Amsterdam

Cities place an increasing demand on urban logistics to provide them with goods. In order to fulfill this need in a financially feasible and sustainable way, the concept of the Urban Consolidation Centre (UCC)has been used.

Reinventing the concept of an Urban Consolidation Centre using Light Electric Freight Vehicles

The case of a coffee and vending machine supply company

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ABSTRACT

Cities place an increasing demand on urban logistics to provide them with goods. In order to fulfill this need in a financially feasible and sustainable way, the concept of the Urban Consolidation Centre (UCC)has been used. Although there are some successful implementations of a UCC, most projects are terminated after a short time. In order to increase the appeal of a UCC, the delivery to the final customers from the UCC can be done using light electric freight vehicles (LEFV). These LEFV provide numerous operational benefits due to their smaller size while being more sustainable than regular delivery vans. LEFV have several operational limitations as well, mainly concerning their range and loading capacity. In order to successfully combine a UCC with LEFV, smaller inner city microhubs have to be added to the supply chain to provide forward bases of operation for LEFV. Goods are consolidated at the UCC, after which they are shipped to a microhub near the delivery area. From here, LEFV carry out the final delivery to the customer.

In this paper, the case of a coffee and vending machine supplier in Amsterdam was used to see the effect of using microhubs and LEFV. This company already operates out of a UCC, in our research we added microhubs to the supply chain to see their effect. The results showed that using a microhub in the city, in conjunction with a UCC at the edge of the city, was financially more feasible scenario than just using a UCC and delivering directly from it using diesel vans. We can conclude that in order to make a UCC financially feasible for urban deliveries, it needs to be used in conjunction with LEFV and microhubs.

Keywords: Urban logistics, consolidation, UCC

Introduction and motivation

Urban logistics is one of the backbones of maintaining life in cities. With the increase in population that is going on in cities, an increasing demand is being placed on urban logistics to deliver goods at the right time and at the right place. The goods that are being delivered in cities can be categorized in several flows. These are hotel and catering industry, construction, services, retail and waste. The goods within each of these flows have their own characteristics and thus place their own demands on logistics. This makes it hard to combine these flows within one single, efficient delivery process. As a result, the utilization rate of vehicles used to deliver these goods is lower than it could be. Besides the difference per flow, the customers within each segment also have their own demands concerning delivery times, frequency, volume and conditions. A company delivering hotel and catering supplies for example, might have to deliver to some customers during the morning and some in the afternoon. This means two supply runs have to be made, even when both of these runs could have been done in one run. This is causing the utilization rate to drop even further. Furthermore, suppliers do not cooperate with each other, resulting in multiple partially loaded vehicles driving in the same area (Ploos van Amstel, 2015).

To improve the efficiency of the delivery process , the concept of an Urban Consolidation Centre has been developed. Instead of directly delivering to the customer by the suppliers, the goods are being delivered by the suppliers to a UCC at the edge of the city. Here, the goods from different suppliers that are bound for the same customer or same delivery area are consolidated into one shipment and delivered by a single vehicle. The benefits are a reduction of vehicles in the city and a reduction of kilometers driven in the city. This causes pollution and traffic jams to decrease and increases traffic safety due to there being less vehicles on the roads. The overall quality of life within cities will increase (Browne, Sweet, Woodburn & Allen, 2005; Leonardi, Browne & Allen, 2012; Van Duin, Tavasszy & Quak, 2013).

Although the use of a UCC can reduce the problems caused by urban logistics, the concept has only sparsely been implemented successfully so far (Browne, Sweet, Woodburn & Allen, 2005). There are several reasons for this, most of which revolve around the costs associated with the use of a UCC. Besides this, a UCC still transports the goods to the final customer using a delivery van or truck. Deliveries are still subjected to time windows, areas with restricted access to polluting vehicles and congestion. The current form in which UCC exist, does not provide enough incentive to attract suppliers or transport operators. In section 2 of this paper, these reasons will be explored further. We believe that in order to make the use of a UCC more appealing, it needs to generate extra benefits to the delivery. This can be done by delivering the goods using clean vehicles. An example of clean vehicle is a Light Electric Freight Vehicle, from now on referred to as a LEFV. In section 2.1 of this paper we will take a look at these vehicles, their potential to reduce the negative impacts of urban logistics and the conditions necessary to operate with LEFV.

