POLICY ADVICE PAPER: FRAMEWORK FOR THE IMPLEMENTATION OF A LEV SYSTEM FOR URBAN LOGISTICS

REGIONAL FOCUS: LATIN AMERICAN CITIES

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PROJECT PARTNERS

ABOUT

This deliverable aims to provide policy advice from the SOLUTIONS+ consortium partners to the implementation of a LEFV system for urban logistics providing a complete framework as guidance

TITLE

Policy Advice Paper: Framework for the implementation of a LEV system for urban logistics

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LAYOUT

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PICTURES

All the pictures are provided by the SOL+ partners

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Executive Summary

The **SOLUTIONSplus project** aims to enable transformational change towards sustainable urban mobility through innovative and integrated electric mobility solutions. It is funded under the European Union's Horizon 2020 research and innovation program and is implemented from January 2020 to December 2023. The project encompasses city-level demonstrations to test different types of innovative and integrated e-mobility solutions, complemented by a comprehensive toolbox, capacity development, and replication activities. The project is able to provide technical and financial input to partner cities as the consortium gathers some of the leading e-mobility industry and research actors.

In Quito, the SOLUTIONSplus demonstration supports electric mobility for last-mile passenger connectivity and logistics. The promotion of light electric vehicles (LEV) is focused on the local production of electric cargo bikes and electric 3&4-wheelers local manufacturing.

SOLUTIONSplus has developed a **logistics model for the implementation of LEV in the historic center of Quito for urban logistics**. The model develops a complete framework for the implementation of electric vehicles and their integration into city operations.

This advice paper includes the proposed framework, with all the operational details for its use, to be applied by any city aiming at implementing LEV for urban logistics in a selected area.

The framework is based on a **market analysis** to gain valuable insights into the size of the market, market profiling, and market trends. Four crucial perspectives for the successful launching and establishment of a LEFV system for urban logistics are covered by the framework:

- **Organizational perspective:** includes organizational improvements related to building a cooperative business network between all actors, directly and indirectly involved in the city distribution system. It is based on a phased approach starting with a small-scale pilot and limited number of actors and extending the service to a broader area with several additional actors involved in the service;
- **Hardware perspective**: it contains recommendations for the optimal design of light electric cargo vehicles based on experiences from other projects;
- **Software perspective**: includes building a web application for determining the optimal vehicle routes supplying customers from one already determined depot location. This application serves as a short-term service planning tool, however, with possible extensions, it can also serve as a mid-term (cost effective planning of services on a weekly and monthly scale) and long-term planning (LEFV fleet sizing);
- **Legislative perspective**: the existing policy framework related to conventional vehicles is assessed and the need for specific policies and regulation for LEFVs is examined.

All perspectives must co-evolve together to enable successful implementation and long-term effects of the innovative value proposition for the LEFV distribution system in Quito.

The content of the present policy advice paper is structured following the step approach of the implementation of a Light Electric Vehicles system for urban logistics, which is synthetized as follows:

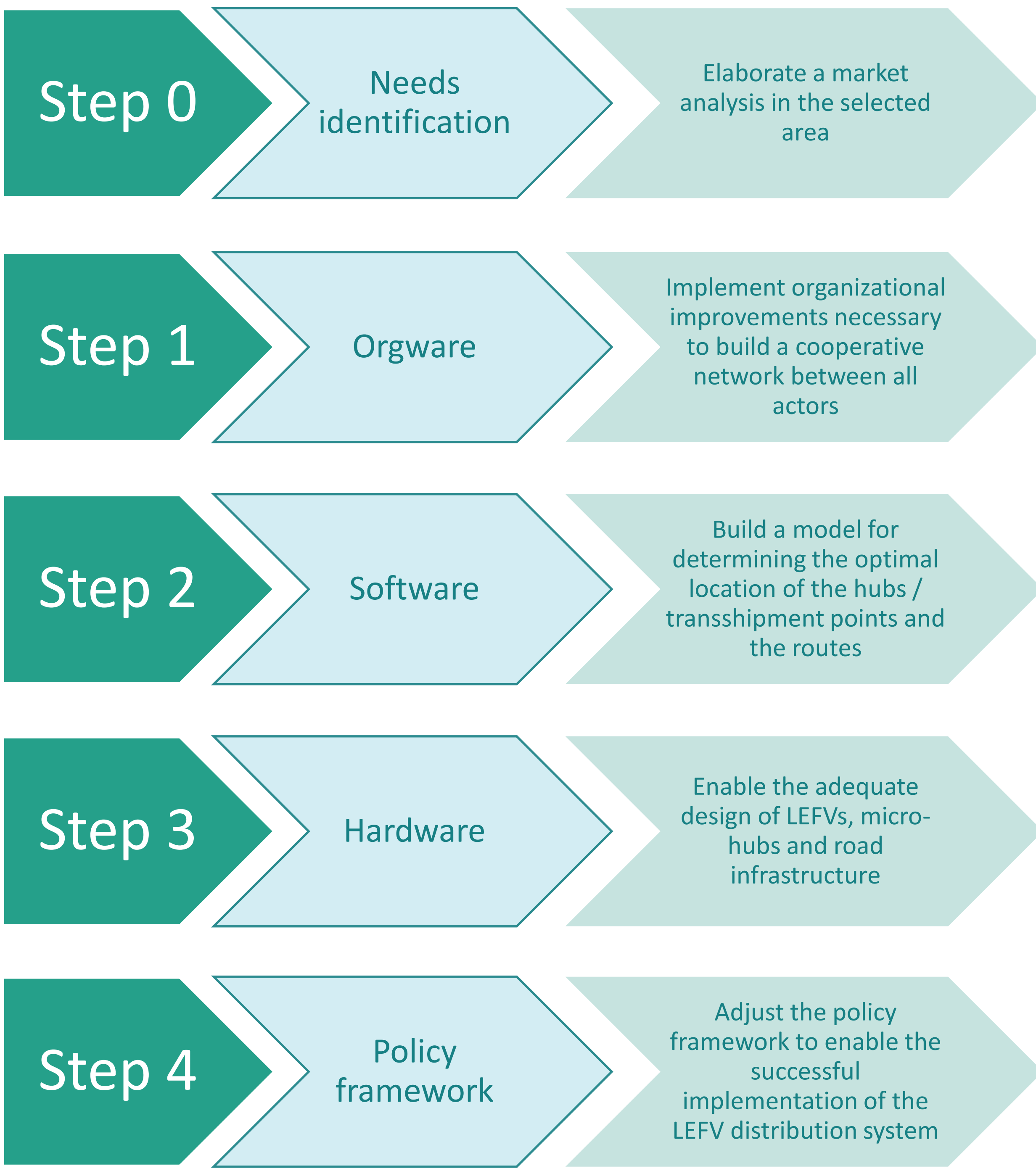

Figure 1. Step approach for implementing a Light Electric Vehicles system for urban logistics

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List of Abbreviations

BM - Business Model

CBM - Courier Business Model

GBM - General Business Model

LEV - Light Electric Vehicles

LEFV - Light Electric Freight Vehicles

SBM - Supplier Business Model

1. Introduction

1.1 The importance of logistics to decarbonize cities

1.1.The importance of logistics to decarbonize cities

The freight sector, despite of being responsible for 8% of the GHG emitted worldwide and projections of doubling emissions by 2050 (International Transport Forum, 2019), still has a secondary role in the public debate and in the policy agendas of cities and countries as a decarbonization priority. In the transport chapter of the Fifth Assessment Report of the IPCC (Sims et al., 2014), however, it is stated that the reduction of the carbon intensity of freight in emerging markets could play an important role in offsetting the rise of GHG emissions in developing countries by 2030. This is where decarbonization strategies such as electrification of the freight fleet comes into play.

Logistics are key for the normal functioning of cities, as they keep the economy running and citizens served with the products and goods that they need for their daily activities. With urbanization, logistics have become more complex, in particular in large urban areas and megacities. As a matter of fact, it is estimated that in cities worldwide freight vehicles represent in average 25% of the total vehicle fleet, occupy 40% of the road space, are responsible for between 30% and 50% of the main air pollutants (PM and NOx), and contribute to up to 40% of GHG emissions related to urban transport. Furthermore, it is estimated that the transport of urban goods will triple by 2050 in comparison to 2010 (Taryet, 2019).

In Latin America, one of the most urbanized regions of the planet with 80% of its population living in cities, transport is responsible for 36% of the GHG emissions. Road transport represents 80% of it, having passenger and freight transport almost equal shares (Martínez Salgado, 2018). Accordingly, 27 out of the 33 countries in Latin America and the Caribbean mention transport as one of the sectors that need to decarbonize in order to reach the targets set in the country's Nationally Determined Contributions (NDCs) and thus contribute to the achievement of the 1.5 C goal of the Paris Agreement. Furthermore, 13 of these countries mention explicitly the introduction of electric mobility as one of the measures towards this pathway (PNUMA, 2021). Nevertheless, the e-mobility strategies that are being elaborated and implemented at the national and local levels focus on passenger transport, mainly public transport, disregarding the importance of the freight sector in the countries and cities decarbonization pathways.

In Latin American cities the distribution of goods to the commerce, office, and HORECA sectors (hotels, restaurants and catering), as well as to households at the metropolitan level happens usually with vans and small trucks, which are normally old and polluting. This sector is experiencing an important transformation due to changing consumer behavior, the increase of e-commerce and online shopping, and the boom of the gig economy (Taryet, 2019), which during 2020 and 2021 grew exponentially as a consequence of the covid-19 pandemic. Estimates show that in the region e-commerce sales increased 70% and approximately 50 million consumers tried e-commerce for the first time in 2020 (Rodríguez, 2021a). These new consumption trends, along with the digitalization of delivery services, the low entry barriers and high informality of the sector, the polluting and unsafe character of the vehicles used for these types of deliveries and the inefficiency of the system (loading capacity it's not used at its maximum, vehicles return empty), show a great potential for improvement (reducing the VKT of this sector) and GHG emissions reductions of this sector in Latin America.

This is where the concept of Last Mile Logistics (LML) comes into play. LML, i.e., the last segment of the supply chain, is often the most expensive, unsafe, inefficient and pollutant section of the supply chain (Olsson et al., 2019). Thus, it is conceived as a segment with high potential for energy and economic efficiency gains. Several pilot projects to reduce the emissions of urban logistics by integrating light (electric) vehicles in the last mile operations have been conducted in Europe in the past decade. Some of the main results from the European pilots show that (Wilmsmeier et al., 2015):

- One quarter of the commercial merchandise currently being transported by trucks or pick-ups could be delivered by cargo bikes (cyclelogistics)
- In Germany, 42% of the deliveries could be conducted by cargo-bikes in 19% of the kms travelled (Initiative "Ich ersetze ein Auto" of the German Ministry of Environment – BMU)
- Reduction of CO2 emissions and distance travelled per package by half integrating bicycles in last mile deliveries (Gnewt Cargo)

Thus, the potential of integrating small vehicles, such as cargo-bikes, in LML revealed by these initiatives has also led to the creation of new vehicle concepts, the so called Light Electric Freight Vehicles (LEFVs), that have larger ranges due to their electric motors, and an increased loading capacity, being able to fulfill the needs of many customers. LEFVs are described by the LEFV-LOGIC project as "bike, moped or compact vehicle with electric assistance or drive mechanism, designed for the distribution of goods in public space with limited speed. LEFVs are quiet, agile and emission-free and take up less space than conventional vans and trucks." (Moolenburgh et al., 2020, p. 3). A comprehensive discussion about the definition and categories that fall under the Light Electric Vehicle (LEV) umbrella can be found in the Policy Advice Paper on Regulations for LEVs (SOLUTIONSplus, 2024). According to this paper, LEV can be defined as those vehicles with a number of wheels >= 1 and <= 4, designed for personal mobility, transport of passengers or goods in an urban setting, propelled by electric motor(s) in pedal assistance mode or in exclusive mode. Their maximum continuous power is fifteen (15) kilowatts (kW) and their recommended maximum speed is 45 km/h.

In the case of Latin American cities, (non-motorized) light delivery vehicles, such as cargo bikes and tricycles, are embedded in the mobility system. However, despite its existence and extended use, there are very few regulations for this type of vehicles, because they are not considered as a formal mobility possibility and are associated with precarious practices (Wilmsmeier et al., 2015). At the same time, the region has been keeping up with the worldwide developments related to LML. For the past 5 years e-commerce has grown at an average rate of 16%. In 2020, Latin America was the second fastest growing region after Southeast Asia (Canalizados, 2021). New companies providing last-mile delivery services such as Rappi, PedidosYA, 99 Minutos, Chazki, and the giant Mercado Libre, among others have been expanding unstoppably within the region in recent years (Rodríguez, 2021b), however, not always with business models that promote road safety, clean vehicles and fair working conditions. Demonstration actions to test LEFVs, many of them produced locally, in last mile operations, similar to the ones carried out in Europe, are getting traction in Latin American cities promoted by public, private and international actors. The first results of these pilots in Bogotá, Medellín and Buenos Aires show important results in terms of CO2 emissions avoided and economic savings for the companies that participated.

Hence, the question that arises is how the old and new practices and business models around last mile logistics in Latin American cities can be improved by the introduction of LEFVs and thus contribute to an increase in the efficiency and a reduction in the GHG emissions, without disregarding the socioeconomic aspect.

1.2 The SOLUTIONSplus project

1.2.The SOLUTIONSplus project

The SOLUTIONSplus project aims to enable a transformative shift towards sustainable urban mobility through innovative and integrated electric mobility solutions, which are implemented as pilots in 10 cities globally. It was funded by the European Union's Horizon 2020 research and innovation program and ran from January 2020 to June 2024. The project encompassed city-wide demonstrations to test different types of innovative and integrated e-mobility solutions, complemented by a comprehensive toolbox, capacity building, business model development and policy, scale-up and replication activities. In addition, the project provided technical and financial support to the local actors, relying on the knowledge and expertise of a consortium of 46 partners that bring together some of the main research and industry players in electric mobility. The project was implemented in 10 demonstration cities, i.e.: Kigali (Rwanda), Dar Es Salaam (Tanzania), Hanoi (Vietnam), Pasig (Philippines), Kathmandu (Nepal), Najing (China), Quito (Ecuador), Montevideo (Uruguay), Hamburg (Germany) and Madrid (Spain), and in more than 15 replication cities around the globe.

In Latin America, the SOLUTIONSplus carried out demonstration activities in Ecuador and Uruguay and replication in Colombia and Argentina focusing on the five main action lines depicted in Figure 2.

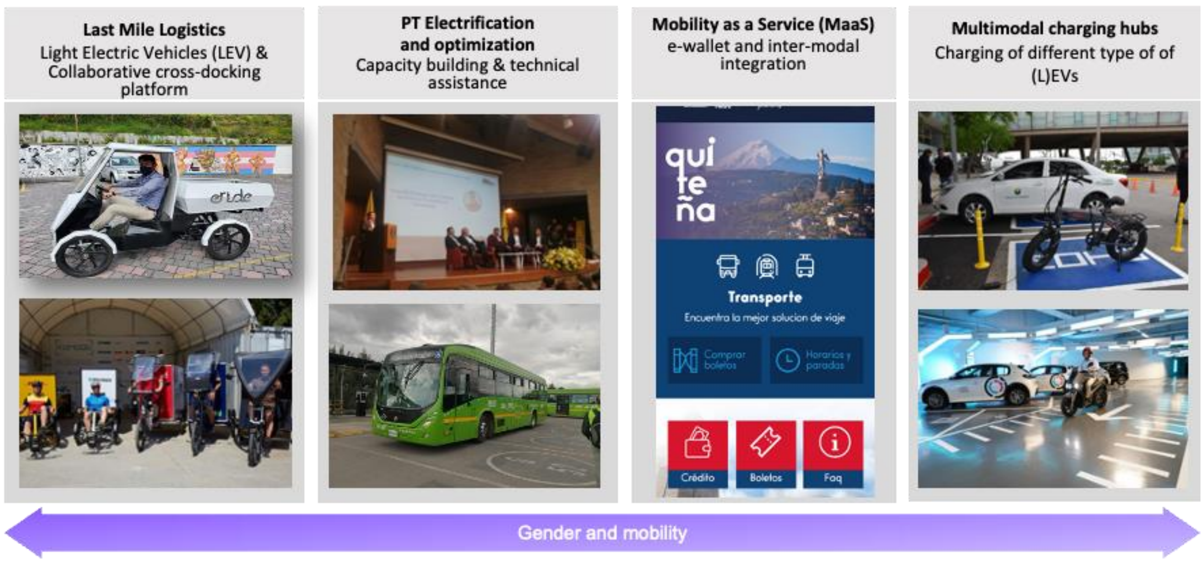


Figure 2. SOLUTIONSplus action lines in Latin America

In this context, SOLUTIONSplus provided seed funding for the manufacturing of 15 different types of LEVs by a total of 11 local SMEs. These vehicles were tested in 12 different use cases, mainly in logistics operations, but also in passenger transport. The results of the pilots carried out in 2 demonstration cities (Quito, Ecuador and Montevideo, Uruguay) and in 10 replication cities (Escobar and Buenos Aires in Argentina, Cuenca in Ecuador, Bogotá, Medellín, Barranquilla, Bucaramanga, Baranoa and Sabanalarga in Colombia) show high scale-up potential of this solutions in Latin America.

Furthermore, with the aim of strengthening the local capacities and knowledge about the topic, SOLUTIONSplus provided various training and capacity-building opportunities from which the regional stakeholders benefited. For instance, the Regional Training for Latin America 2021, that took place online, focused on low-carbon urban logistics and regulations for LEV. Moreover, the Latin American Electric Mobility Forum that took place in Bogotá in March 2024 had as one of the focus areas low-carbon urban logistics and included presentations by most logistics' operators and vehicle manufacturers involved in the project in the region, as well as site visits to innovative approaches to urban logistics, such as Grupo Nutresa’s micro hubs. This has been complemented by several peer-to-peer exchanges, site visits and participation in international events such as the International Cargo Bike Festival (ICBF) in Amsterdam, The Netherlands.

Hence, this Policy Advice Paper aims at detailing the steps necessary to implement a LEV system for urban logistics in Latin American cities. The framework for the introduction of such a system was developed by the Zaragoza Logistics Center (ZLC), one of the SOLUTIONSplus consortium members, specifically for the case of Quito, Ecuador. However, given the replication potential identified in other Latin American cities, we make it available as a tool for cities in the region to decarbonize their urban logistics. Moreover, the framework developed was published in the peer-reviewed Journal Research in Transportation Business & Management in June 2024 (Milenković et al., 2024).

The following sections present the characteristics and results of the urban logistics pilot implemented in Quito and are followed by a summary of the other 5 LML pilots implemented in Latin America in the context of the SOLUTIONSplus project.

1.3 The Quito demonstration project

1.3. Urban logistics demonstration – The case of Quito, Ecuador

The main component of the project in Quito, the multimodal e-mobility hub in the Historic Centre of Quito aimed at contributing to the consolidation of the Zero Emissions Historic Center through the introduction of locally designed and assembled Light Electric Vehicles (LEV) to improve the last mile logistics and connectivity in the area.

The Historic Center of Quito (HCQ) comprises an urban area of 3.75 km2, with a population of approximately 29.071 inhabitants. Declared by UNESCO as the first World Heritage Site in 1978, it is considered one of the most important historical sites in Latin America. Even though the HCQ has been losing residents for the past 3 decades and until 2030 the population projections estimate that the population will be reduced by 28% (22.371), during the daytime it attracts important influxes of locals and foreigners because of its commercial and touristic importance. According to the Municipal database, there are approximately 2,000 businesses in the area, of which more than 80% are wholesale and retail trade activities and 14% accommodation and food service activities.

