van-kilometres in the city centres. This is not an entire new insight. Many transition ideas and studies reason from the so-called trias logistica, often interpreted as, 1) avoid, or reducing the volume or the amount of trips / kilometres travelled, 2) changing to a less (or none) polluting transport mode, and 3) cleaning or making the existing trips and kilometres more sustainable. The trias logistica, derived via the (also not very well know) concept of the trias mobilica of the Trias Energetica, is not a very well known concept in the scientific literature, but is quite often used in policy documents and plans as it provides a clear frame of mind to structure different directions to improve the sustainability of transport, in line with the is a three-step improvement strategy to create an energy-efficient (building) design that is proposed in the Trais Energetica.

The trias-logistica is related to the ASI (avoid-shift-improve) approach (see for example Bakker et al. 2014) that aims at improving efficiency in the mobility system in the transition towards a more sustainable mobility system. The ASI approach focusses on the demand side of the mobility system. The ASI approach follows a clear hierarchy: avoid-measures should be implemented first, secondly shift and finally the improve-measures. The avoid (or reduce) direction aims at reducing the need for (motorized) mobility, for example by making sure that residential, work and leisure activities are more closely connected and intermixed. The shift (or maintain) direction aims at improving the

individual trip efficiency, for example a modal shift from the most energy consuming and polluting urban transport mode (cars) towards more environmentally friendly modes, such as active transport and public transport. Finally, the improve direction focuses on improving the vehicle and fuel efficiency.

In the remainder of this section, we use this trias logistica / ASI framework to examine what range of solution directions are available for logistics actors to organize the (urban) logistics more sustainable – or even zero emission. For (urban) freight transport we argue using this framework, and especially the ASI hierarchy, could provide directions that are in the current ZE practice often overlooked, due to the focus on the technical solution (i.e. the improve direction only) of replacing (polluting) diesel vehicles by (non-polluting) battery-electric vehicles. The different levels in the ASI hierarchy have also different complexity in the change process; the higher the option in the ASI hierarchy, the more stakeholders are needed to actually make the change. Avoid or reduce requires cooperation in the supply chain and / or in the spatial environment, whereas shift especially means closer cooperation with one or a few extra service providers and improve often is within the control of the carrier or shipper.

2.2. Search for solution directions

The approach in this article is as follows: we – and with us many students, who over the last few academic years worked on zero emission urban logistics in various assignments – examined what actions different companies were actually taking or planning to take in their (future) zero emission logistics strategy and what solutions were mentioned in academic literature and in more practical, applied, and or consultancy studies. Based on these studies, we classify these directions in the ASI hierarchy to make it clear that private players have more options to comply with ZE zone rules than electrifying the fleet. The combined search efforts led to interesting list of newspaper articles, websites, documents / reports, academic articles, youtube or other videos and, municipality communications. Most of these sources focus either on how to establish zero emission zones (or policy schemes) or on the challenges and opportunities for ZE-vehicles and charging infrastructure. However, some also examined or mentioned possibilities in the avoid or shift directions (as well as the improve-direction concerning the optimization of routes, deliveries and reducing stopping time, next to the electrification only). The following sections discuss the main categories we found to enable a transition to zero emission urban logistics. (Note that not all sources from the list are mentioned, we focus on the presenting the various categories rather than aim at a complete literature in this contribution, but some solutions are listed in TDA, 2019; N&M, 2021 and Rotterdam, 2020).

2.3. Direction 1: avoid (or reduce)

The first solution direction to avoid or reduce the need for urban freight transport includes several options for carriers or shippers, usually in combination with other stakeholders, such as customers / receivers, other (transport) companies, or using other services.