The objective of this paper is to see whether or not using a UCC in conjunction with LEFV can provide a clean and financially feasible alternative for urban logistics. In section 3 we will explore the option of combining a UCC with LEFV to deliver goods in cities. We take a look at the effect on the supply chain and the conditions necessary to use both of these concepts together. In section 4 the knowledge gained will be applied to a case in Amsterdam, using several delivery scenarios. These results will be discussed in section 5, followed by the conclusion and recommendations in section 6.

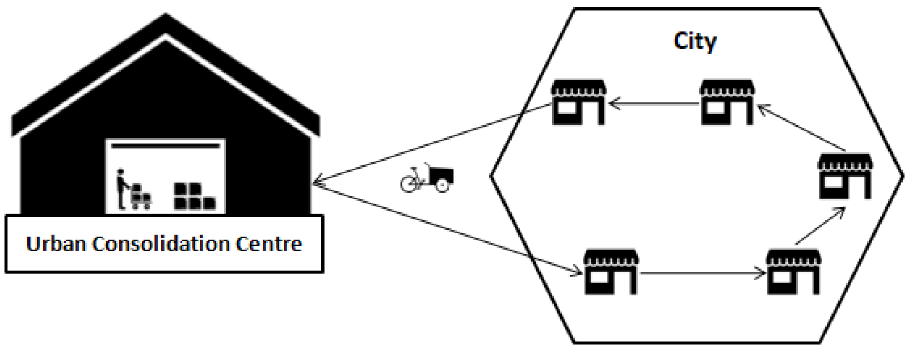

Figure 1 Goods flow UCC

Logistics facilities offer a number of benefits to its users, as mentioned in chapter 1. Despite this, there usage has not been widespread and most facilities are terminated after some time. The main reasons for this are the high costs associated with setting up a UCC, the increase of costs in the supply chain due to the extra handling it creates and the lack of stakeholder participation. This lack of participation is caused by the loss of the direct interface between customer and supplier, the unwillingness to share data with other users of a UCC and the unwillingness to invest in a UCC that is shared by multiple users (Browne, Sweet, Woodburn & Allen, 2005; Kin, Verlinde, Van Lier & Macharis, 2016; Verlinde, Macharis & Witlox, 2012) .

From the various papers referenced previously, we can identify a number of critical factors that increase the chances of success for logistics facilities. First of all, stakeholders must be made aware of the benefits a UCC can provide them with. Despite the high setup costs, the operational costs will decrease. This means that over time, with enough throughput, the UCC will become more financially feasible than not using it. Both the setup costs as well as the handling costs can be offset against the operational benefits. Once the stakeholders are aware of this, their lack of motivation to be involved should rise. Another way to increase motivation to participate in a UCC, is for local government to restrict or tax urban freight movement into the city. By increasing the cost per trip (for example, toll charges) or by denying larger vehicles access to the city, suppliers will be more willing to consolidate their shipments at a UCC. In order to make using a UCC more appealing and cost efficient, clean and small vehicles can be used to carry out the final shipment. The effect of using such vehicles will be discussed in the next chapter. The beneficial effects that these vehicles have, such as being able to deliver in restricted access areas or being able to deliver more quickly, can provide the stakeholders with extra motivation to use a (Browne, Sweet, Woodburn & Allen, 2005; Marcucci & Danielis, 2008).

Another important factor of success is identifying which goods flows should be targeted first for consolidation. Non-food retail and clothing are two flows that are relatively easy to deliver using a UCC, because these do not need specific logistics performances or services. HoReCa and specialized stores are more difficult to deliver using a UCC, because their products need sophisticated logistics performances (such as temperature controlled shipping), because their delivery frequency is higher and because there is more need for punctuality (Marcucci & Danielis, 2008; Van Damme, Levelt & Rademakers, 2016).