Seed funding for the local design and assembly of Light Electric Vehicles (LEV)

SOLUTIONSplus, via UN-Habitat and the Environmental Fund, allocated seed funding for the development of prototypes and subsequent assembly of Light Electric Vehicles, both for passengers and cargo. The SMEs Bixicargo (10 e-cargo bikes), Sidertech (4 e-quadricycles) and Grupo Miral (4 e-mini vans) received seed funding for the local manufacturing of different types of LEVs, mainly for logistics, but also for passenger transport. It is worth noting that all the SMEs received technical support and, in some cases, even components from the SOLUTIONSplus consortium members. For instance, Sidertech received Valeo drivetrains in a kit to be easily integrated in the e-quadricycles. In addition, PEM Motion, one of the companies selected under the European Innovators Calls supported Bixicargo, Sidertech and Grupo Miral in vehicle design and battery sizing. Further support on vehicle design, charging, batteries and homologation was provided by IDIADA. ERTICO and FIER, on the other hand, provided guidance on business models and innovation management as part of the SOLUTIONSplus Start-up Incubator. The pictures and characteristics of the vehicles are presented in Section 2.4.2 SOLUTIONSplus LEFVs in Latin America.

Moreover, all the vehicle prototypes were tested in terms of performance and safety in a controlled environment and following the national standards. For the e-cargo bikes and e-quadricycles these tests were conducted by the LIAVMS (former CCICEV), a vehicle and sustainable mobility laboratory ascribed to the National Polytechnical School (EPN). Based on the tests, improvements and adjustments were suggested before producing the whole lot of vehicles and before the corresponding pilot phases.

The pilot design

Between July and September 2021, SOLUTIONSplus conducted a data collection process, following the ZLC market study logic, in order to better understand the logistics dynamics in the Historic Center of Quito. In total, 241 economic establishments were surveyed, representing 12% of the universe of 1,905 establishments. A total of 241 establishment-based freight survey were performed, based on the data from the Municipality Business License (LUAE by its Spanish Acronym) database from 2019, which identified the presence of 1,905 businesses located in the study area, mainly focused on wholesale and retail trade activities (82.27%) and accommodation and food service activities (13.67%). The selected sample represents 12% of the population and has statistical significance at a 95% confidence level. The questionnaire asked 27 questions about business logistics practices (main inputs, suppliers, hours and frequency of supply, among others) and willingness to pay and interest in joining of the electric mobility pilots, for which images with the prototypes of the vehicles were presented.

The study area was defined through the analysis of secondary information from various public and private sector institutions such as the Partial Plan for the Development of the Historic Center of Quito prepared by the Metropolitan Institute of Heritage (IMP), the Institute for Innovation in Productivity and Logistics CATENA-USFQ and ARCA Continental, a company that distributes Coca Cola nationwide. The selected area constitutes the commercial core of the historic center, 58% of the businesses are located on pedestrian streets. The defined area (see Figure 3) is bounded on the North by the Carchi Street, on the South by the 24 de Mayo Street, on the West by Juan Pío Montúfar and on the West by Chimborazo Street.

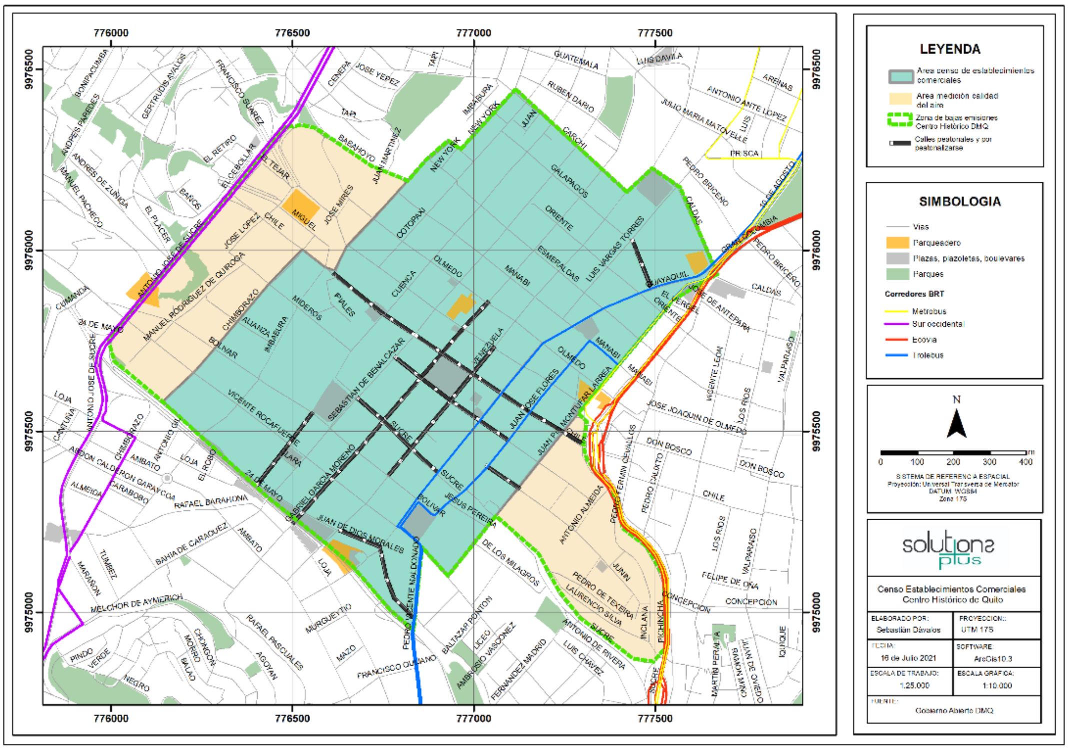


Figure 3. Defined Area

Moreover, for the design of the pilot the local team counted on the support of the Center for Productivity and Logistics (CATENA) of the San Francisco University (USFQ), which supported in the operations design and stakeholder engagement. During the design phase, that took place during the first semester of 2022, stakeholder engagement a workshop was held with more than 50 stakeholders, including municipal institutions, food distribution companies, entrepreneurs, non-governmental organizations, academia, and businesses in the Historic Center, among others. The event focused on showcasing low-carbon Last Mile Logistics (LML) pilots in the region. It counted with the presentation of ICLEI's EcoLogistics Project and other successful cases of LML with LEV in Latin America such as Express Logística in Argentina, Lola te Mueve and Bici carga in Colombia and Grupo Entregas in Ecuador. This peer-to-peer exchange was key to eliminating barriers and generating interest in LML with LEV among private sector representatives. In August 2022, a public event with support of the Municipality and academia (CATENA and EPN) took place with the goal of socializing the prototypes of Sidertech and Bixicargo and allowed potential users to provide feedback regarding the design, ease of drive and accessories.

This process was followed by the submission of 20 expressions of interest (EoI) from the entities willing to test the SOLUTIONSplus LEV in the different phases of the pilot. The interest came from various types of applicants, ranging from large courier and food / beverage distribution companies such as Moderna de Alimentos, Grupo Entregas (Fedex) and Urbano Express to informal actors such as stevedores and recycling associations.

Based on stakeholder engagement, the ex-ante data collection process carried out in 2021 and the EoIs received, 5 operating schemes and their operators were defined (Figure 3). An operational scheme, in this case, shows the way in which the last mile is done. It illustrates the types of goods transported, the types of vehicles used in each segment of the trip and if it is point-to-point distribution or if it is supported by an intermediate hub. Schemes 1 to 4 were piloted in the first phase, while the second phase focused on schemes 3 to 5.

For the cross-docking platform, the local team together with the Municipality identified and visited several public properties that were either not used or underused. However, given the legal and administrative constraints of the Municipality to make the space available for the pilot, a cross-docking platform was established in the Medranda private parking lot, located on Bolívar Street. The space was adapted for the parking and charging of 6 out of 10 e-cargo bikes, in the first phase and the 4 e-quadricycles in the second phase. The rest of the vehicles were stored and charged in the premises of the pilot participants.

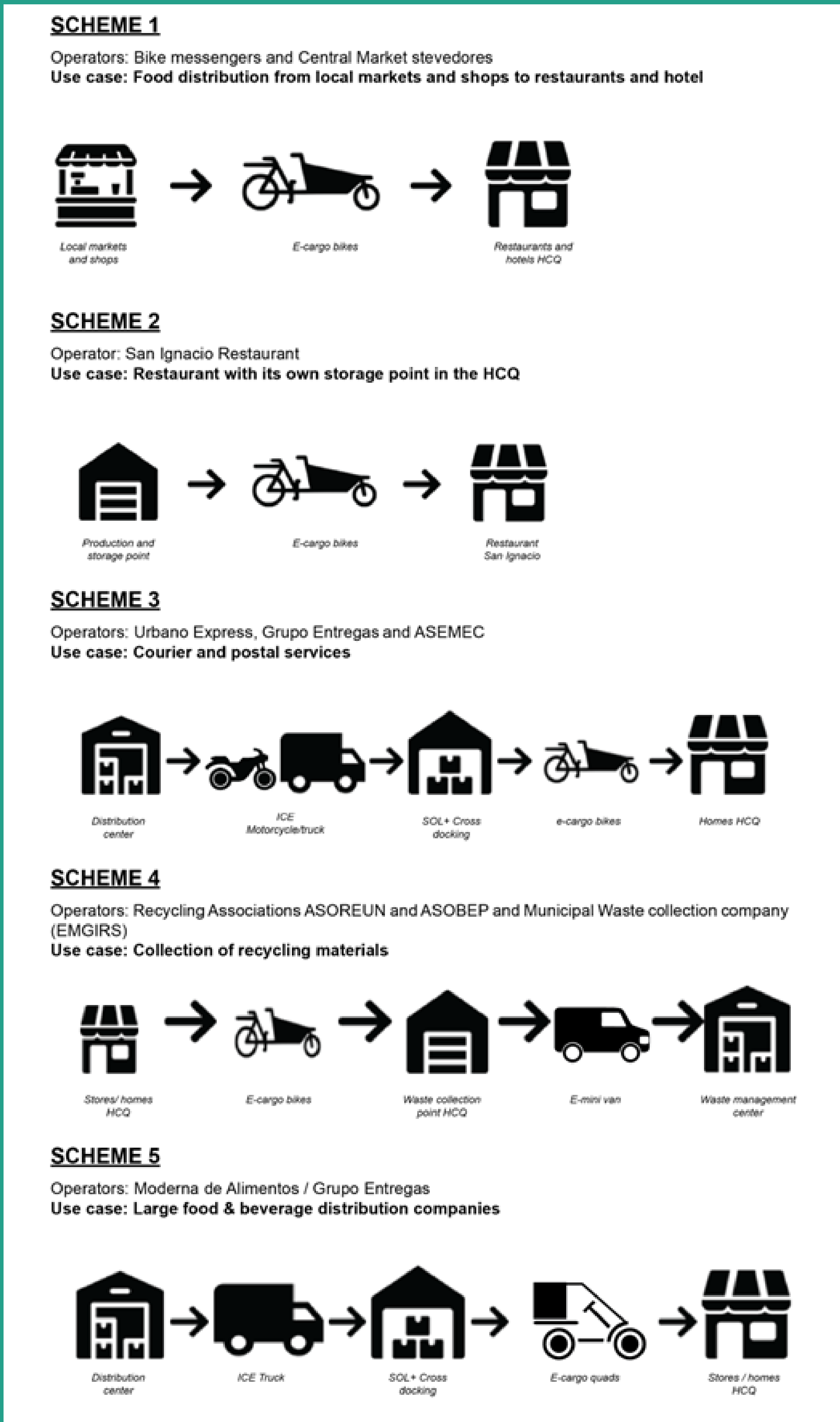


Figure 4. Five operating schemes

The pilot implementation and monitoring

The implementation of the pilot was executed in two phases. The first phase of the pilot tested 10 e-cargo bikes for last mile logistics. The second phase tested 4 e-mini vans, 2 for cargo and 2 for passenger transport, and 4 e-quadricycles.

For monitoring the results of the pilot, the local and regional teams of SOLUTIONSplus with the support of VTT, the entity responsible for the impact assessment in Latin America, and CATENA outlined a comprehensive assessment framework that included:

- Daily information
    1. Mobile air quality sensors were installed in all e-cargo bikes to collect information on air quality, delivery routes and distance travelled
    2. Data sheets were filled in by participants daily with information related to the number of trips and deliveries, the kms travelled, operational time and incidents
- User perception surveys were conducted at the end of each pilot phase to:
    1. Logistics operators
    2. Drivers
    3. Final users

In addition, a collaboration with the Inter-American Development Bank (IDB) allowed for a pedestrian survey and data collection process with a control group to determine: 1) the perception of pedestrians towards LEVs and in particular e-cargo bikes, 2) the scale-up potential of the pilot from the perspective of the logistics companies. The IDB also supported the SOLUTIONSplus team in the analysis of the data collected by the mobile sensors.

The first pilot phase started on November 7th, 2022, and ended on January 6th, 2023. During this period, the pilot worked with 4 operating schemes and 7 users, i.e., 2 food distributors, 1 restaurant, 2 couriers and 2 recycling associations, as it is shown in Figure 4. The overall results of the operation of the 10 e-cargo bikes during 2 months in the HCQ can be seen in Figure 5.

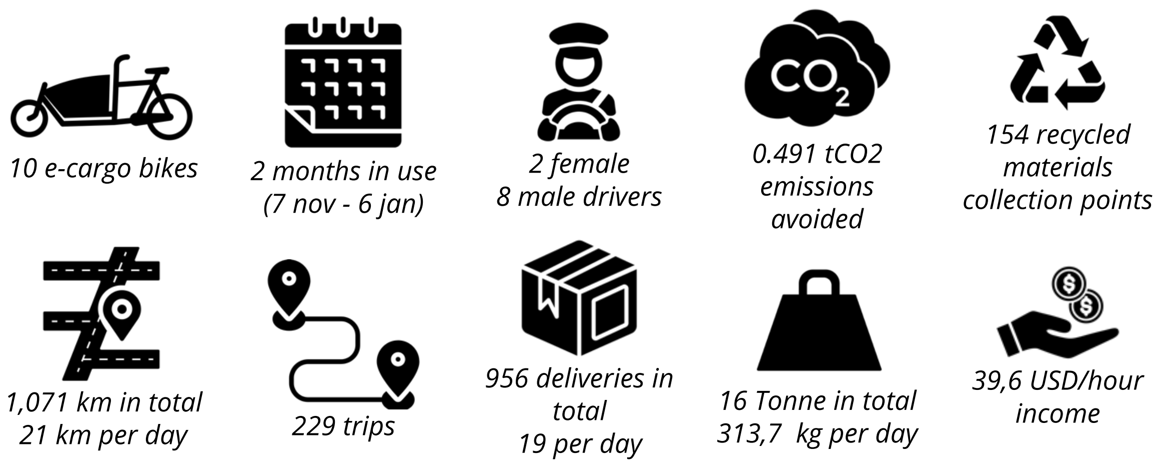


Figure 5. Overall results of the pilot

The results by operating scheme (Figure 6 and 7) show important efficiency and economic gains. In operating schemes 1 and 4, the market stevedore and the recycling associations, which are characterized by their informal character and the previous use of manual carts, increased their income per hour in 81% and 25% and reduced their working hours in 43% and 56%, correspondingly. Moreover, in both cases the packages per trip doubled. These results translate into a significant improvement in the working conditions and, thus, the quality of life of these actors. In addition, the economic gains show the viability of scaling up these schemes. Finally, an increased efficiency and formality of these use cases could attract more customers and reduce the number of deliveries conducted by ICE vehicles in the area for the distribution of food in the area. Operating scheme 2, the restaurant with its own storage unit, shows a similar result, i.e., significant efficiency gains, in this case, however, compared to the use of an ICE vehicle in a congested and pedestrianized area like the HCQ.

Operating scheme 3, i.e.: the courier companies, also showed important efficiency gains going from the 8 to 35 packages delivered per day from the beginning to the end of the pilot. It is worth noting that in the particular case of Grupo Entregas, the pilot area was expanded from only the HCQ to the Central Business District (CBD), as it was identified by the courier company that it was its core delivery zone. This adjustment enabled the company to assess the coverage that they could have when using an e-cargo bike.