- *Arrangements* – the first group of alternatives includes making arrangements in the supply chain with other actors so that fewer transport trips are required. These arrangements can be made by different actors (see e.g. Rotterdam, 2020). There are several examples of arrangements that contribute to reducing freight kilometres in the cities, such as (but not limited to):
    - receivers can collectively order in order to reduce deliveries, for example large offices in a business district can coordinate with respect to suppliers (in their sourcing) and with respect to frequency of delivery so that is coordinated. A way to do this is enforcing bundling through procurement.
    - transport companies can make arrangements with their receivers in for example the delivery time, so that an efficient roundtrip can be performed (for example in Horeca-deliveries).
    - arrangements can be made in the collection of waste; instead of an individual waste contract, entrepreneurs can (together with their contracted waste processors) organise bundled waste collection in a certain street or commercial area. After the bundled collection the collected waste can be distributed to the different processors.
- *network cooperation* – carriers: distribution networks (such as TransMission, TeamTrans and Netwerk Benelux) offer their members the opportunity to decrease unnecessary handling activities, lead time, and harmful emissions that would otherwise be produced by superfluous less-than-truckload transport, while also providing clients with a reliable service coverage. Depending on the network's distribution strategy, goods can be consolidated in regional or central hubs. With regional consolidation centers, shipments-to-be-delivered in a particular city are all bundled together and transported to a nearby hub. With the goods being close to their final destinations, a network member in the respective territory distributes the goods to their final customers. When considering the use of a central hub, the consolidation and distribution process is as follows: a network partner that has shipments with destinations outside of their own service zone delivers the goods to a central hub. When making the trip back, the truck is loaded by other members whose shipments have a final destination set within the partner's service area (see for example Quak, 2012).
- *platforms* – in line with making the agreements in the chain, the platform solutions aim bundling and reducing trips by first bundling the information flows in an IT platform; this can be for ordering, as the example that is discussed in Den Boer et al. (2020) where a platform for Horeca – deliveries is explained; i.e. the wholesalers already have a good platform infrastructure. If they further develop their ordering platform and open up their distribution for third parties, they can become the platform for hospitality delivery (including logistics), driven by IT developments. Suchlike platform solutions

can also work for other than Horeca segments. The e-commerce shows examples, where for example Bol.com also offers the goods from other webstores via the Bol.com platform – logistics bundling is often not the case here. But other examples can be found in bringing together local producers and consumers, see e.g. www.beukk.nl and many others. TDA (2019, p.17) also mentions mutualised management demand and capacity platforms as a solution to enabling increased efficiency and effectiveness

- *sharing and co-loading*: one possible solution for businesses transporting goods in and out of zero-emission zones would be to participate in co-loading activities with other organizations. The strategy of co-loading refers to two or more parties collaborating in order to share the capacity of (electric) vehicles, thus optimizing the load factor per trip and sharing purchase and maintenance costs. Companies can implement such a solution either by becoming part of a distribution network, or by forming co-loading agreements with other parties. Another example of such like possibilities are sharing logistics (see Van Duin et al. 2022), or crowd sourcing (see e.g. Pourrahmani and Jaller, 2021).
- Revamping supply chains towards more *local and circular production and consumption systems* – where most other solutions in the avoid-category focus on what a particular actor can achieve in agreements, this deals with a very different economic organization (see e.g. Bell, 2023). The whole idea of having a more circular economy could lead to more vehicle movements in the city as well, because different small streams have to be collected to get back into the chain. But of course the idea is also that fewer long chains would be needed in many areas, so less transportation should be needed overall. Local for local, for example around food, is a well-known example of transporting less throughout the chain. Examples exist in many different regions, see for example www.boerschappen.nl/.

2.4. Direction 2: shift (or maintain)

The main group of possible solutions in the shift category is about taking apart the logistical movements to (and from) the city and the movements within the city. This requires a transfer point somewhere. (Of course, it can also be arranged between carriers, but then it fits into the arrangements and network cooperation as discussed in the previous section). There are many examples of initiatives, studies, strategies and ideas on these transfer points; we limit it in this contribution to categorize the different directions, but these hub solutions all offer some kind of ZE-delivery as a service (Zdaas) as solution for ZE transport (note that the hub or transhipment point is not the solution, but only a means to make Zdaas possible).

An innovative solution to the issues posed by the introduction of zero-emission zones could be Mobility-as-a-Service (MaaS) platforms for commercial electric vehicles. MaaS is defined as a service that offers