State of the art of LEFV

There are various types of clean vehicles to carry out deliveries in cities. Examples are hybrid vehicles, electric vehicles and hydrogen fueled vehicles. In this paper, the focus will be on electric vehicles, specifically light electric vehicles. These LEFV can provide additional benefits to their operators when used in an urban setting, compared to regular electric vehicles. Three types of electric freight vehicles can be defined (Kleiner, et al. , 2017), based on their maximum mass. The smallest category, N1, consists of vehicles weighing less than 3500kg. Within this category, researchers from the Amsterdam University of Applied Sciences have made a further separation (Balm, 2016). They have defined Light Electric Freight Vehicles, or LEFV, as an electric vehicle weighing less than 750kg while fully loaded and being smaller than a van in size. Examples of these are cargo bikes and e-scooters.

LEFV have a number of benefits when compared to regular electric freight vehicles. They are smaller and more agile in city traffic and can therefore carry out deliveries more quickly. They are cheaper to purchase than regular electric freight vehicles and their drivers often do not require a driver's license (LEVV Logic, 2016), meaning that their salary is lower than that of regular drivers. As with regular electric vehicles, they are exempt from having to pay road tax and benefit from low fuel costs. Downsides of these LEFV are their small loading capacity and short driving range.

Using LEFV in urban logistics has multiple beneficial effects. Due to their small size, the vehicles can easily maneuver through traffic, reducing the effect of congestion on delivery times. They are also small enough to be able to drive on cycling paths, allowing shorter and more efficient routing. As with all electric vehicles, LEFV do not cause pollution. This means that they can enter areas that are restricted to vehicles emitting greenhouse gases. Another benefit from using an electric vehicle, is the lack of noise pollution from the engine. Due to their silent nature, these vehicles can be made exempt from time window restrictions that exist in cities (Holguín-Veras, 2008).

Despite the benefits that these vehicles can provide to vehicle operators in urban logistics, their usage is not widespread. According to Balm (2016) this is caused by several factors. The first is the short driving range. Because of this, the vehicles can not cover large distances. Even driving back and forth from a depot at the edge of the city can prove to be too far. Especially when we consider the second disadvantage of using LEFV, which is their small loading capacity. Because LEFV are incapable of carrying large amounts of goods at once, they might require two or more trips to deliver the same amount of goods a larger vehicle can deliver at once. If the distance to the depot is far, the vehicles will need to recharge their battery in between trips. This causes a delay of a few hours, reducing the operational time during a day significantly (Kleiner, et al. , 2017; Arvidsson & Pazirandeh 2017; Nesterova, et.al., 2013) . A third barrier is the uncertainty over the residual value of the vehicles. The market is still very new, meaning that a second-hand market has not developed yet. Potential buyers of LEFV are therefore hesitant to purchase these vehicles (Nesterova, et al., 2013; Lebeau, Macharis, Van Mierlo & Lebeau, 2015). All of these barriers cause vehicle operators to be unsure about the effect of using LEFV on their financial and logistics processes. The supply chain will have to be adjusted to incorporate these vehicles, but how exactly is still unknown. Several studies suggest using logistics facilities within cities, to shorten the driving distance to the customer and thus negating the impact of the shorter driving distance. This will also reduce the effects of the small loading capacity, making multiple trips back and forth to the depot will take a smaller toll on the range of LEFV.

Combining UCC and LEFV

In order to create a financially feasible way of delivering goods in cities that is also sustainable, both UCC and LEFV have the potential to accomplish this. By combining the two, their deficiencies can be reduced or even cancelled out completely. Using LEFV can make the UCC more appealing to potential users by providing an extended delivery window, providing transportation with a sustainable vehicle and by providing shorter delivery times to the final customer at a lower cost than delivery by van. The UCC, on the other hand, provides users of LEFV with a depot close to their delivery area, negating the effects of the short driving range and small loading capacity. It can also provide a recharge location close to the delivery area. Potentially, batteries can be swapped out at the UCC, thereby completely taking out the need to spend time recharging. Using LEFV can also broaden the amount of goods flows that can be targeted by a UCC. Because of their faster delivery times, they can more easily serve flows that require shorter lead-times or higher delivery frequency, such as the hotel and catering industry.

The location of the UCC is of great importance however. If it is located too far away from the city, the impact it will have on the operational use of LEFV will be minimal. Therefore, in order to operate with LEFV in urban logistics, adding smaller logistics facilities in the inner city is a must. Shipments are consolidated in the UCC at the edge of town, after which they are shipped to a microhub in the delivery area in one trip by a van. From this inner city facility, goods are then distributed by LEFV. In the next chapter, we will look at the effects of adding microhubs to an existing supply chain of a company already using a UCC.