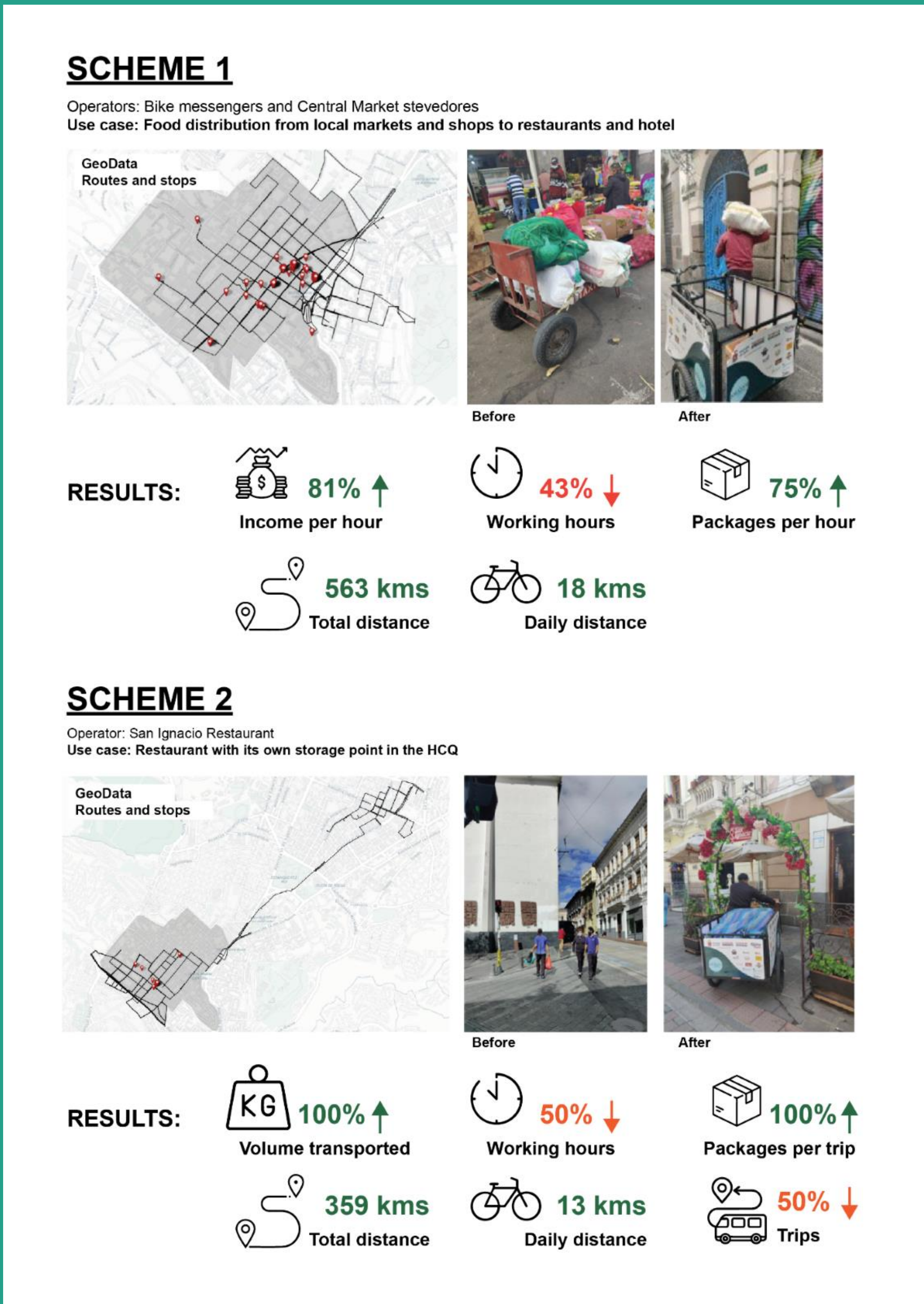


Figure 6. Operating schemes 1 and 2

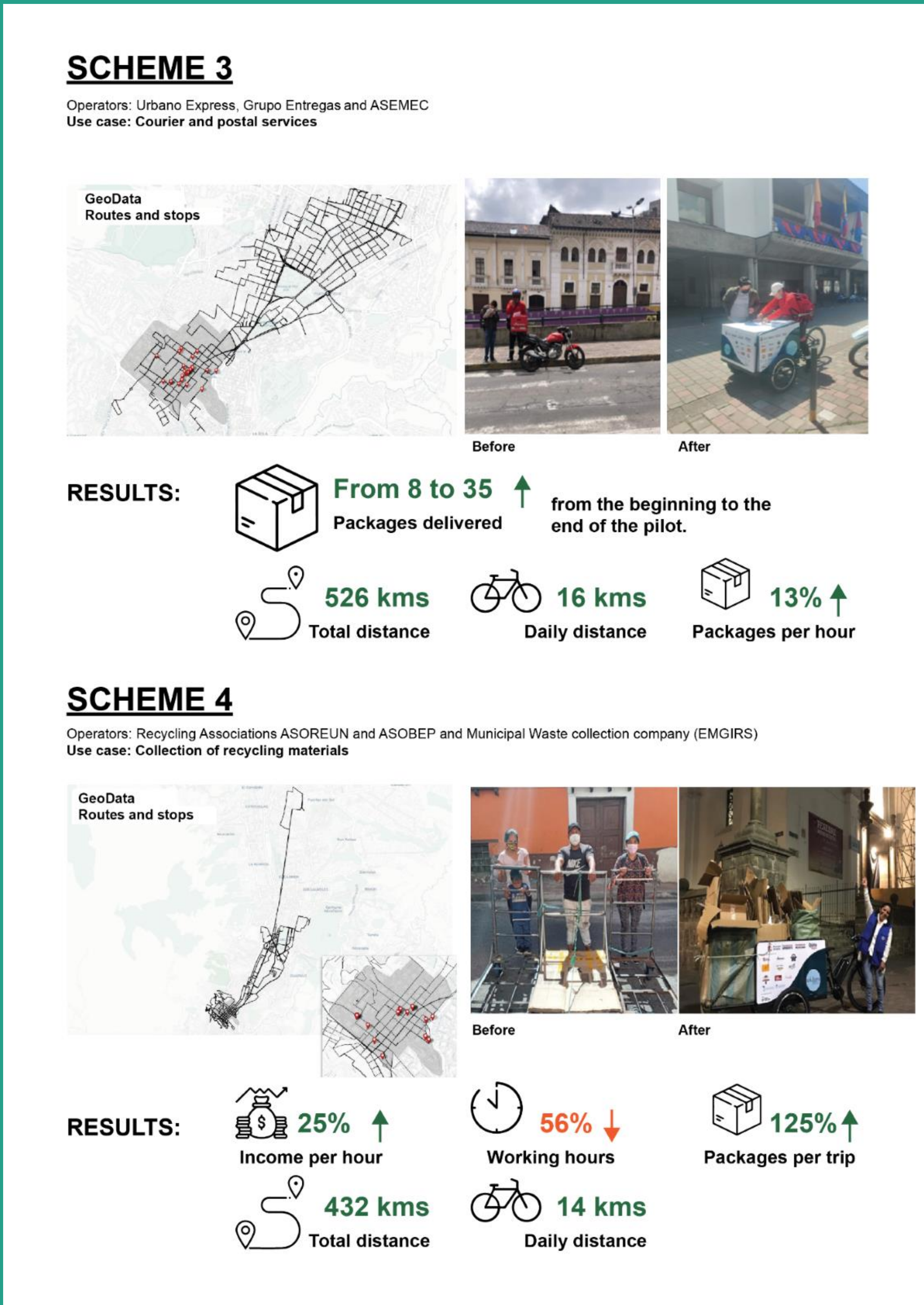


Figure 7. Operating schemes 3 and 4

In April 2023, a call for expressions of interest for permanent custody of the e-cargo bikes was launched among pilot participants. The 10 e-cargo bikes were handed over to the pilot participants that showed the best results in all operating schemes. Since then, the SOLUTIONSplus e-cargo bikes have transported approximately 300t, travelled 25,000 km and avoided 6 tCO2. According to the scale-up assessment conducted, if all ICE logistics vehicles in the HCQ were replaced by electric, approximately 600t CO2 emissions would be avoided every year.

The 4 e-quadricycles and the 4 e-vans manufactured by the local SMEs Sidertech and Grupo Miral, correspondingly, are being tested by large food and beverage distributors, courier companies and municipal companies responsible for passenger transport and waste collection. The results are being processed.

1.4 Urban logistics pilots in Latin America

Delivery platform Montevideo

City/Country: Montevideo, Uruguay
Supporting partners: PedidosYa, Fundación Julio Ricaldoni
Manufacturer: CargoBikeUY & Wheele
Origin: Uruguay
Category: Long john e-cargo bike (pedal-assisted)

Figure 8. Pilot Pedidos Ya

About the pilot

Two e-cargo bikes, one of each manufacturer, were introduced in the operations of PedidosYA, the Latin American subsidiary of Delivery Hero, which conducts 80% of its deliveries in ICE motorcycles and 20% in regular bicycles. The drivers were trained for using and riding the e-cargo bikes. In the two weeks the e-cargo bikes were tested, 156 trips were made, 90 packages delivered with a total weight of 135 kg, and a total of 187 km travelled. Overall, the e-cargo bicycles were positively perceived by the male user and negatively by the female rider, which shows the need of specialized training for different population groups.

Main Results

2 e-cargo bikes tested

2 weeks in use

6 hours operating time

1 female 1 male drivers

5.3 km/hr Vehicle speed

0.15K km total travelled distance

17.2 deliveries/hr

135 kg total cargo transported

0.09 tCO2 emissions avoided

0.4 kWh/km energy consumption

Scale-up potential

The overall evaluation showed that the e-cargo bikes were not ideal for PedidosYA's current operations, which focus on 1 delivery per trip. However, the company is working on a new line of business that will allow for the consolidation of goods and the delivery of larger goods, for which the e-cargo bikes would be ideal. In addition, the construction of bicycle lanes on major roads in Montevideo, partially funded by SOLUTIONSplus, will give regular bicycles and e-cargo bikes a competitive advantage over ICE motorcycles, which have to circulate with regular traffic.

Electrifying the last-mile distribution in Colombia

Figure 9. Pilot Lola te Mueve

City/Country: Bogota, Barranquilla, Baranoa, Sabanalarga, Medellin, Colombia
Implementing partner: LOGYCA
Supporting partners: Universidad Tecnologica de Pereira
Manufacturer: Stark Dongfeng, Lola Te Mueve, Brenson
Origin: Colombia
Category: Rear load e-tricycle (pedal-assisted), L5

About the pilot

This pilot tested the performance of three different types of electric vehicles (3 e-tricycles, 2 e-motorcycles, and 2 e-vans) in the real operating conditions of the multinational food distribution company, Nutresa. Five Colombian cities were selected for the pilot, to ensure the replicability of the model, considering the different characteristics of the area of operation, such as geographical and weather conditions, road infrastructure, traffic flow, among others. The operational models and vehicles selected for each city depended on the specific conditions of the area. Overall there is a positive balance in all the operational models, with an average increase of 70% in the number of deliveries per hour in all operations, reaching almost 15.000 deliveries in the 5 cities.

Main Results

3 e-cargo tricycles, 2 e-cargo motorcycles, 2 e-vans tested

3 months in use

5.03 hours operating time

7 male drivers

12.1 km/hr Vehicle speed

16.8K km total travelled distance 169.38 km per day

7.61 deliveries/hr 227 per day

78.1 ton total cargo transported 1008.3 kg per day

15.37 tCO2 emissions avoided

0.5 kWh/km energy consumption

Comparison with baseline

Deliveries
63.82% ⬆
Baseline: 4.7 deliveries/hour

Distance
15.41% ⬆
Baseline: 4.55 km/hr

Costs
-17.87% ⬇
Baseline: 1983 total operating cost $USD/month

Scale-up potential

Nutresa has already started its transition to electric mobility and has therefore tested different types of vehicles and operational models, such as microhubs. However, to electrify 100% of Nutresa's own fleet, a budget of approximately US$7 million would be required, 80% for the vehicles and 17% for the installation of the corresponding charging infrastructure. Thus, identifying the right financing sources would be key for Nutresa's electrification plan.

National Postal Services Buenos Aires

City/Country: Buenos Aires, Argentina
Implementing partner: Correo Oficial de la República Argentina SA (CORASA)
Manufacturer: L Vouture Sero Electric
Origin: Argentina
Category: L6

Figure 10. Pilot Correo Argentino

About the pilot

Two electric mini vans replaced CNG vans in the logistics operations of the National Postal Services of Argentina (CORASA) for the delivery of small and medium parcels around different hubs and distribution centers in the outskirts of Buenos Aires. The results of the pilot showed that the vehicles tested were not optimal for the initially selected routes, which turned out ot be too long for the autonomy of the vehicles. However, when moved to closer routes and switched from distribution to collection mode, their performance improved significantly. Moreover, the perception of users and the public was very positive, with only few minor inconviniences reported.

Main Results

2 e-mini vans tested

2 months in use

6.52 hours operating time

2 female drivers

13.15 km/hr Vehicle speed

5.3K km total distance travelled 85.63 km per day

13.2 deliveries/hr 78.7 per day

8.6 ton total cargo transported 142.7 kg per day

1.53 tCO2 emissions avoided

0.12 kWh/km energy consumption

Comparison with baseline

Deliveries	Distance	Costs
80% ⬆	122% ⬆	13,3% ⬆
Baseline: 7.3 deliveries/hour	*Baseline: 5.9 km/hr*	*Baseline: 22453.5 $USD/month fixed cost*

Scale-up potential

- Correo Argentino considers future replications of this pilot nationwide, focusing on central urban areas in large Argentinian cities such Buenos Aires, Gran Córdoba, Gran Rosario, Gran Mendoza, among others, which are the places where according to the results the impact of the use of LEFVs could be maximized.

- Expected benefits include a significant reduction in CO_2 emissions in the last mile and a decrease in the financial expenditures by replacing traditional vans.

Electric pick-ups for Agro-ecological gardens in Escobar

City/Country: Escobar, Province of Buenos Aires, Argentina
Implementing partner: Asociacion Sustentar
Supporting partners: Municipio Escobar
Manufacturer: Coradir SRL
Origin: Argentina
Category: L7

Figure 11. Pilot Asociación Sustentar

About the pilot

Two mini electric pick-ups (L7) were used for transporting the products harvested in the context of the Agro-ecological Gardens Municipal Program of Escobar to local community centers. The goal was to increase the delivery frequency of nutritious food to the community, while reducing the emissions in the supply chain. The vehicles tested, 2 "Tita" model, with a loading capacity of 500 kg and an autonomy of 100 km, replaced an ICE van. In total 534 trips were made, reaching 3.517 km travelled. Overall, the users highlighted their satisfaction with the vehicle's autonomy, power, together with the air quality improvement and noise reduction.

Main Results

2 e-pick-ups tested

3 months in use

1.78 hours operating time

2 male drivers

9.52 km/hr Vehicle speed

3.5K km total travelled distance 57.11 km per day

5.21 deliveries/hr 8.88 per day

5.3 ton total cargo transported 125.83 kg per day

0.53 tCO2 emissions avoided

0.09 kWh/km energy consumption

Comparison with baseline

Deliveries
32.2%⬆
Baseline: 3.94 deliveries/hour

Distance
42.6%⬆
Baseline: 23.75 km/hr

Scale-up potential

- Potential of scaling up the pilot within the Municipality if they are able to access the necessary funding.
- Potential of replication in other municipal programs.

Last mile delivery of medicines with LEV in Azogues

City/Country: Azogues, Ecuador
Implementing partner: Kradak S.A.
Supporting partners: Farmasol EP, GIZ, Cities Forum, Universidad del Azuay
Manufacturer: Ecotriciclos
Origin: Colombia
Category: Rear load e-tricycle (pedal-assisted)

Figure 12. Pilot Farmasol

About the pilot

The objective of the pilot was to reduce CO2 emissions and other externalities from last mile logistics operations of the Farmasol EP company in the delivery of medicines and home supplies in the Historic Center of Cuenca replacing its diesel truck by two electric tricycles with a load capacity of 300kg. All this in line with the City's e-mobility plan –eCuenca- and the Low-emissions Historic Center (CHBE) Project funded by the German Development Bank (KfW). However, given the significant regulatory barriers in Cuenca regarding the circulation of tricycles on urban roads, the pilot took place in the neighboring city of Azogues.

Main Results

2 e-tricycles tested

1 month in use

1.5 hours operating time

2 female drivers

6 km/hr Vehicle speed

0.3K km total travelled distance 7.5 km per day

3 deliveries/hr 2 per day

16.4 ton total cargo transported 455 kg per day

0.02 tCO2 emissions avoided

3 kWh/km energy consumption

Comparison with baseline

Distance
84% ⬆
Baseline: 1.63 km/hr

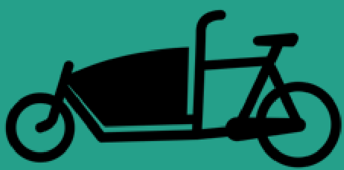
Costs
-63.2%⬇
Baseline: 6770 $USD/month total operating cost

Scale-up potential

Farmasol aims at becoming the first company in Cuenca to achieve zero emissions in its transport operation. The expansion of last mile logistics operations with e-tricycles and other types of LEVs to Cuenca's downtown is forseen, providing medicines from the main pharmacy to different clusters. For that, testing different types of EVs and logistics models and proposing regulatory changes for their operation is necessary.

Overall results for all pilots

Figure 13. Map of 10 cities, Source: [Dashboard Results SOLUTIONSplus Latin America]



25 LEVs tested
13 models

13 use cases

26,1K km total travelled distance

108.5 ton total cargo transported

29.06 tCO2
Total emissions avoided

7 female drivers and 18 male drivers

In collaboration with Logyca, SOLUTIONSplus developed a dashboard with 3 main objectives:

1. To present and compare the results and impact of all urban logistics pilots implemented in the region by SOLUTIONSplus (Figure 14)
2. To provide a decision support tool by which logistics service providers input the characteristics of their operations and obtain suggestions on the best way to start the transition to (L)EFVs (Figure 15)
3. To showcase an example of real-time data collection in logistics operations (Figure 16).

The dashboard is available in the following link: https://logyca.shinyapps.io/SolPlus_LATAM/

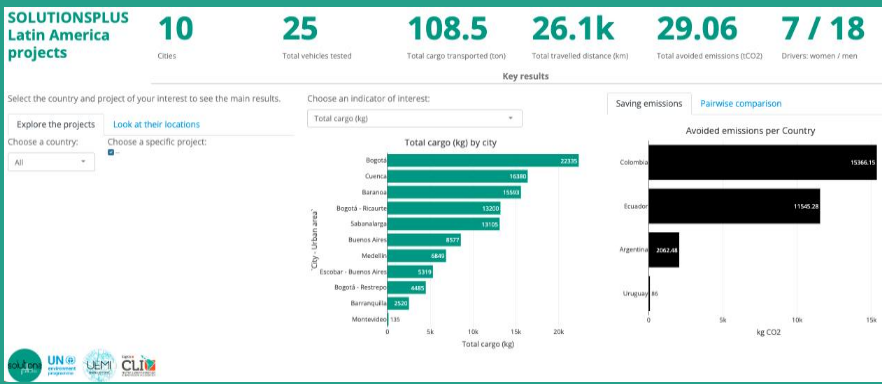


Figure 14. Project Dashboard. Source: Dashboard Results SOLUTIONSplus Latin America

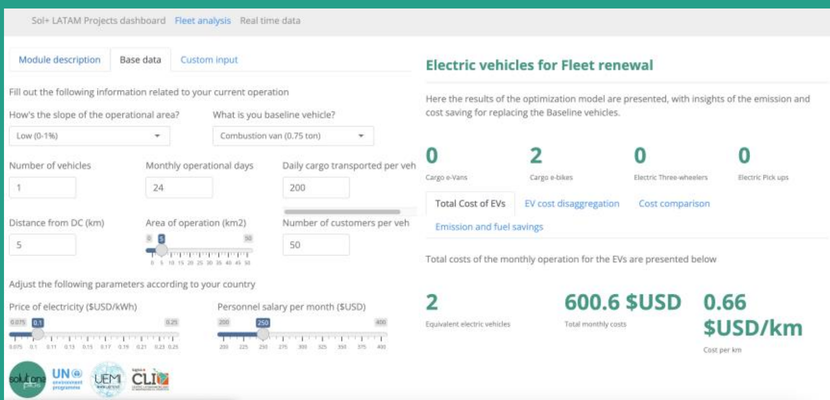


Figure 15. Fleet Analysis. Source: Dashboard Results SOLUTIONSplus Latin America

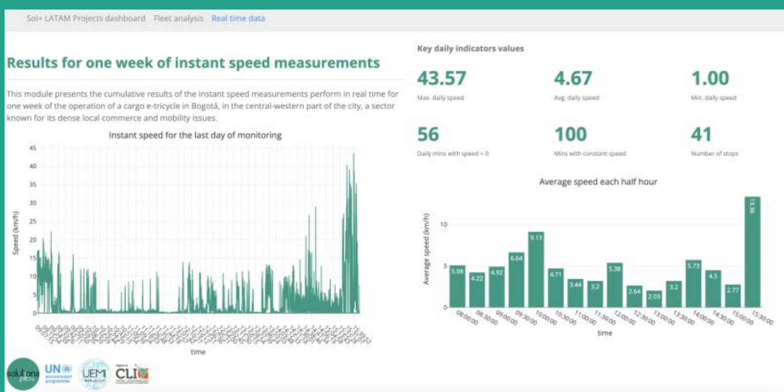


Figure 16. Real time data. Source: Dashboard Results SOLUTIONSplus Latin America

2. Implementation of a Light Electric Vehicles system (LEVs) for urban logistics

This policy advice paper approaches the implementation of a Light Electric Vehicles system for urban logistics in a specific urban area through five main steps:

- Step 0 – Needs identification: Elaborate a market analysis in the selected area
- Step 1 – Orgware perspective: Implement organizational improvements necessary to build a cooperative network between all actors
- Step 2 – Software perspective: Build a model for determining the optimal location of the hubs / transshipment points and the routes
- Step 3 – Hardware perspective: Enable the adequate design of LEFVs, micro-hubs and road infrastructure
- Step 4 – Policy framework: Adjust the policy framework to enable the successful implementation of the LEFV distribution system

Practical research in recent years has shown that city logistics with light cargo vehicles requires (Ha et al., 2023; Lauenstein & Schank, 2022; Narayanan & Antoniou, 2022; Ranieri et al., 2018):

- Good location for hubs in the distribution network;
- Robust processes;
- Cooperation between customers, logistics service providers and suppliers;
- Good insight into the costs involved;
- Modern ICT (Information & Communication Technologies);
- Good organisation.

Therefore, a comprehensive approach should include a balanced strategy aiming to tackle the orgware, software, and hardware perspective of the innovative value proposition for the cargo distribution in the designed area (Figure 17). Policy framework as the fourth pillar should provide a solid base for an innovative value proposition.

The **orgware** stage aims at designing or redesigning an urban freight system to develop cooperative business and governance models, which would serve as a base for the establishment of a cooperative last mile e-cargo distribution network. At this stage, a range of alternative business models and governance considerations to meet the diverse requirements of the potential LEFV system network need to be tackled. The network should be orchestrated by a neutral entity – this actor should coordinate/contribute to building synergies and solving misalignments between the actors in the network.

The software stage targets proposing an optimization scheme for determining suitable micro hub locations and optimal routes conducted by LEFVs for an average day, resulting in a cost-effective web-based solution for optimizing LEFV routing. The approach should result in a significant reduction of mileage covered by the trucks per day and therefore significant CO_2 reductions. **Software perspective** is related to the optimal design of the LEFVs system. The first step would be to solve the location-allocation problem based on a set of potential locations so that the distances between each demand point and its closest hub are minimized. The second step would be to solve the routing problem – determine optimal e–cargo routes and delivery time considering some or all relevant variables (travel speed, mass of load, slope of streets, etc.).