arranged transportation for consumers via the use of a digital platform. For private individuals this could mean the arrangement of door-to-door transport by utilizing shared bikes, forms of public transport, shared vehicles, and more. But for businesses handling transport processes, the concept of MaaS could be (and in some instances has been) applied for the use of commercial electric vehicles such as vans and trucks. Company cases of organizations based in the Netherlands and abroad (Fluid Truck, UZE Mobility, Green Mobility) provide examples of how MaaS can be implemented in the case of commercial transportation services. Fluid Truck, for example, is a US-based company that offers its customers a platform, accessible via a website or app, which allows companies (and private individuals) to rent one or multiple commercial vehicles on an hourly or daily basis, making it a flexible alternative to independently purchasing and maintaining an electric vehicle fleet. The appeal of this solution is strengthened when one considers that even renting an electric vehicle could be a strenuous process – this is bypassed by MaaS platforms, where leasing a vehicle can take minutes. Other European-based businesses that have developed similar MaaS platforms currently seem to currently be providing solutions revolving around lower capacity EVs, and on a lower scale than the example presented above. The concept of MaaS is relatively new, but it could provide companies with the financial and operational flexibility of leasing short-term, rather than committing medium- or long-term to a zero-emission logistics solution. Therefore, this is one of the innovative zero-emission logistics strategies that could be further investigated and developed.

For the facilities that need to be in place to develop more Zdaas-services we distinguish:

- *city hubs*: a logistics solution that gained popularity especially after the introduction of the Uitvoerings Agenda is that of urban consolidation centres (also referred to as city hubs). In theory, the concept involves transport companies delivering goods to consolidation centres situated outside of zero-emission zones, with the goods being redistributed to their final destination by the hub operator (or another carrier). Such a solution means carriers would be able to continue servicing customers situated within zero-emission zones by outsourcing their last mile delivery services to a third-party, rather than having to invest in fleet electrification to do so. The relevant professional literature shows that the initial concept of consolidation centres can be utilized to develop different business models, each one incorporating distinct core logistics activities. A traditional approach to developing this concept would typically include a consolidation centre operator (see e.g. City Hub) offering storage, consolidation, and zero-emission transport services. In other cases, however, it has been shown that by partnering up with larger carriers who have the means to invest in an electric vehicle fleet, hub operators could only be responsible for the storage and consolidation of goods. A similar variant of the latter strategy involves organizations operating a consolidation centre, and then allowing third-party drivers to make use of the hub's electric vehicle fleet (Liefergrün); but also for example the over 100 local hubs that DHL e-commerce operates in the Netherlands could serve as a hub for companies that want transfer their parcels / small goods to

another carrier (in this case DHL) for ZE transport on the last mile. We identify several hub types, next to the more classical urban consolidation centers that can contribute to achieving a shift in the city logistics movements towards e-vehicles, LEFVs, or cargobikes (see Quak and Kin, 2024; Rotterdam, 2020), such as micro hubs, pick-up points, facility hubs, construction hubs, food hubs.

- Transshipment/bundling points could also be a viable zero-emission logistics solution. Essentially, such areas offer the opportunity to consolidate goods, change vehicle modalities, and subsequently distribute deliveries to their destinations within ZE zones. In this case, products would not be stored in a facility, but would rather be bundled together and loaded on electric vehicles in order to achieve an efficient and sustainable last mile process. Several examples of such transhipment points can be:
    - transhipment point, locations where goods can be transhipped to another modality, such as boats (for example Horeca deliveries in Utrecht, waste collection, or construction logistics in Amsterdam), LEFVs (light electric freight vehicles) or cargobikes (for example parcel deliveries by Coolblue or Fietskoeriers, or demonstrations and trials for services, see for example pilot 'Trap je bus eruit'). Physical locations need to be available – although that can be relatively small to make these transshipments (see TDA, 2019, p. 21).
    - some transhipment point solutions combine the transhipment with innovative vehicle concepts, such as the TRENS-solar city train (see https://trens.eu/en) and - in the past - the Cargohopper in Amsterdam. The combination of having a new logistics concept and innovative vehicle make it difficult in practice (to scale up, as well as to become competitive). Other ideas, albeit mostly in pilots, include the use of autonomous vehicles, such as delivery robots, but these are not yet feasible as a solution for daily practice at this moment.
    - a transhipment point solution that is possible is a location where a detachable swap body or a trailer can be left by a diesel truck or tractor that carries out the transport to a city (and can pick up an empty swap body or trailer) and from where a ZE truck or ZE tractor can carry out the last kilometers in the city without emissions. This concept has been demonstrated by Breytner in practice, but is not common practice (yet, as there are also no ZE zones yet). The advantage is that the ZE truck or tractor can make many short delivery roundtrips in ZE zone and – as long as e-vehicles are scarce – is used to make as many as possible ZE deliveries within the zone, and the kilometers outside the zones can be performed with the existing diesel fleet. A technological solution that could do a similar job is the plug-in hybrid truck or van. The idea would be that the kilometers outside the zone are performed on the diesel driveline and the kilometers in the ZE zone on the battery-electric driveline. However, as enforcement of what line is used when was considered difficult, it has been decided that plug-in hybrid vans and trucks are not allowed in ZE zones.
    - and finally, the use of P&R sites as transshipment points for construction staff that need to go to a construction site (although this can also be the case for other segments where craftsmen