Reinventing UCC: the case of a coffee company

Company description

In order to see the effects of adding an inner city facility to a supply chain, we looked at the case of a coffee and vending machine supplier in Amsterdam. This company supplies goods to both the public and private sector. In the current situation, they operate out of a UCC at the edge of the city, which is supplied from their main base of operations in Eindhoven. From this main base, they supply their customers throughout the Netherlands. There is a weekly supply run made from Eindhoven to their UCC in Amsterdam. The goods are then distributed by diesel vans from this UCC to the final customer. With the lease of their current UCC not being renewed, they are looking to explore their options for supplying their customers in Amsterdam.

This company has collected data of its shipments in Amsterdam over the first 9 months of 2016. This data contains the type of goods that were delivered and the volume in cubic meters of the deliveries. The dates of delivery were collected, as well as the location of the customer being delivered. From this data, we can calculate the weekly demand of goods for the entire region of Amsterdam, as well as the demand for each individual customer. We narrowed the customers down to only the customers within the inner city of Amsterdam, as this area is affected by congestion the most. This brings it down to a total of 114 customers, with a weekly demand of goods of 64 m3. The coffee company will be known as company X from now on, as anonymity has been requested by them.

Scenario description

In order to fully explore the options for company X, we have come up with several scenarios for their deliveries in Amsterdam. These scenarios are based on the different possibilities of delivering goods with LEFV through microhubs. A total of 5 scenarios has been made, consisting of the following:

1. Delivery by van from the UCC
2. Delivery by LEFV from the UCC
3. Delivery by LEFV, using a microhub in the city that is being supplied from the UCC
4. Delivery by LEFV, using 2 microhubs in the city that are being supplied from the UCC
5. Delivery by LEFV, using 3 microhubs in the city that are being supplied from the UCC

The first scenario is the current situation, the other scenarios are different variations of using a LEFV instead of a diesel van. The scenarios will briefly be described later on. For each scenario, we have made new routes, as we do not have access to the routes currently used by company X and because the LEFV routes will be different anyway, since they can travel on cycling paths.

Routes were created by the research team based on the maximum capacity of the vehicles and the demand of the customers in each postal area. The deliveries have been grouped per postal code area, all deliveries to one postal code area are treated as if they were delivered to the center of this area. A total of 114 customers are being supplied across all of these areas, deliveries are done every two weeks (26 times a year) to each customer. The drivers cost per hour has been set to 20 euro an hour, based on interviews with logistics service providers. The distance and time driven from the UCC and the microhubs to the postal areas has been calculated using Google Maps. For the LEFV, cycling routes were selected. The average speed for both types of vehicles was set to 15 km/h. This is based on the paper of Armstrong (Armstrong, 2014), by talking to logistics service providers and by considering the time taken for a route according to Google Maps. The time it takes to drop off the goods at each customers was set to 10 minutes for the LEFV and 20 minutes for the van. Although these are assumptions, they are based on the fact that LEFV can park on the sidewalk at each customer, with the van driver having to find a parking spot nearby and having to bring the goods from the parking spot to the customer.

There are a few important factors to note in this section. We had to make multiple assumptions on matters concerning the operational benefits of using LEFV versus using regular freight vehicles. Things like driving speed and the duration of parking and unloading at the customer are known from previous studies to be more efficient with LEFV than regular vehicles, but exact numbers are unknown. Furthermore, to calculate driving distances, the goods were grouped per postal code area and delivered to the exact center of these areas. This causes some inaccuracy, the customers within these areas might be more spread out. In reality, vehicles would also have to drive from customer to customer within these areas, potentially altering total delivery times. In this paper, we assumed that LEFV are allowed to drive on cycling path, based on Dutch law. In other countries this might not be the same, therefore negating the effect of the shorter routes when using LEFV. If usage of LEFV rises in the future, the added amounts of traffic on cycling paths may cause legislation to change as well.

Delivery by van from UCC

This scenario is the current situation. A diesel van is being used to deliver the goods from the UCC to the customers in the city. The vehicle in question is a Volkswagen Crafter van, its specifications are listed below. Routes were created by the team, a total of 3 routes are needed to supply all customers.