The **hardware** stage includes the design of LEFVs, the sizing of micro hubs and providing the adequate road infrastructure for their safe and efficient circulation. These are related to software stage in terms of the demand – its intensity and structure, spatial distribution, time windows as well as the location of micro hubs. The network configuration needs to be also analyzed and the best LEFV mix fleet be identified. Specific needs should be identified for the selected area (these and other that can arise from the market analysis – survey conducted) for the adequate design of cargo vehicles.

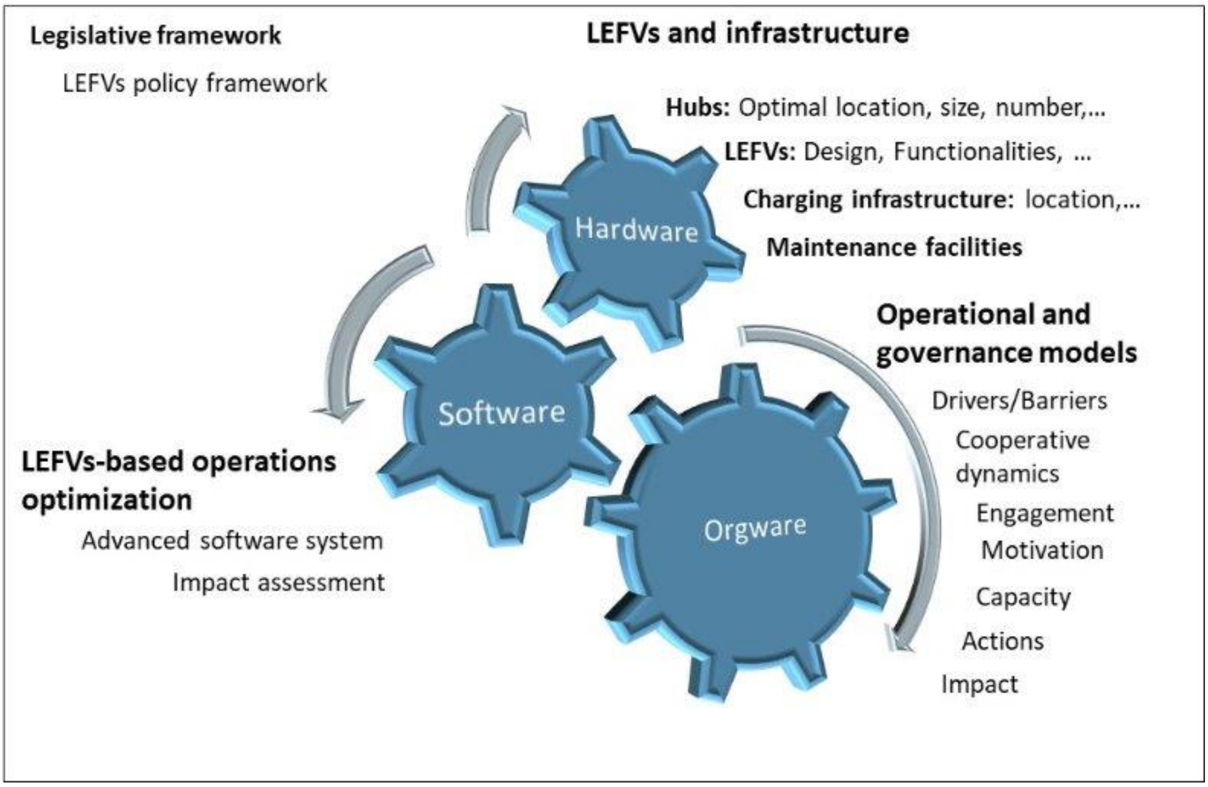


Figure 17. Framework for development of last mile distribution system.

The logistics model needs to consider and integrate the legislative perspective, this is the assessment of the existing policy framework (a review of current policy support for implementing the LEFV system) related to conventional vehicles and the need for specific policies and regulation for LEFVs.

All these perspectives must co-evolve together to enable successful implementation and full effects of the innovative value proposition for the LEFV distribution system.

Step 0: Need identification

2.1. Step 0: Needs identification

Performing a market analysis of the urban freight transport in the selected area helps to gain valuable insights regarding the size of the market, market profile, and trends which will help to assess the potential for the optimal LEFV system to be implemented.

It is essential to consider the following market aspects:

- *Market size*: includes an evaluation of the overall intensity of flows originating and terminating within the selected area (first mile/last mile flows), as well as point-to-point flows (begin and end at businesses/customers), number of actors on the market and customer density.
- *Market profiling*: includes a detailed analysis of the main stakeholders, their impact, dominating segments, leading customers, and the role of the public sector.
- *Market trend analysis* includes analysis of what trends are the most dominant on the market – both on the supply side and the demand side (new modes, new regulations, consolidation, expansion).

2.1.1. Market size

To assess the potential for LEFVs a better understanding of the following issues is needed:

1. Who is driving freight vehicles in the selected area? (e.g.: logistics service providers, large suppliers, own transport, service delivery, etc.)
2. Which type of goods are being transported by market sector (i.e.: retail, couriers and postal services, HoReCa, construction, waste, etc.) ?
3. What are the main issues and the main impacting factors of the current last mile/first mile/point-to-point distribution system in the designed area?
4. What is the supply chain type mostly involved in goods delivery and how does it impact the performance of the urban freight transport system?
5. Delivery patterns – delivery scheduling (planned or unplanned), deliveries by time of the day, deliveries by day of the week, deliveries by season of the year
6. Spatial structure of freight transport demand

2.1.2. Market profile

This part of the market analysis includes a detailed profiling of the actors, directly and indirectly, involved in the designed urban freight area market, and the assessment of their interactions.

For this purpose, the following questions need to be analyzed:

1. Who are the main actors on the supply side?
2. The share of actors on the market? Consolidation / atomization
3. Value network map – interrelations between the actors on the market?
4. Main interests, motives and barriers from the aspect of introducing the LEFV system?
5. What are the main issues in the designed area from the perspective of policy makers and logistics stakeholders?

2.1.3. Market trends

The structure of, and trends, for each of the major market sectors analyzed in the first step will largely determine the nature of the challenges posed by the LEFV system in the future. For example, an increase in e-commerce parcel deliveries will increase the potential for LEFVs system development.

Therefore, the following aspects need to be considered:

1. Current structure and dynamics of each of the major market segments in the selected area
2. Demographic trends
3. Trends on the supply side
4. Existing measures and initiatives for sustainability in the selected area

Special attention should be given to existing measures oriented towards sustainable urban distribution in the area, ongoing and planned, such regulatory measures, market-based measures, land use planning measures, infrastructure measures, new technologies: vehicle technologies, management and other measures.

2.1.4. Target groups identification

Based on the findings from the market analysis, the target groups can be identified. The target groups correspond to all the stakeholders affected in any way by the LEFV system. Some examples of the target groups are listed below, however according to the specific nature of the LEFV system, application and area, other stakeholders can be identified.

- Retail businesses in the area (stores, restaurants…)
- Suppliers (big- and small-sized)
- Delivery (post office, couriers, logistics)

Step 1: Orgware

2.2. Step 1: Orgware

The aim of this stage in the design or redesign of an urban freight system is to **develop a cooperative business model which would serve as a base for establishment of a cooperative last mile** LEFV **distribution network**. The proposed business model, for the sake of successful launching, operation and longevity, must address the different interests, motives, and barriers of the main stakeholders involved. A successfully established cooperative network will make the process of urban freight system redesign easier, more efficient, and effective.

Efficient governance is crucial for involved stakeholders to gain a competitive advantage and create value from the proposed business model. The governance structure should explain the network organisation structure in the sense of which actors are involved, how the chain is managed, how roles and responsibilities are distributed, and how decision making and change processes are organized.

In order to design a sustainable LEFV system, a number of decisions have to be made. Figure 18 presents a decision-making process for the introduction of the LEFV system.

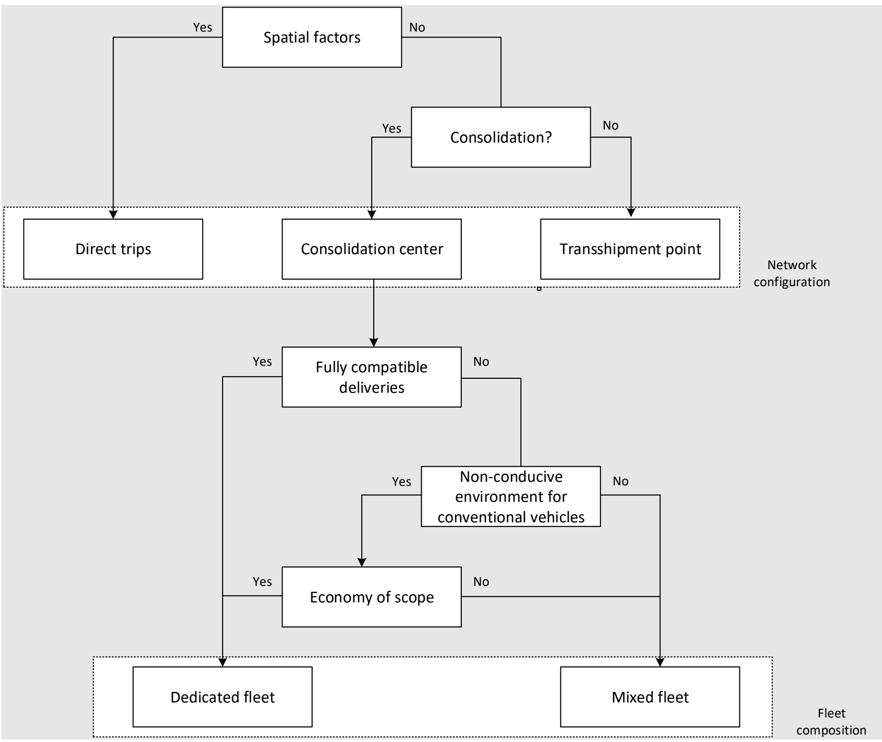


Figure 18. Decision making process for the introduction of a LEFV system.

2.2.1. Setting up a collaborative framework for the LEFV system

The advanced business and governance models required are based on a synergy between organizational (orgware) innovations (new cooperative organizational design of LEFV based freight distribution network) and software (information sharing platform for enhanced visibility) innovations.

The framework for setting up and maintaining the proposed LEFV collaboration system includes a multi-step approach that contains the following phases:

- Legal framework design;
- Strategic positioning of all actors within the network;
- Design of cooperative network;
- Information sharing platform;
- Implementation of the cooperative network;
- Establishing a feedback mechanism for permanent monitoring of performances.

The time horizon for implementation of the LEFV system depends on the type of the model. The General Business Model (GBM), which will be explained in detail below, has the highest complexity and requires maximum time for implementation of every phase. **Error! Reference source not found.** contains a brief description of each of the activities, responsible parties and their roles.

Table 1. Sequence of activities and responsible parties.

Activity	Brief description	Responsible organisation	Other organisations involved	Activities of responsible organisation
Legal framework design	To enable appropriate framework conditions to support more intensive collaborations between all actors in first/last mile LEFV distribution network	Municipality, Ministry of Transport	National transport authorities	Design and promoting innovative measures for facilitating LEFVs. Creating incentives schemes and support initiatives for developing first/last mile using LEFVs.
Strategic positioning of all stakeholders within the system	Initiating, building and maintaining the LEFV oriented business vision and mission.	Neutral Network Orchestrator	All involved stakeholders in the network	Building and maintaining internal behavioural elements that facilitate relational exchange - addressing the cooperation related barriers. Alignment the business models of all actors involved in the network.
Information sharing platform design	Design of cooperative information sharing platform.	Neutral Network Orchestrator	All organisations involved (the extent of their involvement depends if the platform belongs to the Neutral Orchestrator or if it is a relationship specific asset)	Assessment of the needs for information sharing platform. Integrating individual platforms - creating one federative platform.
Cooperative network design	Assessment of potential for developing a cooperative network, possible partners, business case alignment, gain sharing mechanism and defining a clear vision and strategy of cooperation.	Neutral Network Orchestrator		Cooperative engagement - Involvement of the right partners. Assessment of business case and developing a financial mechanism Developing a clear strategy and vision of cooperation Design of the shape of cooperation considering the drivers and objectives identified.
Cooperative network implementation	Designing and adequate contractual framework and developing information sharing platform.	Neutral Network Orchestrator	Actors involved in the cooperative relationship	Contractual framework design.
Monitoring mechanism establishment	Feedback mechanism based on permanent monitoring of defined of KPIs	Neutral Network Orchestrator	Actors involved in the cooperative relationship	Determining the set of appropriate KPIs. Establishing a KPIs monitoring mechanism.

The main prerequisites for the success of proposed business and governance models are:

- Ensured willingness of all stakeholders for risk, cost and profit sharing

- Ensured willingness of all stakeholders for information sharing

In order to efficiently address these requirements, it is needed to overcome the following barriers:

The “soft barriers” to cooperation between stakeholders in new LEFVs based distribution: culture, trust; and ‘hard barriers’: cost-benefit, critical mass, investments, and market engagement. Defined terms can be described as follows:

- *Culture*: Includes a mental shift of individual stakeholders in the proposed business network and orientation towards more sustainable modes of transportation, LEFV in this case.
- *Trust*: Roles, stakes and drivers for different types of stakeholders need to be clear. Arrangement of an independent and neutral coordinating function (set-up by all partners) could help to realise the cooperation structure. This role could also be performed by a trusted (third) party.
- *Cost-benefit*: Building a successful and long lasting first/last mile LEFVs based service requires a collective effort of all involved stakeholders, which results in a collective improvement and therewith not a competitive advantage for one of the stakeholders. The business plan of the collaboration should provide insight in the balance between costs (investments and operational costs) and the benefits that will result from the necessary investments (information, transport and freight handling infrastructure). A profit-sharing mechanism also represents one of the most important features of a cooperative relationship.
- *Critical mass*: To get sufficient stakeholders and mass to realise the impact in the market a step-by-step approach can be employed. Start with a select group of the right partners and build further upon this. For this, the collaboration contracts should be flexible and contain mechanisms for allowing the addition of new partners.
- *Investments*: A clear common understanding of investments to be made is required and should fit in the cost-benefit considerations and balancing of the value case.
- *Market engagement*: Like adding new partners, a step-by-step approach, can be taken for attracting new customers and improving the customer interface.

Specific additional barriers exist for information sharing, e.g. related to data ownership, (economic) sensitivity of data, data quality, technical format (standards and interoperability) and cost-benefit considerations of sharing data.

2.2.1 Network configuration and fleet composition

Two crucial aspects for building the LEFV system are **network configuration and fleet composition**. The network can be based on direct trips in case there is a smaller catchment area and higher demand density. In case there are unfavorable spatial factors, or as in the case of a city center, where there is a mixed process of supplying (big and small suppliers) direct trips must be combined with a node for transshipment and/or consolidation.

The fleet composition must be made in such a way to reflect both, the interests of shippers and the community. The fleet can be dedicated or a mixed fleet. A dedicated fleet is composed only of e-cargo bikes. A mixed fleet includes LEFVs, e-cargo bikes and electric vans. The decision about the fleet composition depends on whether the market analysis results are pertaining to a mixed fleet or only e-cargo cycles. Optimal LEFV fleet size exclusively depends on the efficiency of LEFV system in terms of transshipment (synchronization and the time lost for consolidation) and routing (the length of a cycle – from depot, to depot, the waiting time for pickup and delivery process).

Figure 19 illustrates alternative multimodal schemes for LEFV distribution in a city central area. The nodes outside the city represent distribution centers, warehouses or manufacturing facilities. The type of consolidation node and its location represent important factors for the overall sustainability of the solution. Moreover, C**onsolidation contributes to reducing shipment delays, when there is a substantial demand since it is possible to pick-up multiple consolidated shipments**. However, not all distribution nodes need to allow for consolidation, some can be exclusively used for transshipment. The types of nodes are listed below:

An **Urban Consolidation Center (UCC)** is a node where the freight is transshipped from several forwarders to the same vehicle for the last leg of the journey. UCC is not suitable for cycle logistics due to the long distance to the delivery area.

A **Micro Consolidation Center (MCC)** is a transshipment point located close to the delivery area, operated by different cargo courier companies and where consolidation via various logistics operators is performed.

A **Transshipment Point (TP)**, a location such as a parking lot could be used for transferring the merchandise from larger vehicles to LEFV, not necessarily for the storage and consolidation of goods. In this case, a **temporal synchronization,** i.e., matching arrival times and determining the time windows between inflows (trucks, vans) and outflows (LEFVs) is required. Transshipment points can be individual or cooperative, depending on the number of users. In the case of an individual transshipment point only one logistics provider uses this location. Individual transshipment points can be **stationary, semi-stationary and mobile**.

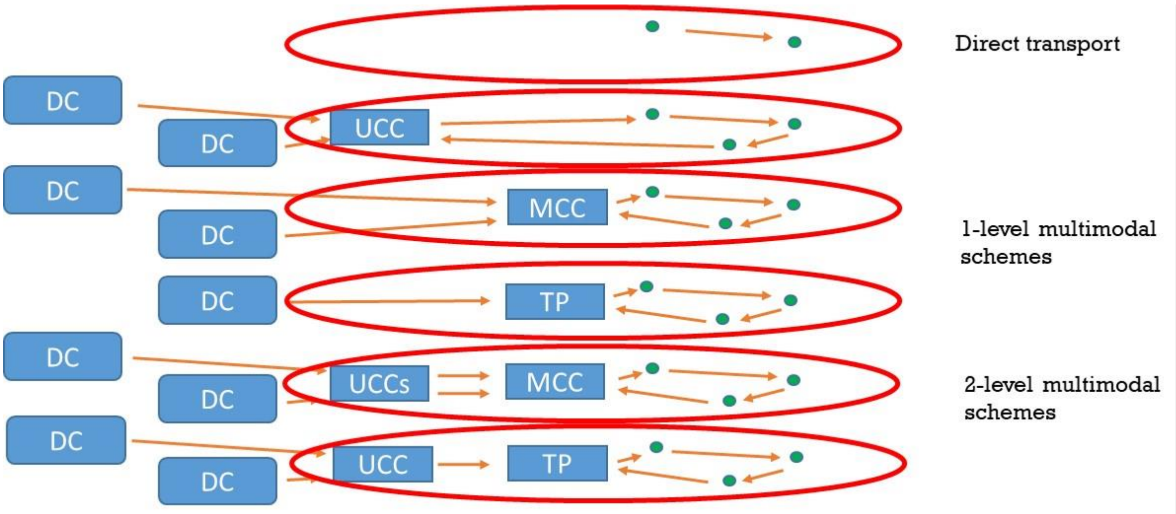


Figure 19. Classification of multimodal schemes integrating LEFVs according to level and consolidation principle.

Multimodal scheme 1: Direct transport system

The first scheme in Figure 19 represents a direct transport system, the second and third represent single-level whereas the 4th type of multimodal system is a multilevel system.

In the case of the direct transport scheme, the freight is not transferred between vehicles on the way between its origin and its final destination. In this case, LEFVs services are used for point-to-point services and for delivery runs. Point-to-point service may involve other intermediate stopping points for picking up/delivering the shipments. In this case, there are neither transshipments nor consolidation processes. A typical example of direct transport consists of transporting for own account or picking up and delivering by local businesses.

Multimodal scheme 2: Single level

A single-level multimodal system is characterized by one transshipment process between origin and destination. The freight is sent by a truck from the origin, i.e, the DC, warehouse or a manufacturing facility, to a transshipment node in proximity to the delivery area, where the goods are then transferred to LEFVs. This transfer node can be a UCC, micro-consolidation center (MCC) or a transshipment node.