basically commute with their vans). For some construction sites, in very crowded areas, a shared shuttle service from a P&R location to the construction site showed to be feasible.

2.5. Direction 3: improve

In this last group of solutions we see a lot of things happening. Before, we discuss the actual improve solutions, we emphasis that most of the technical solutions in this category are – at the moment – still more expansive for the transport companies. Therefore, there are initiatives such as minimum bid for green fleet or financial incentive for green freight (see TDA, 2019), stimulating the use of ZE vehicles in (public) procurement, for example in construction logistics or at local authorities. In addition to this incentive from the market, which incidentally can also help ensure that solutions from the avoid or shift categories are chosen, various subsidies are also available to help carriers be able to purchase ZE vehicles. Although, more and more e-trucks and e-vans are available, the majority of the vehicle fleets in the Netherlands is still diesel-powered (see RVO, 2024) and is expected to be like that for the coming years (see TNO, 2023). In order to support companies in the transition towards ZE vehicles, there are several measures developed. For example TCO-calculation tools are available, to estimate how the total cost of ownership compares between diesel and battery electric trucks over a longer time-period, instead of only comparing the difference in purchase price (see TSL, 2024). Next to that, there are subsidies available (although not sufficient for all applications, as in previous years subsidy-schemes were oversubscribed within a day) to help the companies in their extra purchase costs for ZE vehicles. A crucial factor when considering fleet electrification is the involved purchase/lease costs. New electric vehicles are expensive compared to fuel-powered vehicle models, with purchase prices starting around €30.000 for a Renault Kangoo (Renault Netherlands, 2023), and going up to more than €55000 for high-kilometre-range alternatives. A substantial number of companies in the Netherlands are unable to afford such a large investment on their own at this moment, even if the TCO is lower for the lifetime of the vehicle. This is where the subsidy scheme for e-vans comes in, i.e. Subsidieregeling Emissieloze Bedrijfsauto's (SEBA) or translated to English, the Subsidy Scheme for Emission-Free Commercial Vehicles, provided by the Dutch government, comes in. This grant covers 10% (12% for small businesses) of the net price of new, fully electric vehicles purchased in the name of a company. It is valid for purchasing, as well as operational and financial lease agreements. The subsidy has several important conditions for applicants. Also importantly, the subsidy can amount to a maximum of €5000 euros per vehicle. The first condition listed on the RVO (Rijksdienst voor Ondernemend) government website is that the vehicle must not weigh over 4250 kilograms. The purchase/lease agreement must not have been concluded at the moment of applying - businesses must apply for the grant with a non-final agreement for the EV. The vehicle itself must be new, not second-hand; its net list price must not be below €20.000, and the range of vehicles under 3.5 tons should not be below 100 kilometres (see website RVO for actual information). Applicants must also provide the following information: first,

'eHerkenning' registration (EH level 2+), a platform which allows businesses to access various government agencies from one place, similar to the use of DigiD by private citizens). Finally, to apply businesses also need the Chamber of Commerce or BSN number on which the vehicle is registered (RVO, 2020). Another subsidy option businesses have when purchasing a zero-emission vehicle is the Aanschafsubsidie Zero-Emissie Trucks (AanZET) for the purchase of e-trucks. This subsidy applies to zero-emission commercial vehicles in the N2 and N3 categories, with the required vehicle weight starting from 4250 kilograms. The covered subsidy percentages available per vehicle are substantially higher than the covered percentage by the SEBA subsidy – the subsidy for an N2 rigid chassis vehicles above 4250 kilograms is 12.5% for large companies (up to €17.800), 19% for medium-sized companies (up to €26.800), and 25% for small businesses (up to €35.700). For N3 rigid chassis vehicles up to 18.000 kilograms the percentage is 15% (up to €43.600) for large companies, 21.5% (up to €63.700) for medium-sized companies, and 28.5% (up to €84.000) for small businesses. The covered amount for N3 rigid chassis vehicles above 18.000 kilograms is 16.9% (up to €56.700) for large businesses, 24.3% (up to €81.500) for medium-sized companies, and 31.7% (up to €106.300) for small businesses (Netherlands Enterprise Agency, 2022). The conditions for the AanZET subsidy to be granted are similar to those of the SEBA, with the only notable differences being vehicle classification and the fact that the electric vehicle must have not already been subject to the Subsidieregeling Schoon en Emissieloos Bouwmaterieel (SSEB) grant. Other than that, the zero-emission vehicle in question must be new and fully zero-emission. The extra costs for the charging infrastructure to charge (larger) e-fleets, and the issues in getting a connection to the congested electricity grid are serious challenges for these solutions in the shift direction (the most obvious solution towards ZE city logistics), more information and ways to deal with these challenges can be found at NAL (2024).