Table 1 Specifications diesel van

Price	20.000 euro
Loading capacity (in m^3)	$17m^3$
Fuel usage	9.5 liter per 100 kilometer in city traffic
Roadtax	1984 euro a year
Average speed in city	15 km/h
Time per drop	20 minutes

Delivery by LEFV from UCC

In this second scenario, the deliveries are still being done directly from the UCC to the final customer, but instead of being done by a diesel van, they are being done with a LEFV, the MaxVan Trike. Due to its lower loading capacity, each postal code area is delivered to separately. This means that unlike the van, the vehicle has to drive back to the UCC after servicing each area. The specifications of the LEFV are listed below, these are the same for all scenarios using a LEFV.

Table 2 Specifications LEFV

Price	1.000 euro
Loading capacity (in m^3)	$1.5m^3$
Fuel usage	Not applicable
Roadtax	0 euro
Average speed in city	15 km/h
Time per drop	10 minutes

Delivery by LEFV, using a microhub in inner city and a UCC

This third scenario introduces the use of a microhub to the supply chain. Its location is located in the inner city, in an industrial zone. Although a microhub can also be placed in a residential area, we chose not to because this increases the traffic flows within that residential area, thus reducing traffic safety. It is located so that it can best serve the inner city areas that are furthest away from the UCC. The areas within 5 kilometers of the UCC are still being delivered directly from the UCC. In the map on the next page, the location of the UCC is shown, as well as the various microhub locations. The postal code areas are also shown here, only the ones within the green line are being supplied. For this scenario, microhub 1 is being used. The goods are taken from the UCC to the microhub by a van, with the final delivery being carried out by a LEFV. The delivery from the UCC to the microhub is being done by a third party logistics service provider, at a cost of 75 euro per trip (assumptions made based on other projects).

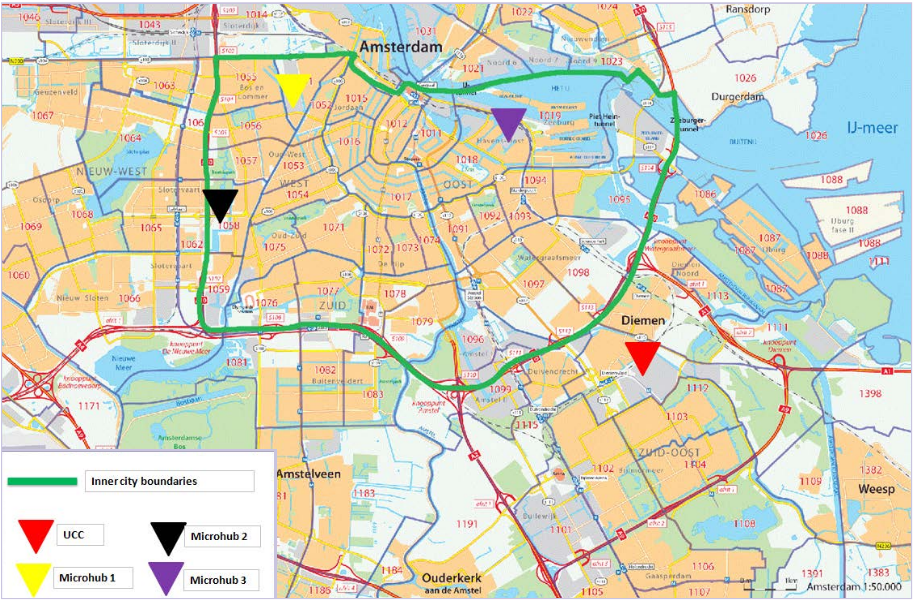

Figure 2 Map of Amsterdam with delivery area and microhubs

Delivery by LEFV, using two microhubs in inner city and a UCC

In this scenario, two microhubs are used to deliver the goods instead of just the one. This scenarios has been selected because some of the delivery areas are still quite far away from both the UCC and microhub 1. Two new locations were selected for the microhubs, to better cover the delivery areas. In the map above, these are shown as microhub 2 and microhub 3. Microhub 1 is no longer used in this scenario, deliveries from the UCC to the areas that are closer to it than they are to the microhubs are being done directly from the UCC.