In the case of DC-UCC, the primary focus is on the consolidation of freight designated to the city (center) on specific vehicles for the last mile. These points are mostly located at the city's edge. The last mile can be conducted by cargo bikes as well as by other electric vehicles (vans, trucks). Freight of all sizes is transferred and consolidated and therefore, the facility needs to have space and equipment for those, like pallet trucks or forklifts.

MCC represents a very small UCC for transferring and consolidating parcels. Its size can equal a container or smaller, it can be either mobile or stationary. Due to its size, it can be in closer proximity to the delivery area and is connected to a distribution center or warehouse.

Transshipment points (TPs) do not fulfil and allow the consolidation of goods. In comparison with UCC or MCC this facility is used by just one shipper or carrier. This network consists of the DC from where freight is shipped to a TP at which the load changes to LEFVs.

Multimodal scheme 3: Two levels

Two level multimodal systems are characterized by two transfers of freight between the outside and the urban delivery area. UCC is located at the city edge, it consolidates freight from the DCs outside the city. Within the city, several MCC or TP may exist to enable transferring of shipments on LEFVs for the last mile. Those are in very close proximity to the city center.

The intermediate transshipment/consolidation nodes **must be maintained by a neutral party**, who does not compete with the delivery operators, to avoid undue advantage and conflicts.

2.2.2. Business models

This Policy Paper includes a description of the main business models, business actors and their roles, as well as a description of the potential benefits with a description of the sources of revenues.

The proposed business models are based on Osterwalder's theoretical framework or business model canvas. Osterwalder & Pigneur (2010)present a business model canvas that exposes the rational of how an organization creates, delivers, and captures value. They define nine building blocks for the model which are the following ones:

- Customer Segment – specifies for whom are the company creating value since an organization serves one or several customer segments
- Value Propositions – it seeks to solve customer problems and satisfy customer needs with value propositions

- Channels – Value propositions are delivered to customers through communication, distribution, and sales channels
- Customer Relationships – are established and maintained with each customer segment
- Revenue Streams – result from value propositions successfully offered to customers
- Key Resources – the assets required to offer and deliver the previously described elements
- Key Activities – activities, distribution channels, customer relationships and revenue streams that the value proposition requires
- Key Partnerships – some activities are outsourced and some resources are acquired outside the enterprise
- Cost Structure – the business model elements result in the cost structure

In this section, three alternative business models for LEFV introduction are proposed. The most important characteristics of the proposed business models are as follows:

1. *General business model* (GBM): a comprehensive cooperative business network composed of all the actors (supply and demand) which are directly and directly involved in the last mile distribution system of teh designed area. This model corresponds to a broad implementation (micro to macro scale transition) of the solution. This model is the most complex since it includes all types of services related to last mile, first mile as well as point-to-point services
2. *Supplier business model* (SBM): a cooperative business network concentrated around the big suppliers and limited to Pilot implementation (in terms of scale and scope)
3. *Courrier business model* (CBM): a cooperative business network concentrated around the courier companies and limited to Pilot implementation (in terms of scale and scope)

2.2.3. General business model (GBM)

GBM Canvass

GBM represents a comprehensive cooperative LEFV business network that covers all the main actors on the supply and demand side of freight distribution in a city and corresponds to a scaled up solution for the designed area.

<table>
<tr><th rowspan="4">Key Partners
Municipality (administration)
Network coordinator
LEFV service providers
Freight transport operators (such as DHL, FedEx)
Suppliers
LEFV repair service</th><th>Key Activities</th><th rowspan="4">Value Proposition
Delivery on time offering reliable performance
More efficient service for last mile delivery
Less congestion, emissions
Better environment for pedestrians
Air quality
Job creation</th><th>Customer Relationships</th><th rowspan="4">Customer Segments
B2B and B2C
Express deliveries
Parcel delivery for mail orders and e-commerce businesses
Parcels delivery for local shops
Fresh product delivery</th></tr>
<tr><td>Pick-up and delivery service</td><td>Cooperative and client-centric</td></tr>
<tr><td>Key Resources</td><td>Channels</td></tr>
<tr><td>Urban Consolidation center (UCC)
Employees & LEFVs
Routing and assignment software
Cooperative platform</td><td>Internet/telephone
Subcontractor to express delivery companies</td></tr>
</table>

Cost Structure Employees' wages, running and maintenance costs of LEFVs, rent of facilities	**Revenue Streams** Customers pay for the service (senders), depending on volume, frequency, destinations; advertisement

Figure 20. Conceptual framework of GBM based cooperative network.

A cooperative business network of GBM looks as in Figure 21.

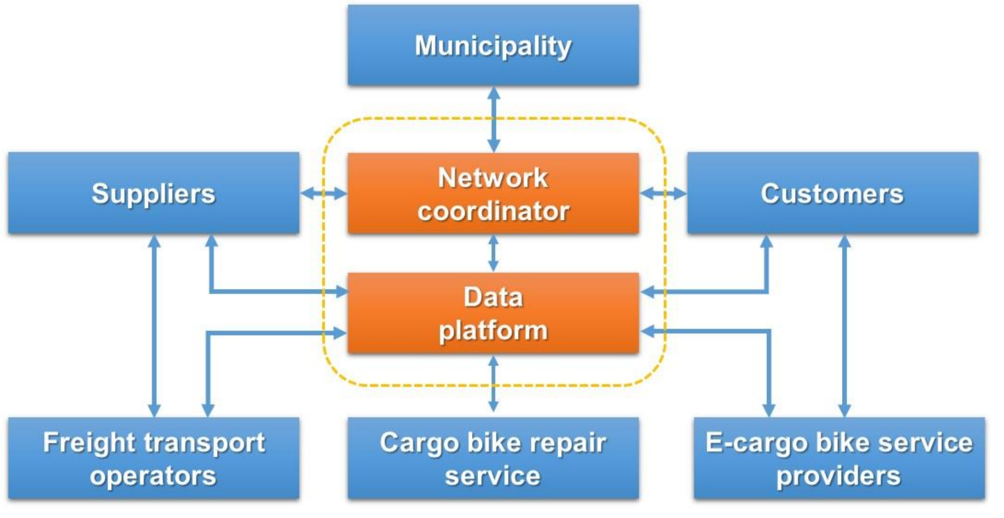


Figure 21. GBM based cooperative network for LEFV system.

The building of the LEFV system is based on a high level of coordination between the main actors in the network.

The ***network coordinator***, as an organisation composed of the representatives of all stakeholders in the network, on an operational level, manages the flows (synchronization between long haul and first/last mile), resolves all disturbances in the network (such as delays, traffic deviations which can influence on performances of the system), on a tactical level, plans the operations on midterm level (monthly) – in terms of the fleet, hub capacity, LEFV maintenance, on strategic level considers the fleet and hub capacity requirements in the future period. The network coordinator also manages the cooperative network and resolves all issues between the actors which may lead to opportunistic behaviour of some of the stakeholders in the network.

The ***municipality*** acts as a support in terms of all measures that can improve the efficiency of the system and contribute to its expansion.

The last mile/first mile flows of ***freight transport service providers*** will also be subject to operation and therefore, the network coordinator must handle these tasks in an efficient manner. Depending on the efficiency of coordination (in terms of reliability, flexibility and time) the success and the perspective (in terms of future volumes) of this subcontracting activity will result.

Customers of the transport service. The network coordinator maintains a close relationship with the customers and manages their requests in a timely and reliable manner.

The ***LEFV service providers*** are the logistics companies or individuals subcontracted on a commission basis. They are in a close relationship with the network coordinator via information sharing platform as well as with the customers in order to ensure timely and efficient service.

The ***LEFV repair service maintains*** all types of regular and irregular maintenance of LEFVs in order to minimize the time lost due to malfunctioning LEFVs. One technician should be available at MCC at any moment during the day.

The proposed business structure enables synchronization of last mile/first mile transport requests and transport from DCs in the designed area. The developed business network must generate positive effects through sustainability, lower cost, and improved first mile/last mile service (especially reliability, flexibility, and visibility).

The most important aspect of cooperation among all the actors in the proposed network is trust. Actors have to be open to sharing their data, at least with an orchestrator as a third party. A certain level of commitment, loyalty, and reliability is desirable with enough freedom for partners to leave cooperation. For GBM implementation the communication between all stakeholders which constitutes a cooperative value network needs to be timely, detailed, and reliable. Information technology will enable fast and accurate transfer and will process the data between all stakeholders in the transport chain. Therefore, appropriate ICT infrastructure represents a cornerstone for success.

GBM Governance

Cooperative business network based on GBM, technologically empowered by an information sharing platform, should enable the provision of a smooth, visible, reliable and flexible, and sustainable LEFVs service in the designed area.

This network shows a high level of interdependence between actors because the resources necessary to perform the service are managed by different stakeholders. Managing relationships between key partners in GBM represents a complex task for the Orchestrator, having in mind the number of partners and differences in their individual business models.

Stakeholders in this network have their own perceptions of potential problems, solutions, and strategies which imply substantial differences in interests and goals and even value conflicts and disagreements about policies to be implemented or actions to be taken. Therefore, this goal directed network must be governed in order to be effective. Efficient governance is crucial for involved stakeholders to gain a competitive advantage and create value from this business model.

The governance structure should explain the network organisation structure in the sense of which actors are involved, how the process is managed, how roles and responsibilities are distributed, and how decision making and change processes are organized.

The network coordinator is responsible for the governance of the proposed LEFV business network and manages the value chain. It has a nodal position in the network and in the value creation process.

The preferable governance structure will depend on the costs of production, transaction costs, and strategic costs and benefits associated with a particular governance structure. The proposed structure contributes to decreased production costs since it supports the economy of scale and scope.

The network coordinator as a knowledgeable intermediary has contacts with various suppliers and freight transport operators and long-term contracts with LEFV service providers and therefore it will be capable to make necessary arrangements in overtaking the responsibility of efficiently forwarding the shipments through the proposed multimodal solution. It contributes to:

- Reduction of transaction costs via scale and scope economy
- Avoidance of moral hazard and opportunism

In the beginning stage, it is most important to subcontract services of freight transport operators and involve at least one important supplier in order to establish a fully functional network.

Building an integrated network that satisfies the relevant criteria of suppliers/FTOs, as well as the customers, should attract more actors from both the demand and supply sides to participate in this strategic relationship.

All parties involved in this strategic alliance recognise each other as partners and coordinate activities and planning with a long-term focus that may progress beyond the coordination of activities to the integration of activities.

GBM contractual framework

Two types of governance mechanisms exist in inter-organisational governance: contractual and relational governance mechanisms.

Contractual governance means governing a transaction through formal contracts. Formal contracts between parties are the base for forming the transactions while talking about contractual governance. Contracts are a way to provide guarantees to companies in freight distribution and allow conformities on actions performed. Many times, a way to achieve business goals is through the provision of incentives.

Relational governance is to govern transactions through relational norms such as trust, cooperation, and solidarity. The main reason for developing relational governance is that it is not possible to forecast every future eventuality and put them into a formal contract. Under relational governance, the parties govern their joint efforts by relying on bilaterally developed norms. This form of governance induces a desire for contributions from supply chain partners and encourages value creation through specific investments and implicit social norms. However, the development and maintenance of relational governance may be time and resource consuming. Therefore, **reliance on a single governance mechanism is not sufficient**.

Contract design should be based on criteria that provide an environment of trust. Figure 22 presents a contractual framework for governing the transactions in the proposed relationship.

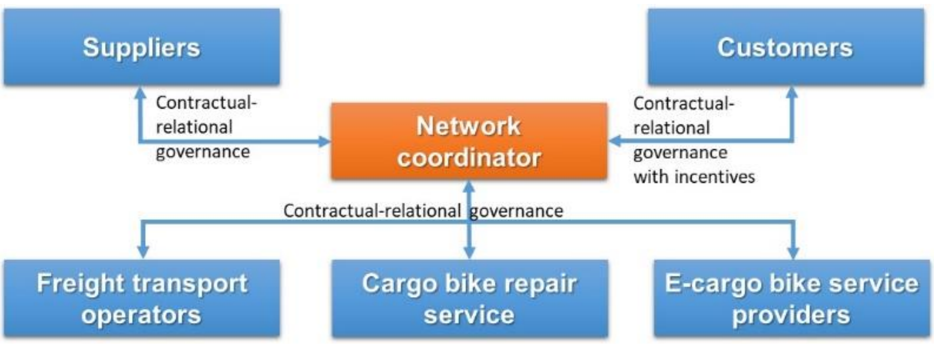


Figure 22. Contractual governance of proposed LEFV business network.

Network coordinator, a number of customers, suppliers, freight transport operators, one or more LEFV service providers, and LEFV repair service form an independent entity enabling smooth and reliable direct as well as multimodal service.

The most important feature of this strategic alliance is trust between all actors. Trust will contribute to overcoming initial suspiciousness about potential partner opportunism which may prevent effective implementation of this cooperation.

Imbalances in organisational power, indicated by disparities in the resources contributed and controlled by the partners can impede trust creation due to the partner's unequal capacities to fulfil their obligations.

On the one hand, contracts can be classical forcing the stakeholders involved to strictly adhere to the written contractual terms and conditions. Classical contracts typically govern transactions that are limited in scope, anonymous, and measurable. In relational contracts, on the other hand, written terms are not the only reference as harmonising and preserving the relationships are more important.

The potential contractual model is based on long-term relational contracting with strategic partners in LEFVs freight distribution. By including the relational exchange aspects in the urban LEFV system, it is sought the soft, normative, and informal side of the relationships between stakeholders.

We suggest a complementary governance mechanism characterized by a dynamic interplay between contractual and relational governance. More specifically, between all parties and the Network Coordinator a well specified contract should exist which encourages cooperation and trust. In case of the absence of previous experience (where trust and relational norms are not well developed) contracts should be more formal in order to complement relational governance by providing confidence for each of the partners through safeguarding transaction specific investments and controlling opportunism.

After some time (or in the case of previous experience between partners) the trust and relational norms will create more opportunities for cooperative parties to learn knowledge and contracting skills. Here, **a dynamic process of interplay between two governance mechanisms arises**. The proposed governance mechanism could be adapted to support long-term trusting relationships and to address necessary variations in the internal and external transport chain environment.

In the beginning phase, this model should be a "small scale" with a critical number of actors who may already have some relationships between them. In that case, the Network Coordinator should take into account existing relationships during designing an optimal contracting scheme for the entire alliance.

Considering the motives and barriers of all actors it can be concluded that there is an interest of all involved actors to participate in this strategic relationship so the relational long-term contracts based on trust between actors are appropriate options between the network coordinator and each of the partners.

Relation with customers and FTOs represents a crucial component of this network. In order to be really functional, this cooperative alliance must have stable and intensive flows of shipments. In that sense strategic long-term contract with a number of customers and FTOs represents necessity. Other customers should be attracted by the quality of the established LEFV service as well as an aggressive marketing campaign by the network coordinator. For other actors out of this governance structure, spot market relations should be established.

The network coordinator should offer attractive incentive contracts in order to motivate customers to join the network.

GBM data framework

Close cooperation of actors in the proposed governance framework assumes an efficient information sharing framework which will contribute to an improved decision making process. Thus, through information sharing, a competitive advantage for urban freight distribution and a win-win situation for all actors involved can be fulfilled. The performances of the designed governance network largely depend on efficient and effective information sharing.

In this section, we show how and to what extent the data frame in the proposed governance model can be explained by the adopted governance structure. More specifically, answers will be provided on "**what" – which information to share and "how" – the mechanism facilitating the information sharing.**

Regarding the type of information shared, the information related to the planning of last mile distribution needs to be exchanged. Figure 23 presents the flow of information between the actors in the proposed LEFV network – inside the established entity and with external actors.

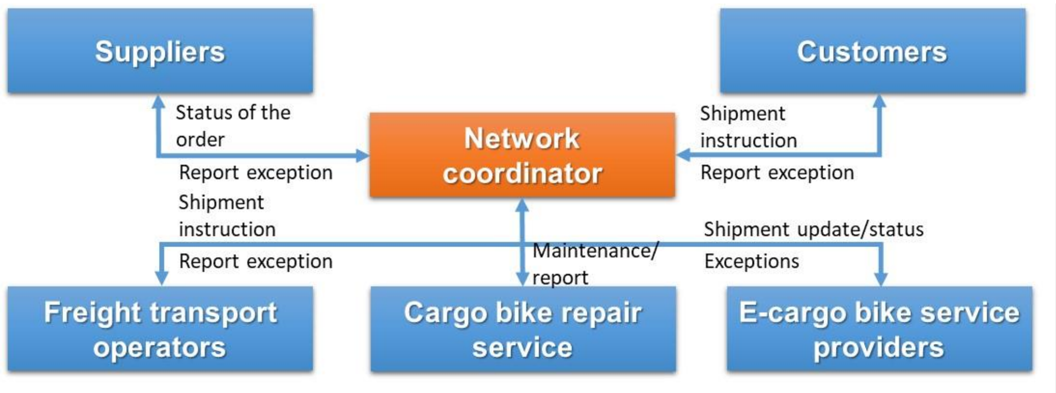


Figure 23. Information flow in proposed LEFV business network.

Customized information related to the service execution process is shared through the automated information sharing platform to partners throughout the developed LEFV based freight distribution network. Service planning information is steered by the Network Coordinator throughout the cooperative governance network. **Usage of an information sharing platform will make transactions more cost efficient.**

To complement continuous information exchange, complementary information between the actors can be exchanged also by other means of communication (EDI, telephone, email). These complementary means could be used in case of a defect of information sharing platform, or providing a suitable form of information, or for following up explanations related to a transaction.

Investments in information sharing infrastructure can be an important factor in implementing the information sharing system. Within the whole network (inside and outside the entity) there are actors which have little financial strength, limited power, and also little willingness to lead the design and implementation of information sharing platform. In this case, an appropriate form of non-financial and financial compensation is suggested. Non-financial and financial compensation might be on a bilateral contractual basis. For example, an LEFV service provider gets an extra fee from the Network Coordinator for implementing an information sharing platform.

The information sharing architecture implies seamless governance, collaboration, visibility and orchestration of the entire LEFVs based urban freight transport chain. Therefore, it is needed to minimize incompatibilities between different interfaces (protocols, formats, transmission frequencies). Better integration of information systems supports a higher level of exchange of information in a cooperative network.

The main responsibility of the Network Coordinator is to share an understanding of the specific benefits of information sharing between stakeholders. This is required in order to overcome a potential divergence of interests. The Network Coordinator needs to provide vision guidance and support in sharing information and create an organizational culture that motivates the exchange of information with other actors in the chain.

Regarding the unwillingness and motivation for information sharing, organizational theory points to internal culture as the main factor. Connectivity and willingness to share are correlated. Volumes of transactions and their frequency represent one of the main factors for the willingness of a company to invest and adopt information sharing platform.

Commitment represents one important prerequisite of a successful and long term relationship. It is highly correlated with trust. Trust among the partners increases the commitment to cooperation and therefore leads to a higher level of willingness for information sharing.

One of the ways for safeguarding the longevity of a relationship is the investment in relationship specific assets. The higher the degree of relationship specific assets the higher the degree to which the partner(-s) is locked into the relationship. Related to trust, when an organisation is willing to make relationship specific investments, it is most likely showing that the organization trusts its partner organization. In the context of the proposed governance structure, this might lead to a potential for a more integrated relationship between partners on a corridor/network (through joint investments in IT or LEFVs).

For the Network Coordinator, it is also important to monitor the partner's behaviour in order to try to minimize behavioural uncertainty which is negatively related to trust and information sharing. However, considering that all actors involved in the governance network share the same values and beliefs that will contribute to the development of trust among them.

All partners in the defined cooperative network must be able to share only information of high quality. If organisations are not willing to do so, transaction costs will increase and the level of trust between the partners will decrease.