Next to these incentives for electrification, in the improve-category we can also mention some other solutions. The use of HVO also reduces the carbon footprint of transport, although not available at large scale and not fully ZE. There are some trucks and vans that are hydrogen-powered, but that is for the moment not a feasible solution (as there are hardly any filling stations, the energy efficiency is low in comparison to other powertrains, and there is only very little green hydrogen available).

Finally, further optimization of trips also is part of the improve-measures. By optimizing the routes (also for other vehicle types), it might be possible to make more stops or deliveries per vehicle. In case other actors are needed, it fits better in the arrangement-solution in the avoid-category, but sometimes optimizing the daily routes is possible; e.g. including real-time information on for example road constructions, or adding more information on the availability of unloading areas, so that no time and kilometers are necessary to make detours for finding available spots. Reducing stop-time can also be a way to improve efficiency, for example in home-deliveries by announcing the (planned) time of the

delivery so that the recipient is at the door ready to receive the delivery – which is common practice in e-grocery deliveries.

2.6. Other directions?

Next to the ASI-directions, many documents mention more possible actions in the transition towards ZE city logistics. Many of these directions cannot be directly implemented by carriers or shippers, but focus on getting more shippers, carriers or other stakeholders engaged in the ongoing transition. Those actions are mostly directed at governments - as drivers of the transition to ZECL - and deal with communication (different strategies to reach companies that are not working on ZECL), participation and partnerships, local communities, and providing (basic) advice on possibilities, i.e. logistics brokers.

Obviously, there are solutions that we did not discuss, but are possible in practice; for example, one way to deal with the ZE zone requirements is simply not delivering within ZE zones anymore, if there are hardly any clients located there (this would fit in the avoid-category). Another way – especially for the smaller zones – is the park outside the zone and make the (incidental) delivery by foot. Obviously, this can be a solution for rare small deliveries in small ZE zones, and it is not applicable for full truckload deliveries. Making small deliveries by passenger car, or use a passenger car for service-trips, can also be a strategy to deal with the ZE zones, as – for the coming years – these zones only apply to vans and trucks. But, besides these shortcuts, that might be applicable to some specific carriers' or shippers' operation, this paper provides a wide range of possible directions to start working on ZECL even in the short term; and above all, to think again about how logistics can be organized differently in order to be able to meet the requirements that will apply to those zones - without relying solely on electrification.

3. Which solutions for whom?

Not all ASI strategies are applicable for all companies. Obviously, the city logistics segment, the type of stakeholder (carrier, receiver or shipper), the volume and shipments that are carried determine what can be applied and what not. Stoganov (2024) examined under 28 professionals in the logistics industry after ensuring they were aware of the coming ZE zone regulations, what strategies they had in the transition towards the ZE zones. It was important to understand whether transport companies, and SMEs in particular, believe zero-emission zones will affect their operations, and whether they have a concrete strategy to counteract the effect of the upcoming laws. Depending on the professionals' answer on the latter inquiry, the next question varied: respondents who answered "Yes" would be asked to name their zero-emission strategy (likely from the set list of last-mile logistics solutions identified in the relevant literature, Figure 2 – Selected ZE Logistics solutions), while those who responded that their organization does not have a concrete strategy would be asked to identify what currently prevents them

from transitioning to zero-emission processes (Figure 2 – Factors bounding ZE logistics transition). The provided answers to the latter questions were developed by examining relevant news sources and reports and identifying the recognized 'bottlenecks' for transport SMEs.