Delivery by LEFV, using three microhubs in inner city and a UCC

This scenario is almost the same as scenario 4, but in this scenario we are still using microhub 1. This increases the coverage of the inner city even more, but also means more handling and more fixed costs. This is beneficial for cases where high volume is being delivered to some areas or when the capacity of the other microhubs is too low.

Results and analysis

We calculated the cost of delivery for each scenario. Deliveries are being done every 2 weeks, so 26 times a year. The results of this are displayed in the graph below.

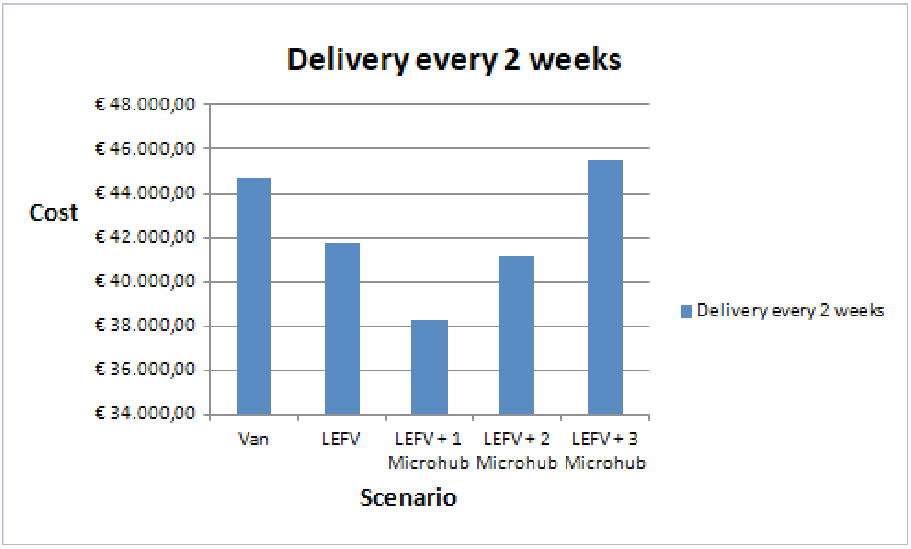

Figure 3 Graph of costs for delivering every 2 weeks

From this, we can see that using a LEFV and having one microhub in the inner city is the most financially feasible scenario for this company. This is due to the vehicle being cheaper, while the delivery time is the same. The LEFV is exempt from road tax and the fuel costs are much lower. This makes up for the extra costs from the microhub. As can be seen from the graphic above, the scenario using a van is more expensive than most of the LEFV scenarios. However, this is based on a scenario with deliveries being carried out once every two weeks. In order to see what happens when deliveries are made daily, we have calculated the effects of delivering the same amount of goods to the same number of clients, but being done daily. This requires multiple vehicles to be used to carry out these deliveries, which has been taken into account. The results from this are displayed below.