An important prerequisite of a successful cooperative GBM is the **secure management of data**. Only the actors authorized to view the data can access it. Therefore, significant work must be done in sense of security, privacy, and trust in order to have an efficient and strategic cooperative network. Following confidentiality, integrity, and authentication areas need to be addressed:

- Access and authentication services
- Data integrity and recovery
- Data privacy and security

In order to identify any barriers or opportunities in sharing data across the boundaries of one organization there is a need to address:

- Data rights management services
- Data location reporting and management
- Liability and commercial sensitivity

There is a need to establish policies for sharing data and events across the boundaries of an organization. It is required to define data/event classifications – open/public, restricted to a specific relation or only accessible within an organization. In this case, it is needed to consider:

- Tools for the collection, distribution, management, and analysis of data;
- Information semantics and ontology systems
- Protocols for establishing data/event sharing
- Data quality and metadata services

A legal framework is needed to ease restrictions on data sharing among the partners.

Data sharing between partners in a cooperative relationship cannot be realized unless **adequate profit-sharing mechanisms** are agreed to by these actors. The overall of the proposed governance structure is to maximize long range individual profit (monetary or intangible) by achieving shared performance goals. Profit sharing mechanism represents one of the most important features of a cooperative relationship. The mechanism should be able to provide benefits to all partners so as to provide them with an incentive for cooperating. And also, it should be fair and reasonable enough to guarantee the longevity of the collaboration. During the development, the appropriate gain sharing mechanism bargaining power of partners in the selected cooperative should be considered.

Regarding the proposed GBM, it has already been emphasized that some potential partners would have high costs of participation. These costs may be allocated to the coordination costs which also have to be considered during the cooperative network forming and extension. Furthermore, for defining the sharing mechanisms coordination costs should also be considered so as to make potential cooperatives with high collaboration costs more motivated to participate, provided that the collaboration can bring substantial cost reduction. In this case, a benefit sharing mechanism based on the Shapley method will be developed. It represents a gain sharing concept from cooperative game theory which calculates a unique allocation of benefits to all the actors in a cooperative network according to their input and importance to the overall outcome.

2.2.4. Supplier business model (SBM)

One of the biggest suppliers must be selected. In the case, Coca Cola was selected to give a common example. The market analysis will identify how many businesses are provided with Coca Cola products (mainly restaurants and retail stores and the frequencies). In this section, a business model concentrated around an important supplier is proposed. This supplier aims to improve last mile distribution by utilizing LEFVs.

SBM Canvass

The conceptual framework of SBM is presented in Figure 24.

Key Partners	**Key Activities**	**Value Proposition**	**Customer Relationships**	**Customer Segments**
Municipality (administration)	Delivery service	Delivery on time offering reliable	Cooperative and client-centric	B2B Product delivery for

Supplier: Coca-Cola LEFVs service providers LEFVs repair service providers Restaurants/retail stores	**Key Resources** Transshipment hub Employees & LEFVs Routing and assignment software Cooperative platform	performance More efficient service for last mile delivery Less congestion, emissions Better environment for pedestrians Air quality Job creation	**Channels** Internet/telephone Subcontractor to express delivery companies	local shops

Cost Structure Employees' wages, running and maintenance costs of LEFVs, rent of facilities.	**Revenue Streams** Customers pay for the delivery service, LEFVs used for advertisement

Figure 24. Conceptual framework of cooperative supplier-based business network.

A cooperative business network of SBM looks as on Figure 25.

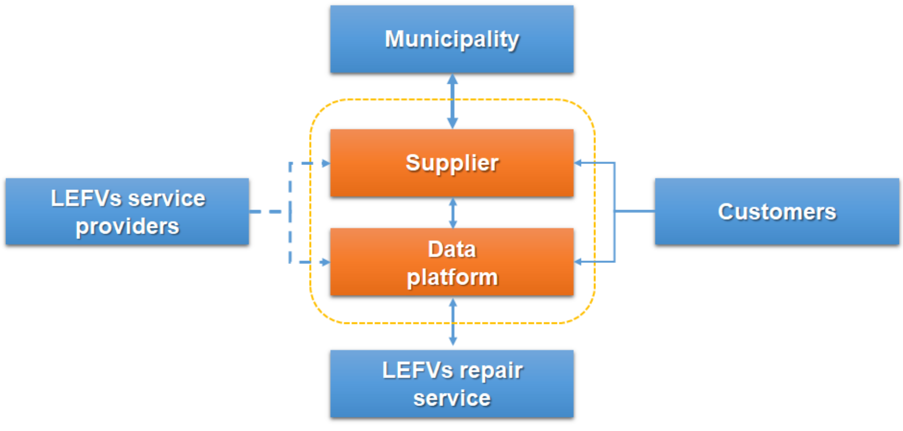


Figure 25. Cooperative business network based on SBM.

In this model, ***Supplier*** leads the network, manages the flows (last-mile distribution) and coordinates transshipment activities. The possibility for coordination by LEFVs service provider represents an alternative (in case if Supplier uses LEFVs as a service).

Municipality has a supporting role. ***Customers*** are mainly the representatives of the retail sectors. The Supplier maintains a close relationship with the customers and manages their requests in a timely and reliable manner.

The ***LEFVs service providers*** are the logistics companies or individuals subcontracted on a commission basis. They are in a close relationship with the Supplier via information sharing platform as well as with the customers in order to ensure timely and efficient service.

SBM governance model

SBM governance model is based on the main prerequisites related to contractual and relational governance in GBM.

Contract design should be based on criteria that provide an environment of trust. Figure 26 presents a contractual framework for governing the transactions in the proposed relationship.

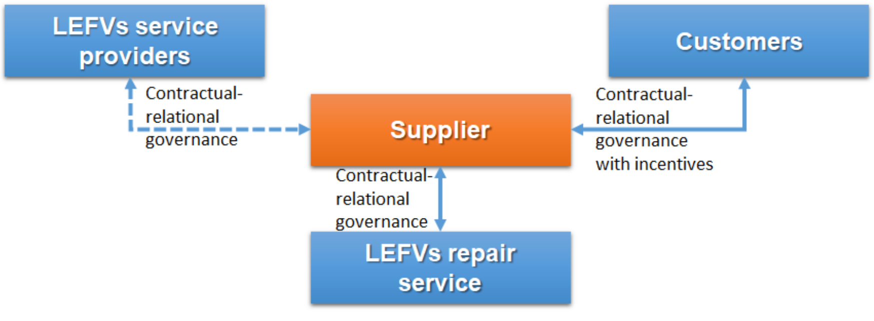


Figure 26. Contractual governance of proposed SBM business network.

Suppliers, a number of customers, one or more LEFVs service providers as well as a LEFVs repair service provider cooperate on a strategic base enabling smooth and reliable last mile LEFVs based distribution service. Again, the most important feature of SBM is trust between all actors. Trust will contribute to overcoming initial suspiciousness about potential partner opportunism which may prevent the effective implementation of this cooperation.

The potential contractual model is based on long-term relational contracting with strategic partners in LEFVs freight distribution. By including the relational exchange aspects in the urban LEFV system, it is sought the soft, normative, and informal side of the relationships between stakeholders.

A complementary governance mechanism based on formal contracts and relational norms should be applied in this case between the supplier, the customers and LEFVs service providers (if any) and LEFVs repair providers.

In the initial phase, contracts should be more formal in order to complement relational governance by providing confidence for each of the partners through safeguarding transaction specific investments and controlling opportunism.

After some time (or in the case of previous experience between partners) the trust and relational norms will create more opportunities for cooperative parties to learn knowledge and contracting skills.

In the beginning phase, this model should be a "small scale" with a critical number of actors who may already have some relationships between them. In that case, the Supplier should consider existing relationships during designing an optimal contracting scheme for the entire alliance.

SBM data framework

SBM already has established "core" of the network between the Supplier (Coca – Cola) and the customers (businesses and retail sector).

Information sharing platform may further improve coordination and synchronization of activities between the main actors in this core network including also LEFVs service providers (in case if Supplier uses LEFVs as a service).

Regarding the type of information shared, the information related to the planning of last mile distribution needs to be exchanged. Figure 27 presents the flow of information between the actors in the proposed LEFV network – inside the established entity and with external actors.

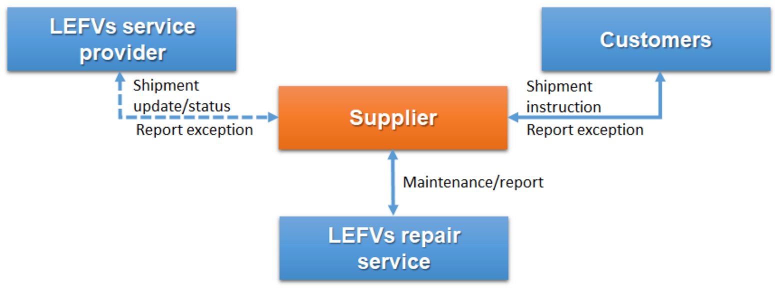


Figure 27. Information flow in proposed SBM business network.

Usage of an information sharing platform will make transactions more cost efficient.

In order to support implementation of cooperative platform, a form of non-financial and financial compensation can be an option.

All main prerequisites and conditions related to information sharing architecture mentioned in GMB hold in this case too.

2.2.5. Courier business model (CBM)

LEFVs are the future for courier and logistics companies. They offer a carbon neutral solution for deliveries along with quicker collection and delivery times when compared to a traditional van service. LEFVs (cargo bikes especially) can travel at up to 50 km/h and weave through traffic more efficiently than traditional delivery vehicles vehicle as these generally travel at slower speeds due to congestion in central areas of the city. In this section, a business model for the uptake of LEFVs concept by courier companies is proposed.

CBM Canvass

The conceptual framework of CBM is presented in Figure 28.

Key Partners	**Key Activities**	**Value Proposition**	**Customer Relationships**	**Customer Segments**
Municipality (administration) LEFVs courier(-s) Customers LEFVs repair service providers	Pickup/Delivery service	Time sensitive delivery/pickup of parcels Flexibility of the service Reliability of the service Shipment efficiency, speed, security Less congestion, emissions Better environment for pedestrians Air quality Job creation	Cooperative and client-centric Strong partnerships and alliances with the key customers (suppliers)	B2B & B2C & C2B & C2C Product delivery/pickup for customers from/to the designed area
	Key Resources Micro Consolidation Center (MCC) Employees & LEFVs (in case if they are owned by Courier) Software (assignment and routing algorithms)		Channels Website/telephone/ cooperative platform	

Cost Structure	Revenue Streams
Fuel costs, packaging, personnel costs, acquisition and maintenance of vehicles & LEFVs, ICT systems Costs of marketing and advertising campaign	Courier service fee LEFVs used for advertisement

Figure 28. Conceptual framework of cooperative courier-based business network.

A cooperative business network of CBM looks as on Figure 29.

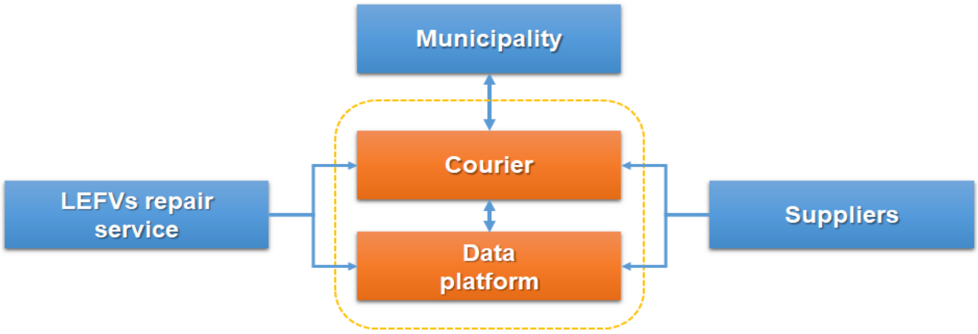


Figure 29. Cooperative (vertical) business network for CBM.

In this model, ***Courier*** leads the network, manages the flows (first/last-mile distribution) and coordinates transshipment/temporary storage activities. ***Municipality*** has a supporting role. Courier company maintains a close relationship with the suppliers and manages their requests in a timely and reliable manner.

If there are more than one Courier company in business model, then the proposed model shifts from vertical network form to a diagonal cooperative network which, due to increased complexity would require a neutral coordinator for stable functioning (Figure 30.).

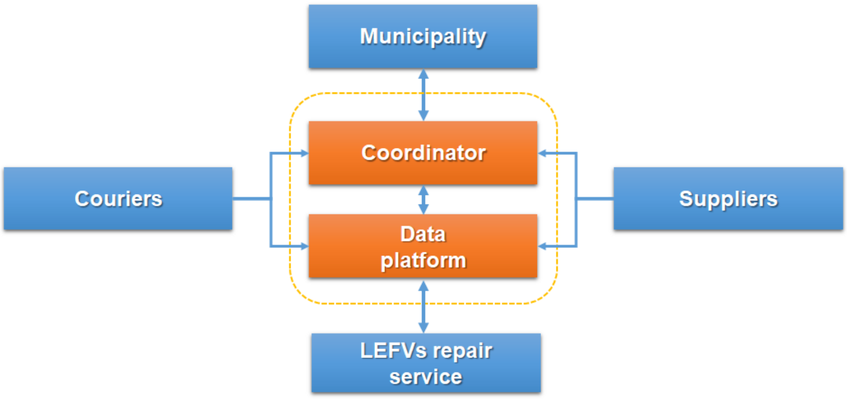


Figure 30. Cooperative (diagonal) business network for CBM.

CBM governance model

CBM governance model is based on the main prerequisites related to contractual and relational governance in GBM.

Contract design should be based on criteria that provide an environment of trust. Figure 31. illustrates a contractual framework for governing the transactions in the proposed relationship.

Figure 31. Contractual governance of proposed CBM business network.

Courier, a number of suppliers, one LEFVs repair service provider cooperate on a strategic base enabling smooth and reliable first/last mile LEFVs based distribution service.

Again, the most important feature of CBM is trust between all actors. Trust will contribute to overcoming initial suspiciousness about potential partner opportunism which may prevent effective implementation of this cooperation.

The potential contractual model is based on long-term relational contracting with strategic partners in LEFVs freight distribution. By including the relational exchange aspects in the urban LEFV system, it is sought the soft, normative, and informal side of the relationships between stakeholders.

A complementary governance mechanism based on formal contracts and relational norms should be applied in this case between the Courier, the suppliers, LEFVs service providers (if any) and LEFVs repair providers.

In the initial phase, contracts should be more formal to complement relational governance by providing confidence for each of the partners through safeguarding transaction specific investments and controlling opportunism.

After some time (or in the case of previous experience between partners) the trust and relational norms will create more opportunities for cooperative parties to learn knowledge and contracting skills.

In the beginning phase, this model should be a "small scale" with a critical number of actors who may already have some relationships between them. In that case, the Courier should consider existing relationships during designing an optimal contracting scheme for the entire alliance.

CBM data framework

Courier companies already have established a "core" of the network of the main Suppliers for which they distribute parcels. This core network should be transferred in strategic form (alliance for example) and extended with a LEFVs repair service provider.

Information sharing intensity depends on the number of actors. A bigger network, with many suppliers (or even with several courier companies), would require more efficient information sharing to fulfil the main service requirements (flexibility, reliability, visibility, lead time, cost).

Regarding the type of information shared, the information related to the planning of first/last mile distribution needs to be exchanged. Figure 32 presents the flow of information between the actors in the proposed CBM network – inside the established entity and with external actors.

Figure 32. Information flow in the proposed CBM business network.

Usage of an information sharing platform will make transactions more cost efficient.

To support implementation of a cooperative platform, a form of non-financial and financial compensation can be an option.

All main prerequisites and conditions related to information sharing architecture are mention in GBM hold in this case too.

Step 2: Software

2.3. Step 2: Software

Currently, distribution within cities is mainly conducted by diesel trucks, implying increased traffic congestion and air pollution. The “software” perspective aims to propose an optimization scheme for determining suitable micro hub locations and optimal routes conducted by LEFVs for an average day. The approach should result in a significant reduction of mileage covered by the trucks per day and therefore significant CO_2 reductions.

In general, the main issues that the “software” perspective addresses are:

- Where can the micro hub locations be optimally placed?
- Which routes are optimal for the LEFVs and what time is needed for delivering process?
- What is the effect of the new solution considering the costs, time, and CO_2 emissions compared to the existing solution?

Therefore, the work in this stage includes:

- Analysis of potential locations of transshipment hubs and finding the subset of optimal locations minimizing the average distance between micro hubs and delivery points;
- Find optimal routes for the LEFVs to deliver the shipments considering the capacities of LEFVs and time window constraints of recipients;
- Assessment of the effects of the new solutions.

2.3.1. Optimal micro hub location (software perspective)

The problem of finding optimal locations for transshipment points can be solved mathematically. The problem belongs to a class of facility location problems and can be modelled as a p-median problem. P-median problem (PMP) is a classical combinatorial problem whose objective is to find p locations out of a set of potential locations for transshipment points such that the sum of weighted distances between each demand point and its closest facility is minimized. The distances between each demand point and its closest facility location will be weighted by the demand that is sent to that point.

The next step includes finding optimal routes for delivering shipments from the selected micro hub locations to the recipients. To make the problem computationally efficient the delivery addresses can be partitioned based on their location and assigned to the nearest micro hub location. For each subset of delivery locations, the problem of finding routes can be mathematically modelled as one of the variants of the Vehicle Routing Problem (VRP).

Synchronization between outer-city delivery (delivery to the micro hubs) and inner-city delivery (LEFV delivery) should be considered in this problem. A critical factor of LEFVs is their travel speed which depends on the load and the slope of the streets.

Since different deliveries have strict or less strict delivery times, delivery time windows are included. The resulting model is capacitated vehicle routing problem with time windows and load dependent travel times.

The size of the LEFVs (the output of the “hardware” dimension) serves as the input parameter to this problem.

2.3.2. LEFV optimization

According to the description of the implementation of the LEFV system in the designed area two problems can be included:

- Micro-hub location problem, if the location is not predetermined
- LEFV routing problem

A software solution (web application or other type of application) can be used for the LEFV optimization, including the description of and optimal e-vehicle routing.

The application should consider the two types of LEFV delivery vehicles: e-cargo bicycles which do not have any traffic restrictions, and e-vans which cannot move through pedestrian streets.

Routing of LEFVs in the first or last mile is of crucial importance for the efficiency and sustainability of the system. Therefore, the process must be supported by a system that will follow one or a set of global optimality criteria.

The application could be used for operational or everyday planning of LEFV services or with certain extensions for tactical/strategic purposes related to the planning of capacities on the mid-term horizon. The application can be integrated with the information sharing platform of the Orchestrator or the android application of LEFV drivers for the sake of improved coordination.

Case Study Box 1: The Cargo Bike Optimizer

To fulfil the software perspective in Quito, ZLC developed a dedicated web application after analysing and considering all the characteristics and requirements found in the Historic Center of Quito. The application uses open resources to make it accessible to all the interested stakeholders. It can be installed on any computer or mobile phone and the obtained routes are sent to the drivers' mobile phone to optimize the delivery.

The web application, called "Cargo Bike Optimizer", determines optimal routes of e-cargo vehicles based on a set of given inputs such as type of cargo vehicle, order details, pickup/delivery locations – customers, traveling times, and service times. All customer details (location, order details, service time) are included in a web database used by the application.

Therefore, the solution for Quito is based on the following components:

- Open Street Maps (OSM): A free editable geographic database of the world that fully covers the area of interest (Quito) in terms of modes (car, bicycle, foot), traffic speeds, street categories etc.;
- Open Street Routing Machine (OSRM): OSRM uses OpenStreetMap as (map) backend;
- Vehicle Routing Open-source Optimization Machine (VROOM): This is a VRP solver. It uses OSRM or OpenRouteService (OSR) as backend to get routes and returns solutions for different classes of vehicle routing problems;
- Docker: Docker is an open source platform for building, deploying, and managing containerized applications;
- Web-based user interface for making the requests and displaying the outputs, created in PHP language;
- Web database created in phpMyAdmin (a free and open source administration tool for MySQ).

All components (OSRM, VROOM, PHPMYADMIN) are "dockerized" and enable using the solution (all its components) in a backend (using docker containers and images).