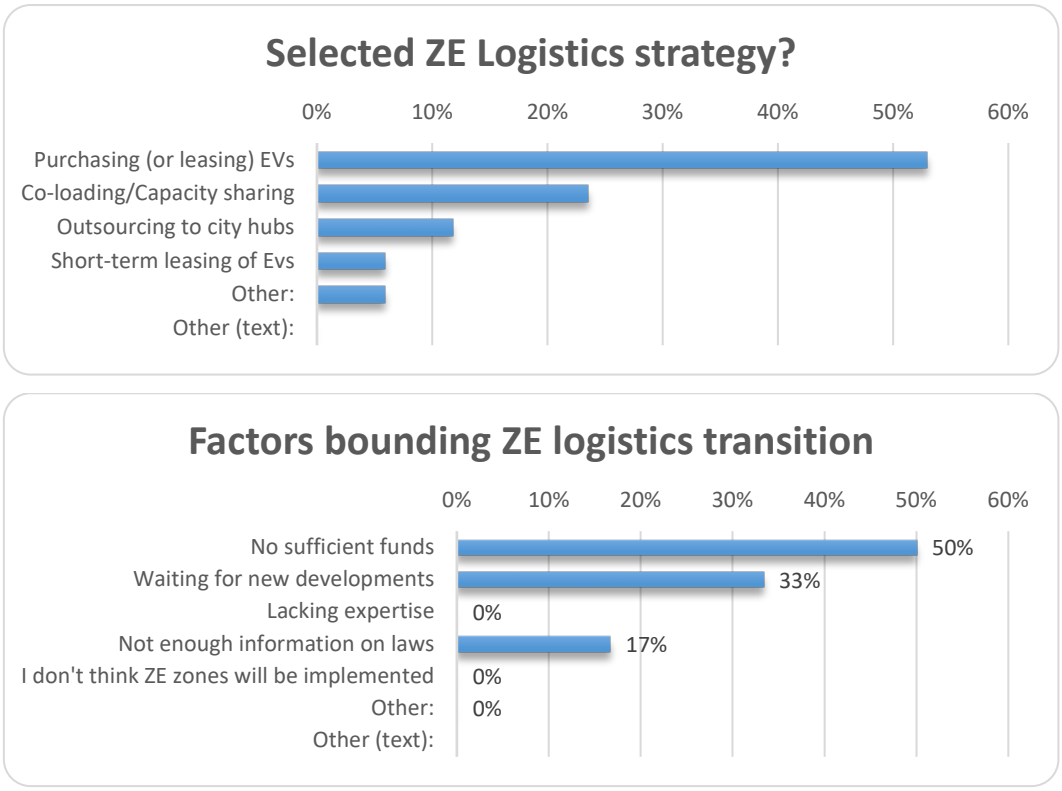

Figure 2: Selected ZE Logistics solutions and factors bounding ZE logistics transition (Stoyanov, 2024)

These answers show that indeed most of the companies are focussing on the 'improve' strategy and then in particular on the electrification. This paper provides a framework and examples to contribute to a broader scope of solutions. The motivation behind paper is that many of the companies and students often have to start from scratch in their quest for background information on what perspective for action there is for their specific case or company, before they can undertake the relevant research, which is often a time-consuming exercise. As a result, many companies (or students doing a company assignment concerning the ZE possibilities of a company) are not able to actually examine the issue from a broad perspective, allowing to do more than find the issues and challenges for electrifying the fleets. This contribution can now form the beginning for newbies in this field, and help them cover a broader scope of possibilities and considerations. We hope that new assignments can contribute to the directions presented, for example, for example, what works and what does not work in practice, or that new solutions are added in this ASI-framework, instead of having more summaries of information that is already available, with a particular focus on fleet electrification (and the available subsidy schemes and available e-trucks and e-vans) which is seen as a low hanging fruit. With this paper's overview,

companies and students can access foundational knowledge onto which they are able to build further insights on, providing value and allowing them to use their time more effectively. And it allows us, to further examine the question as to how the impending ZEZ rollout will (eventually) impact road infrastructure design in the coming years, looking into the plans of shippers and carriers to see what trends may be on the horizon according to the planned adoption of solutions.

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