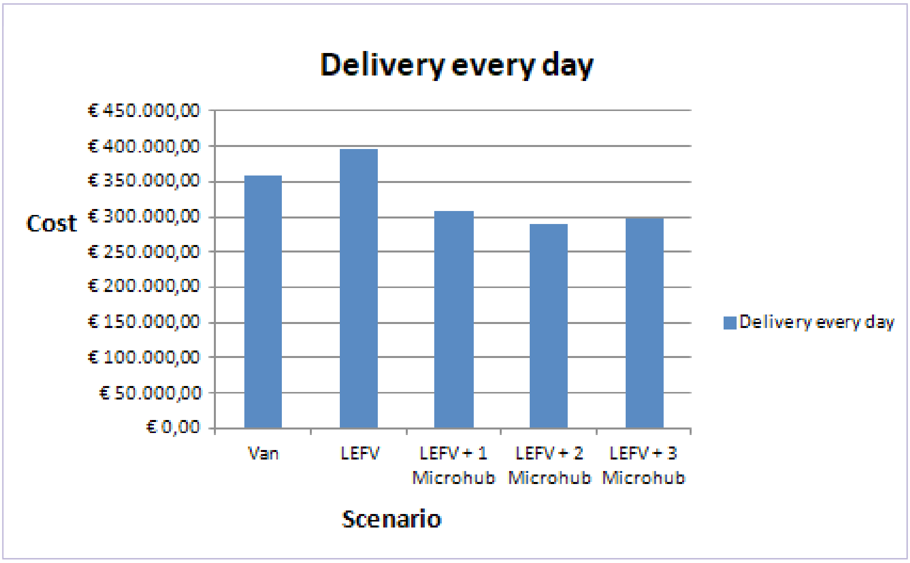

Figure 4 Graph of costs for delivering daily

With these higher volumes, the scenarios revolving around the microhubs are cheaper than the scenarios without it. Scenario 1 is more expensive because of the high purchase price and road tax of the diesel vans, scenario 2 is more expensive due to the fact that 8 LEFV are needed to transport all goods to the customers from the UCC, compared to 5 or 6 LEFV in the microhub scenarios. The scenario in which two microhubs are used is the cheapest, mainly because the effect on the operational costs of adding a third one are minimal, at least not enough to cover the costs of an extra microhub.

Discussion

When looking at an increase of volume or delivery frequency, a few points have to be made. In this paper, the same customers received the same amount of goods as in the current situation, but instead of every 2 weeks they received these goods every day. This is not what would happen in reality, where an increase in volume might also cause an increase in number of drops. The effects of this would have a different impact on the operational process than the increase we used in this paper. In the case we studied, the customers all have fixed locations within the city. Another company might have a more flexible or unpredictable demand, such as a parcel delivery company. Having microhubs on fixed locations within the city might prove to be inefficient in this case, instead a mobile depot can be used. Although this facility is more expensive than a microhub while fulfilling the same role, the added efficiency of being able to move it around the city might offset these higher costs by continuously providing the most efficient location.

Another important matter in this paper is that all supplies are delivered by one company. If the use of LEFV and microhubs is applied to an area that has multiple suppliers, their willingness to cooperate might prove to be an issue. Although the total costs of the entire supply chain might be lower, certain links in this chain might experience higher costs or lower profit margins (For example, logistics service providers will only transport the goods from the supplier to the UCC. As a result of not having to enter the city anymore and saving time on this, their customers might demand lower rates). We believe that the added benefits of using LEFV can increase the willingness of stakeholders to take part in a UCC structure, but this willingness might not exist among all stakeholders.

Lastly, the locations of the microhubs can be calculated in different ways. We tried to create an even spread across the entire inner city. Volumes that were shipped to each postal code have not be taken into account. When these are being taken into account, the microhubs might have to be placed in different locations to make sure the higher volumes receive the highest priority for efficient delivery. In our case, the microhubs were all placed within industrial zones within the city. If these are not available, this will also change the location and thus the outcome of using microhubs. Also, for the costs of the microhub, we looked at rental prices of real estate. When renting is not an option and real estate has to be purchased, the cost of a microhub will go up compared to renting. This may affect the outcome of the scenarios.

Conclusion

The challenges of modern day urban logistics place an increasing demand on operators to find a sustainable way of delivering goods in cities. Logistics facilities and light electric freight vehicles both have the potential to overcome these challenges. Although sustainable use of both of these concepts has proven difficult so far, combining the two can provide the answer to each other's challenges as well as the challenges in urban logistics. By consolidating shipments for certain areas at the edge of the city, that are then transported to a local hub, the number of vehicles in cities will decrease and as a result, the number of kilometers driven will decrease. This will cause pollution caused by greenhouse gasses and noise to be reduced as well, improving the quality of life within cities.

The combination of LEFV and logistics facilities offers numerous operational benefits , by providing shorter delivery times, by providing the ability to deliver outside of time windows and within areas restricted to polluting vehicles and by consolidating shipments to reduce the number of trips needed to deliver the goods. The vehicles are exempt from road tax, have a lower purchase price than regular freight vehicles and have lower fuel costs. Drivers do not require a driver's license to operate these vehicles, as a result their salary will be lower. Using just one consolidation center at the edge of city has proven to be inefficient. The driving time to drops within the city means that the deliveries take longer compared to consolidating shipments at the edge of the city and then taking them to a microhub within the city. If the use of LEFV is to increase, operators will have to setup smaller depots within the city to make it financially feasible. Depending on the location and amount of customers, as well as their demand, multiple microhubs may be required to guarantee an efficient delivery process. With each facility added however, the costs will rise, the benefit of shorter delivery times from each extra microhub have to outweigh the costs of it.

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