Since the traveling times are predefined in OSMs, this is considered an offline solution. To have real-time LEFV routing solutions it is needed to have real-time travelling times which is possible by using Google Maps API (the service is still not available in OSRM and its integration by other in another way would have an associated cost).

The solution, based on VROOM, uses metaheuristics for efficient searching for the best solution.

The constraints considered in the proposed solution are the following:

- One fixed depot station;
- Heterogeneous LEFV fleet;
- Capacities of the LEFVs;
- Time windows of customers;
- Pickup and delivery amounts;
- Streets allowed or forbidden for some types of vehicles;

Case Study Box 1: The Cargo Bike Optimizer

The inputs are the following:

- Locations of customers and micro hub (longitude and latitude);
- Pickup and delivery quantities of customers;
- Delivery time windows of customers;
- Type of electric cargo vehicle;
- Capacities of cargo vehicles;
- Set of streets (traffic.csv file) that are temporary (during some parts of the day)/ permanently forbidden for all/some types of LEFVs;
- Sets of driver email addresses.

All inputs are stored in a web database (the user must be logged in the database with credentials). The database contains 15 tables (Figure 33). The user can change the inputs to adapt the solution to its specific purpose.

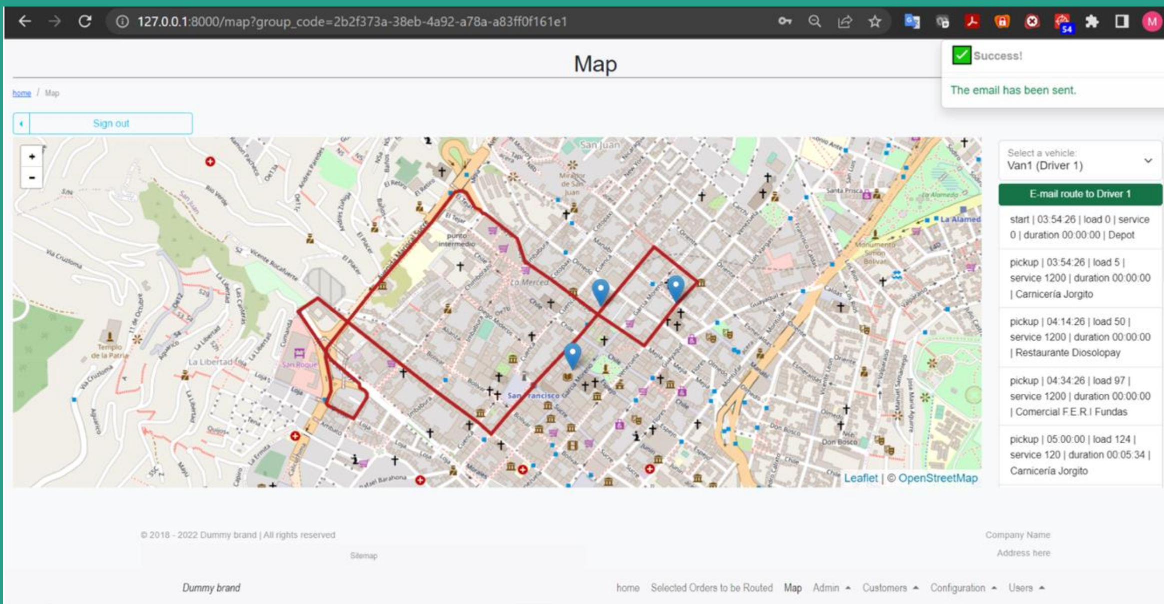


Figure 33. Routing solution for selected set of orders. Source: Milenkovich et al. (2024)

Step 3: Hardware

2.4. Step 3: Hardware

"Hardware" stage includes the design of LEFVs, the sizing of micro hubs and the provision of the adequate road infrastructure for their safe and efficient circulation. These are related to "software" stage in terms of the demand – its intensity and structure, spatial distribution, time windows as well as the location of micro hubs.

In Latin America LEVs are starting to become popular in logistics operation. The catalogue of locally manufactured LEFV tested in the context of the SOLUTIONSplus project will be presented. Moreover, the concept of micro-hubs is rather new in the region. However, two case studies were identified and will be summarized in this section, i.e. the cases of Grupo Nutresa in Colombia (Case Study Box 3) and the one from Express Logística in Buenos Aires (Case Study Box 4) (GCBA, 2022; Nutresa, 2024). To illustrate, the collaborative microhub example of KoMoDo in Berlin, Germany is also showcase in Case Study Box 2 (BEHALA, 2021) .

2.4.1. LEFVs design

LEFVs, in general, are bicycles or compact vehicles with electric pedal assistance or electric drive designed for the distribution of goods on public roads with a limited speed (max 45 km/h).

LEFVs can be of different design and characteristics. For example, on London's market, there is a range of cargo bikes available on the market (Figure 34). Regarding the design of cargo bikes, there is an increasing demand for high payload vehicles to improve the ratio between payroll costs and payload. Bikes and trikes are also available with functionalities such as a hot or cold box for the transport of food and beverages. 42% of cargo bikes, 50% of cargo trikes and all quadricycles are offered with electric assistance.

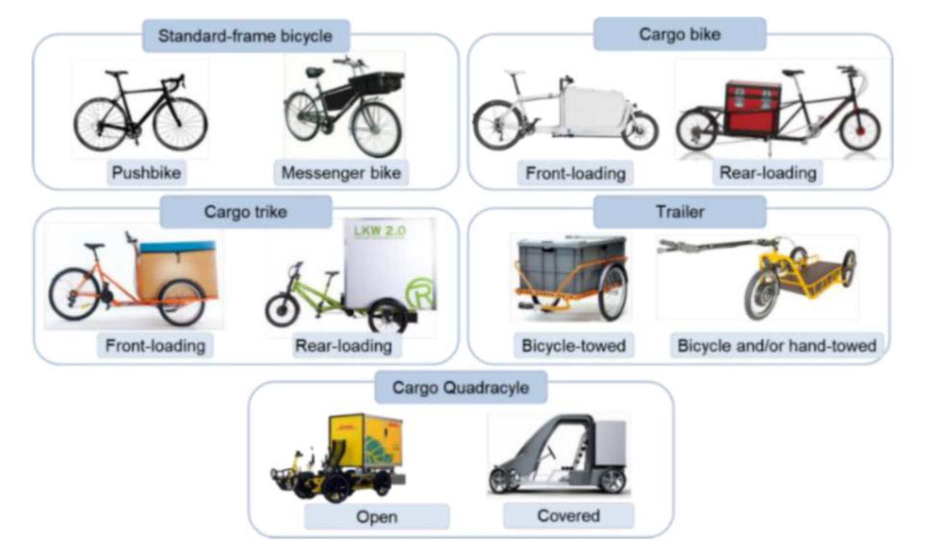


Figure 34. Cargo bikes offer on London's market.

Cargo trikes and quadricycles are capable of carrying up to 300 kg. Both have the option of either front load or rear load boxes with rear load typically offering a larger payload volume and weight. Trailers can be used to extend the capacity. Regarding maneuverability, cargo bikes are more maneuverable than cargo trikes. Trikes typically need wider lanes and access routes to not cause obstruction to other cyclists.

Quadracycles (Figure 35) have the advantage that the rear cargo box is the same size as a standard EU pallet which offers seamless integration into the logistics system.

Figure 35. Quadricycles.

Regarding functionality, manufacturers offer a range of "functional" boxes for various applications. These include hot/cold boxes for transporting food and medicine. Also, manufacturers offer the option of custom-made bikes/trikes to suit individual needs. This includes customization of the length/width and battery size as well as the functionality of the cargo box itself.

Required battery capacity depends on vehicle speed, the weight of the load, and driving distance. For example, for a speed of 20 km/h, load of 200 kg and a driving distance of 70 km required battery capacity is 2.9 kWh.

In summary, during the process of LEFVs selection following aspects should be considered:

- Design of vehicles must correspond to the market needs;
- Cargo bikes and e-vans with higher payload capacity, better maneuverability (overtaking, cornering, parking), with higher customization potential (modifiable boxes to cater to specific needs);
- Cargo bikes are expected to last 5 years, but sometimes they can be written off in only 1.5 years. Longer economic life, lower maintenance costs, manufacturer' guarantee
- Dimensions of LEFVs and their maneuverability features should be aligned with existing cycling infrastructure;
- Existing vehicle regulations must be considered in case of weight, electric power, and speed limitations;
- From the aspect of charging, those models with a larger capacity of batteries, that can be charged at the employee's home should be preferred.

In the next few pages, we present the catalogue of SOLUTIONSplus LEFVs manufactured locally in Latin America to be tested in urban logistics operations in 10 cities in Argentina, Colombia, Ecuador and Uruguay. The vehicles range from e-cargo bikes with load capacities of 80kg to e-mini vans / pick-ups able to carry up to 600kg, i.e., L7-category vehicles. Thus, the SOLUTIONSplus vehicles piloted in the region cover the full spectrum of what we have defined under the LEV umbrella (see Section 2.4.2 SOLUTIONSplus LEFVs in Latin America). It is worth noting that the vehicles produced are in very different stages of development. In some cases, the local manufacturers used the seed funding provided by SOLUTIONSplus to produce the first prototypes of the vehicles. That is for example the case of Sidertech and Grupo Miral in Ecuador. Other SMEs, on the other hand, have already well-established production plants able to produce 50 units per month. That is the case of Sero Electric and Coradir in Argentina. There is clearly a big room for improvement in the design and functionalities of the vehicles. However, the variety of vehicles and their results in urban logistics operations during the SOLUTIONSplus demonstration and replication activities show a great scale-up potential in the region.

2.4.2 SOLUTIONSplus LEFVs in Latin America

Pedal assisted e-cargo bike, Uruguay

https://www.instagram.com/cargo.bike/

Manufacturer Name and Model	CargoBike, pedal assisted e-cargo bike, two wheels type “long john”
Origin of the vehicle	Uruguay
Type of vehicle	Cargo
Vehicle category	Long john e-cargo bike (pedal-assisted)
Vehicle Net Load Capacity (kg)	80 Kg
Vehicle dimensions	20’’ front wheel, 26’’ rear wheel
Continuous motor power (kW)	NA
Battery Type	10 Ah Li-ion battery
Battery storage capacity (kWh)	NA
Battery Recharge Time (hs.)	NA
Range of autonomy on a single charge (km)	NA
Maximum vehicle speed (km/h)	25 Km/h

Electric cargo bike, Ecuador

https://bixicargo.com/

Manufacturer Name and Model	Bixicargo, Long John cargo bicycle
Origin of the vehicle	Ecuador
Type of vehicle	Cargo
Vehicle category	Long john e-cargo bike (pedal-assisted)
Vehicle Net Load Capacity (kg)	100 Kg
Vehicle dimensions [L*w*h]	Width: 790mm - Height: 1000mm - Length: 2450mm
Continuous motor power (kW)	500W – 13 A
Battery Type	Lithium
Battery storage capacity (kWh)	NA
Battery Recharge Time (hs.)	4-5 hours
Range of autonomy on a single charge (km)	NA
Maximum vehicle speed (km/h)	NA

Electric tricycle, Ecuador

https://bixicargo.com/

Manufacturer Name and Model	Bixicargo, Front load tricycle
Origin of the vehicle	Ecuador
Type of vehicle	Cargo
Vehicle category	Front load e-tricycle (pedal-assisted)
Vehicle Net Load Capacity (kg)	100 Kg
Vehicle dimensions [L*w*h]	Width: 790mm - Height: 1000mm - Length: 2450mm
Continuous motor power (kW)	500W – 13 A
Battery Type	Lithium
Battery storage capacity (kWh)	NA
Battery Recharge Time (hs.)	4-5 hours
Range of autonomy on a single charge (km)	NA
Maximum vehicle speed (km/h)	NA

Electric tricycle, Ecuador

https://bixicargo.com/

BixiCargo
Logística sostenible

Manufacturer Name and Model	Bixicargo, Rear load tricycle
Origin of the vehicle	Ecuador
Type of vehicle	Cargo
Vehicle category	Rear load e-tricycle (pedal-assisted)
Vehicle Net Load Capacity (kg)	75 Kg
Vehicle dimensions [L*w*h]	Width: 790mm - Height: 1000mm - Length: 2450mm
Continuous motor power (kW)	500W – 13 A
Battery Type	Lithium
Battery storage capacity (kWh)	NA
Battery Recharge Time (hs.)	4-5 hours
Range of autonomy on a single charge (km)	NA
Maximum vehicle speed (km/h)	NA

E-tricycle, Uruguay

https://wheele.com.uy/

Manufacturer Name and Model	Wheele, electric pedal asssisted tricycle cargo model
Origin of the vehicle	Uruguay
Type of vehicle	Cargo
Vehicle category	Front lead e-tricycle (pedal-assisted)
Vehicle Net Load Capacity (kg)	90 Kg
Vehicle dimensions [L*w*h]	Length: 2340 mm / Width: 880 mm / Height: 1260 mm
Continuous motor power (kW)	NA
Battery Type	Lithium 10 Ah
Battery storage capacity (kWh)	NA
Battery Recharge Time (hs.)	6-10 hours
Range of autonomy on a single charge (km)	30- 50 Km
Maximum vehicle speed (km/h)	25 Km/h

E-cargo tricycle, Colombia

https://ecotriciclos.com/

Manufacturer Name and Model	Ecotriciclos, e-cargo tricycle
Origin of the vehicle	Bogotá, Colombia
Type of vehicle	Cargo
Vehicle category	Rear load e-tricycle (pedal-assisted)
Vehicle Net Load Capacity (kg)	300 kg
Vehicle dimensions [L*w*h]	Length: 1,20 m / Width: 1,00 m / Height: 1.03 m
Continuous motor power (kW)	NA
Battery Type	Lithium Ferrous
Battery storage capacity (kWh)	NA
Battery Recharge Time (hs.)	6 a 8 hours
Range of autonomy on a single charge (km)	40 Km
Maximum vehicle speed (km/h)	30 Km/h

Pedal assisted e-tricycle, Colombia

https://lola.com.co/

Manufacturer Name and Model	Lola – Te mueve, e-assisted tricycle
Origin of the vehicle	Medellin, Colombia
Type of vehicle	Cargo
Vehicle category	Rear load e-tricycle (pedal-assisted)
Vehicle Net Load Capacity (kg)	250 Kg
Vehicle dimensions [L*w*h]	Length: 2727 mm / Width: 1070 mm / Height: 1700 mm
Continuous motor power (kW)	NA
Battery Type	Lithium
Battery storage capacity (kWh)	0,648 KWh
Battery Recharge Time (hs.)	4-6 hours
Range of autonomy on a single charge (km)	40 Km
Maximum vehicle speed (km/h)	30 Km/h

Electric motorcycle Van Version, Colombia

https://www.brenson.co/

Manufacturer Name and Model	E-Motorcycle Brenson CR300 (Van version 3 wheels)
Origin of the vehicle	Bogota, Colombia (assembly)
Type of vehicle	Cargo
Vehicle category	L5
Vehicle Net Load Capacity (kg)	400 Kg
Vehicle dimensions [L*w*h]	Length: 2930 mm / Width: 1100 mm / Height: 1700 mm
Continuous motor power (kW)	NA
Battery Type	Lead Acid in Gel
Battery storage capacity (kWh)	5,4 KWh
Battery Recharge Time (hs.)	6-10 hours
Range of autonomy on a single charge (km)	40 Km
Maximum vehicle speed (km/h)	30 Km/h

GreenStar, Uruguay

Manufacturer Name and Model	Green Star, Kite e-3-wheeler
Origin of the vehicle	Uruguay
Type of vehicle	Cargo
Vehicle category	L5
Vehicle Net Load Capacity (kg)	250 Kg
*Vehicle dimensions [L*w*h]*	Length: 2450 mm / Width: 1450 mm
Continuous motor power (kW)	NA
Battery Type	Second-life lithium-ion
Battery storage capacity (kWh)	NA
Battery Recharge Time (hs.)	NA
*Range of **autonomy on** a single charge (km)*	80 Km
Maximum vehicle speed (km/h)	60 Km/h

Electric Quadricycle, Ecuador

https://sidertech.com/

Manufacturer Name and Model	Sidertech, e- quadricycle
Origin of the vehicle	Ecuador
Type of vehicle	Cargo
Vehicle category	L6
Vehicle Net Load Capacity (kg)	400 Kg
Vehicle dimensions [L*w*h]	Width: 840mm - Height: 1620mm - Length: 2500mm
Continuous motor power (kW)	6.5 kW - 135 A
Battery Type	Lithium
Battery storage capacity (kWh)	NA
Battery Recharge Time (hs.)	4-5 hours
Range of autonomy on a single charge (km)	60 km
Maximum vehicle speed (km/h)	32 - 40 km/h

[Electric Mini Van, Argentina]

https://www.seroelectric.com/

Manufacturer Name and Model	L Voiture S.A Sero Electric, electric mini-van
Origin of the vehicle	Moron, Buenos Aires, Argentina
Type of vehicle	Cargo
Vehicle category	L6
Vehicle Net Load Capacity (kg)	430 Kg
Vehicle dimensions [L*w*h]	Length: 293cm / Width (Without Mirrors): 132cm / Height: 183cm.
Continuous motor power (kW)	4kW
Battery Type	Lithium
Battery storage capacity (kWh)	110 KWh
Battery Recharge Time (hs.)	5 hours
Range of autonomy on a single charge (km)	90/100 Km
Maximum vehicle speed (km/h)	50Km/h

Electric Mini Van, Ecuador

https://www.miral-autobuses.com/

Manufacturer Name and Model	Grupo Miral MTEC S.A, e-cargo mini van
Origin of the vehicle	Ecuador
Type of vehicle	Cargo
Vehicle category	L7
Vehicle Net Load Capacity (kg)	600 Kg
Vehicle dimensions [L*w*h]	Width: 1345mm - Height: 1765mm -Length: 3600mm / Truck bed dimensions: Width: 2650mm - Height: 1000mm - Length: 16170mm
Continuous motor power (kW)	5 kW
Battery Type	Lithium
Battery storage capacity (kWh)	NA
Battery Recharge Time (hs.)	5-7 hours
Range of autonomy on a single charge (km)	60-90 km
Maximum vehicle speed (km/h)	52 km/h

Electric pick-up, Argentina

https://movilidad.coradir.com.ar/

CORADIR MOVILIDAD ELÉCTRICA

Manufacturer Name and Model	CORADIR SRL, electric pick-up
Origin of the vehicle	San Luis, Argentina
Type of vehicle	Cargo
Vehicle category	L7
Vehicle Net Load Capacity (kg)	500 Kg
Vehicle dimensions [L*w*h]	Length: 3705 mm / Width: 1220 mm / Height: 1742 mm
Continuous motor power (kW)	4kW
Battery Type	Lithium Ferrophosphate (LiFePo4)
Battery storage capacity (kWh)	7,680 KWh
Battery Recharge Time (hs.)	8 hours
Range of autonomy on a single charge (km)	100 Km
Maximum vehicle speed (km/h)	45 Km/h

2.4.3. Micro hub location/size (hardware perspective)

Micro hub location/size (hardware perspective)

The cycle freight market in urban areas is composed of two main services that cargo bikes offer: Point-to-Point (P2P) and First/Last Mile delivery (Figure 36). P2P services collect items from one party and deliver them to another party at a different location whereas first/last mile services carry deliveries from a local distribution center to a customer. Dedicated cycle logistics companies typically do both services.

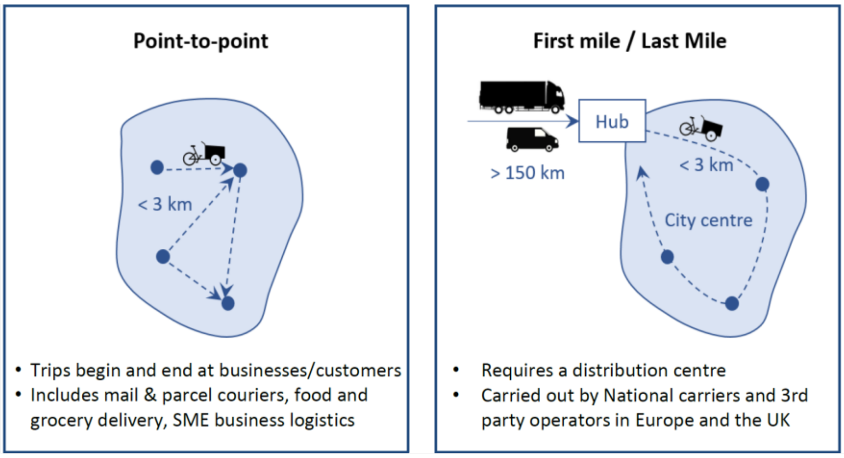


Figure 36. Main cycle freight services

Regarding the micro-hub location, it can be on the outskirts of the city or in the city center (also on the edge of the city center). One of the main determinants of location for transshipment point is a requirement for a short distance from the city because of the range of the vehicles. There are also cases in which companies offer the hub as a service. The cost of a hub (space and personnel) must be balanced with savings in the supply to the hub with fully loaded trucks or with savings in the costs of local transport from the hub. Also, mobile hubs in the form of a truck upon which one parked in a certain location, shipments can be transferred to e-cargo bikes are utilized by DHL and UPS. Containerization (Cubicycle – DHL[1]) as an option that reduces unnecessary transshipment operations and increases safety should also be considered. The cost of a hub in terms of space and staff depends on the real estate prices and the price of human resources. High real estate prices can limit the possibilities of picking up an affordable hub location.

However, according to existing practice, it is possible to use a customer's space, and mobile hubs, share location with other actors and share e-cargo bikes. Municipalities can play a role by making real estate available to logistics service providers at lower rates. The location of logistics hubs can be determined based on a supply chain perspective (reduction in transportation costs and lead time) and considered within the "software" stage. It represents a strategic and long-term decision due to the large amount of capital invested and the length of time that facilities will be available.

The sizing of micro-hubs will depend on their number and the demand for delivery generated by commercial activities in the gravitating area as well as the delivery times. The demand can be subject to variability in terms of magnitude (number of deliveries per day) and time (from one day to another).

[1] https://www.dhl.com/tw-en/home/press/press-archive/2019/first-cubicycle-to-electrify-dhl-express-green-fleet-in-taiwan.html

Case Study Box 2: The KoMoDo project in Berlin, Germany

The twelve-month test phase of the KoMoDo pilot project has proven its worth: The use of cargo bikes for the delivery of parcels and the shared use of a micro-depot location by several parcel service providers works - if certain conditions are met.

The project's aim was to test sustainable solutions for delivery traffic in urban areas and to develop transferable solutions for other municipalities. The KoMoDo project (Cooperative use of micro-depots by the courier, express and parcel sector for the sustainable use of cargo bikes in Berlin) was funded by the Federal Ministry for the Environment. One year after the start of the pilot project, the participants have drawn a positive balance. The practical test has shown that micro-depots and cargo bikes can be used efficiently, especially in areas with a high density of recipients and a consignment structure suitable for cargo bikes (number, volume and weight of parcels).

The use of cargo bikes on the last mile is environmentally friendly as it replaces journeys with conventional delivery vehicles. The delivery staff used the predominantly electrically assisted cargo bikes within a radius of up to three kilometers around the micro-depot location in Prenzlauer Berg. As a result, they drove locally emission-free and were able to save around eleven tons of CO2 compared to conventional delivery vehicles. Up to eleven cargo bikes were in use every day. They covered a total distance of over 38,000 km (BEHALA, 2021).

In the twelve months, around 160,000 parcels have been delivered by the five largest parcel service providers in Germany using cargo bikes in the vicinity of the micro-depots as part of the pilot project. The parcel service providers involved were able to continuously increase the volume of parcels delivered over the course of the project. Public spaces are a scarce commodity in densely populated inner cities. They should therefore be used cooperatively and therefore particularly efficiently. Both cities and companies can benefit from the use of micro-depots and cargo bikes, making the last mile much more sustainable in urban areas.

For the parcel service providers involved the project offered the opportunity to test parcel delivery with cargo bikes from micro-depots in Berlin. Their conclusion: the micro-depot model has basically proven itself. The project partners would therefore like to build on the results to date and are interested in further consolidating the micro-depot approach. The parcel service providers involved will continue to use the current location for another six months after the end of public funding (July 1, 2019) for deliveries with cargo bikes. The Berlin-Pankow district office has already approved the extended use of the space for this purpose. In addition, the Senate Department for the Environment, Transport and Climate Protection will work with the districts and BEHALA to find suitable locations for further micro-depots in Berlin based on the project results. The Berlin Senate Department, as a municipal partner in the pilot project, has drawn a positive balance: Regine Günther, Senator for the Environment, Transport and Climate Protection: “The practical test has impressively shown how modern, environmentally and climate-friendly delivery transport can work. Micro-depots and cargo bikes can be an efficient solution for the last mile of parcel deliveries. I am delighted that our pilot project has been so successful.”

Case Study Box 2: The KoMoDo project in Berlin, Germany

KoMoDo 2.0

Following the completion of the successful project, the location has moved to the Westhafen and the containers are available for use here. A further location is being planned.

Figure 37 shows the example of the collaborative microhub implemented in the city of Berlin.

Figure 37.KoMoDo Collaborative Microhub in Berlin, Germany. Source: BEHALA

Case Study Box 3: Grupo Nutresa, Colombia

Comercial Nutresa is the Company responsible for the sales and distribution of dry products and other allied brands of Grupo Nutresa, a multinational food distribution company founded in Colombia at the beginning of the 20th Century. Comercial Nutresa distributes in 6 regions, has 26 distribution centers (DCs) and a fleet of 895 vehicles, of which 19 are electric, 5 are hybrid, 2 run on gas and 5 are e-cargo bicycles. Comercial Nutresa has participated in different projects with Logyca for the use of electric vehicles in urban distribution, such as the BiciCarga project and the ICLEI EcoLogistics project in the city of Bogotá.

Following the successful results of the BiciCarga Project, implemented by Despacio and Logyca with funding from the World Bank and ICLEI, Grupo Nutresa moved forward with the installation of 2 microhubs in the Chapinero and Ricaurte districts, aiming to serve the dense commercial areas in the North and Center of the city with the use of e-cargo tricycles. These hubs have reduced the working time by 3 hours and avoid approximately 1,2 tCO2 /year (Nutresa, 2024).

Figure 38. Microhub Grupo Nutresa. Source: Despacio

In 2022, Comercial Nutresa, inaugurated a microhub in the Southern Bus Terminal of Bogotá with the aim of improving their operating, environmental and labor indicators. The Southern Bus Terminal is a property owned by the Municipality of Bogotá. Given its partial occupation and strategic location, Comercial Nutresa identified it as a potential space for the establishment of a Microhub able to serve the Southern part of the city and negotiated its renting with the city authorities.

Case Study Box 3: Grupo Nutresa, Colombia

Figure 39. Nutresa's Microhub in the Southern Bus Terminal of Bogotá, Colombia. Source: Comercial Nutresa (2024)

- *Main characteristics*
- *Location: Southern Bus Terminal - Bogotá - Colombia*
- *Area: 346 m2*
- *Infrastructure: 6 containers (89 m2) with individual and secure access*
- *Logistics operators: 3*
- *Number & type of vehicles: 36 ICE vans (Carry type)*

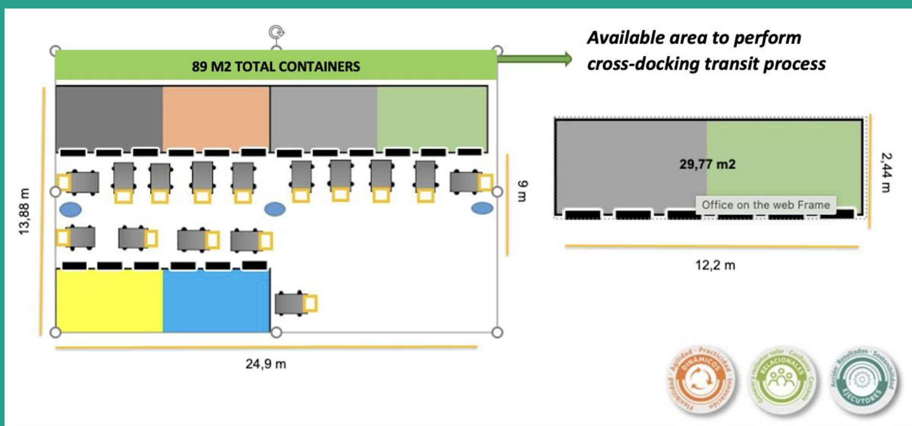


Figure 40. Microhub distribution. Source: Comercial Nutresa, 2024

Main results

- Working time: Since the logistics operators do not need to go to the DC in the center of the city anymore, the time to and from the hub reduced from 180 to 30 minutes, i.e. a time reduction of more than 80%. This has a direct impact in the working conditions and quality of life of the drivers, most of which live in the surroundings of the microhub.
- Distance travelled: In average the daily kilometers travelled were reduced in 24km (12km each way to/from the DC). In total the establishment of the microhub contributed to the reduction of 10078 km / year.
- CO2 emissions: a total of 105t CO2 are avoided every year with the introduction of this microhub in Nutresa's operations.

In only one year Comercial Nutresa was able to recover the investment made in the Southern Bus Terminal's microhub. Thus, now Nutresa wants to continue expanding its microhub network. The next one, already in construction, will be a collaborative hub.

2.4.3 Road infrastructure

It is expected that in the near future an important share of car and bicycle drivers shift to LEVs, which could imply some mismatches between the new ways of mobility and the existing infrastructure (Zagorskas & Burinskienė, 2019). In this context, the space now used by cars can be reorganized to serve public transport and PMVs along with bicycles. On the other hand, sidewalks and bike lanes may be more crowded, but will not create major problems, due to the tiny space used by PMVs compared to a car.

Moreover, the need to plan for designated parking and charging spaces, as well as connecting them to the public transport system in order to promote intermodality, has brought about concept such as multimodal hubs and mobility stations.

Understanding the needs for change that new mobility vehicles and services pose to urban infrastructure, NACTO, one of the international institutions leading the conversation on the design of bike and pedestrian friendly streets, developed 7 working papers to update its Urban Bikeway Design Guide. One of them is titled “Designing for Small Things with Wheels”, in which it acknowledges the required shifts in infrastructure needed to safely integrate micromobility vehicles in the road space (Benton et al., 2023). Figure 41 shows the proposed infrastructure.

Other sources speak of “slow” or “light” lanes to allow these new vehicles to circulate safely.
According to Klein (2019), based on the standard US street design, a “slow” lane takes the travel lane next to the parking lane and reduces its width to 2,5m (vs. its current 3m – 4m). Thermoplastic markings signal the “slow lane” with a 25 km/h speed limit that prioritizes non-cars.

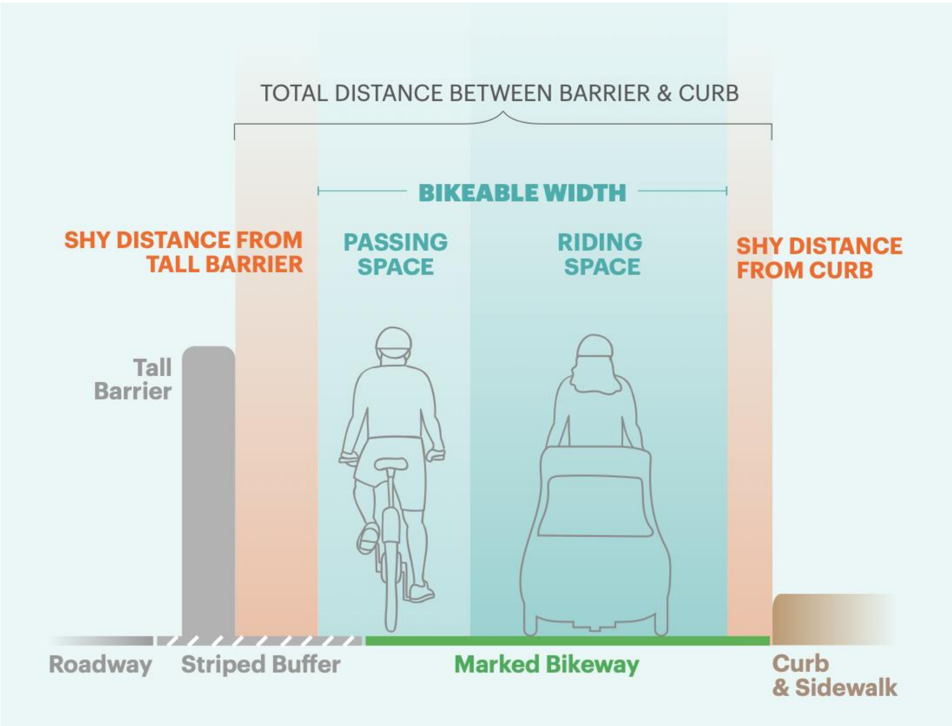


Figure 41. Example of how infrastructure for LEVs can be designed. Source: NACTO (2023)

In the case of Madrid, in its Sustainable Mobility Ordinance the city introduces the concept of multimodal lanes. These are lanes with speed limited to 30 km/h or less if specifically marked, specially conditioned for bicycles and other personal mobility vehicles (PMV), in which circulation is shared with other vehicles. Users of bicycles and PMVs have preference over motor vehicles (Ayuntamiento de Madrid, 2024).

Figure 42. Multimodal lanes in Madrid. Source: enbicipormadrid

In the case of Quito, the Design Studio of the Technical University of Berlin (TUB) conducted a conceptual proposal in 2021 on how the HCQ could look like with the introduction of a LEV system (see Figure 43).

Figure 43. Proposed urban design for a LEFV System in the HCQ. Source: Design Studio TUB (2021)

Step 4: Policy framework

2.5. Step 4: Policy framework

This section summarizes the role of government actors and recommendations for the legal framework. According to experience from different cities, there is a resistance to the use of cargo bikes on already crowded cycling infrastructure. Also, there is a fear that the safety of other road users may be endangered and that the pavement will be blocked by LEFVs. Therefore, the main questions are how do the LEFVs fit into urban infrastructure and what measures can the municipality take to facilitate LEFVs?

According to Rob (2012) municipalities can take: regulatory, coordination, facilitation, stimulatory or experimentation roles.

The regulatory role is related to introducing restrictive measures such as establishing environmental zones with limited or forbidden access to some types of vehicles. Also, some cities like Utrecht allowed cargo bike service operators to deliver all day in pedestrian areas.

Coordination includes actions related to bringing together supply and demand related actors. For example, the Amsterdam municipality links companies who want to charge vehicles to parties with innovative charging solutions. The supply and demand for logistics facilities for storage and transshipment can also be coordinated by the government. Municipalities can share real-time local traffic data to transport management system providers.

The stimulatory role relates to financial incentives for purchasing LEFV. Subsidy amounts in The Hague and Maastricht ranged from 1500 to 4000 EUR for the use of cargo bikes. Municipalities can use their purchasing power to stimulate the development of sustainable solutions such as to organize their own logistics activities or to encourage suppliers of inbound goods to use light e-cargo vehicles.

The experimental role relates to the use of LEFV by the municipalities for their own activities.

The facilitation role is related to different measures for facilitating innovation uptake. For example, introducing bicycle streets in which a lot of space is reserved for cyclists whilst cars are treated as guests. With a speed limit of 30 km/h, this fits well with the deployment of the e-cargo cycling service. Municipalities can also play a role by making real estate available to LSPs at a lower rate.

The following case studies show national and local policies that have been put into place in Argentina and Colombia to support the uptake of LEFVs in urban logistics (Secretaría Distrital de Planeación, 2023).

Case Study Box 4: Enabling national and local policies in Argentina

Important regulatory changes have been introduced in recent years at the national and local level in Argentina to enable the local production of LEVs and their use in urban logistics.

In October 2018, the Decree 32/2018 that modifies the National Transit Law (Ley Nacional N° 24.449/1994) of 1994 was approved. It defines, categorizes and regulates several LEVs, incorporating them into the Argentinian transport system. Thus, in 2019, the first locally manufactured light electric vehicle, an L6-category vehicle called Sero Electric, was homologated in Argentina by the Industry Secretariat, part of the Ministry of Production, accrediting compliance with safety requirements to circulate on public roads. Although the Sero Electric model of the company L Voiture SA (see catalogue 2.4.2 SOLUTIONSplus LEFVs in Latin America page 80) was already manufactured and commercialized since 2015, its utilization was limited to private spaces (SOLUTIONSplus, 2024).

At the local level, on the other hand, understanding the need for policies and regulations for urban logistics, in 2020, the Government of the Autonomous City of Buenos Aires (GCBA) created the Urban Logistics Unit, which is part of the Undersecretariat of Mobility Planning. Since then, this Unit has been promoting and supporting the private sector in the inclusion of new technologies through pilot tests with light electric vehicles (LEVs), implementation of pedal-assisted cargo bikes, conversion from thermal to electric motorization or retrofitting and the joint analysis of new types of operations, including cross-docking and micro-hubs.

In 2020, the GCBA introduced in the Law N° 2.148, i.e., the Code for Transit and Building of the City of Buenos Aires, the definitions of cross-docking and urban logistics micro-hubs enabling commercial garages, parking lots and places authorized by the local authority as places where load breaking, loading and unloading and temporary storage of goods for their final distribution or for their direct distribution to other establishments could be carried out.

These changes in the national and local regulations enabled Express Logística, one of the largest beverage distribution companies in Argentina, to establish micro hubs in private garages in the central neighborhoods of Recoleta and Palermo, from where the goods are distributed using the locally manufactured L6-category LEVs, Sero Electric.

Figure 44. Micro Hub Express Logística, Buenos Aires, Argentina. Source: SOLUTIONSplus Repository

The results in Buenos Aires show that the CO_2 emissions per 100 liters transported can be reduced 25% - 30% when introducing a LEV system (GCBA, 2022).

Case Study Box 5: Better Air Urban Zones (ZUMAs) in Bogotá, Colombia

In October 2023, the Municipality of Bogotá issued Decree 492 declaring the first Better Air Urban Zone, the ZUMA Bosa – Apogeo, delimitating it and defining monitoring criteria. The Bosa – Apogeo District was selected after a comprehensive analysis that assessed environmental, mobility, socio-economic and health characteristics of 15 districts.

ZUMAs are defined as areas aimed at improving air quality through the introduction of intersectorial actions that reduce emissions and their impact on human health and the planet's. Bogota's plan for the introduction of the ZUMAs in the city has a long-term horizon. It starts with an emission reduction phase (1 year), followed by a low-emission phase (6 years) and in the long run the goal is to have ultra-low emissions zones.

Among the actions intended to be implemented in the ZUMAs are to reduce emissions from industry and transportation, increase vegetation cover, maintain road networks, and reduce the risk of respiratory diseases associated with pollution. With regards to transport the measures include:

- To promote active mobility
- To improve public transport
- To prioritize the circulation of zero- or low-emissions vehicles
- To implement goods consolidation measures

It is in this context that the Municipality of Bogotá collaborated with research institutions, the private sector and international organizations for the implementation of the BiciCarga project in Bosa-Apogeo. The results show that with the estimated reduction of 20% of the cargo distributed in ICE vehicles by replacing them by e-cargo bikes, 60 kg PM 2.5 and 95 tCO2 could be avoided per year.

Moreover, based on the positive experience from Nutresa's microhub in the Southern Bus Terminal, the Municipality decided to establish there the first Consolidation Center of Bogotá.

Figure 45. Business in ZUMA Bosa – Apogeo and Southern Terminal Consolidation Center

3. Conclusion

The successful implementation of a LEFV system in a city requires a comprehensive approach encompassing organizational, software, hardware, and legislative aspects. This complex innovation demands careful consideration and planning across multiple dimensions to ensure its effectiveness and long-term success.

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