CITY ROADMAP FOR UPTAKE OF EFFICIENT, INTEGRATED AND INCLUSIVE LOW-CARBON MOBILITY IN QUITO, ECUADOR

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PROJECT PARTNERS

ABOUT

To provide inputs for local and national entities in Quito and Ecuador, as well as for the private sector and other relevant stakeholders to accelerate the transition to low-carbon urban mobility to reduce emissions in the four action lines in which SOLUTIONSplus was active during the 4+ years of the project

TITLE

City Roadmap for uptake of efficient, integrated and inclusive low-carbon mobility in Quito, Ecuador

CONTRIBUTERS

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DISCLAIMER

LAYOUT

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PICTURES

All the pictures are provided by the SOL+ partners

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Executive Summary

The National Government of Ecuador and the Municipality of Quito have taken important steps towards sustainable urban mobility, and in particular on e-mobility, in terms of policies and regulations and have already started some actions to achieve their decarbonization goals. Nationally, these regulations include the Energy Competitiveness Law (2024), the Reform to the Road Transport, Transit and Road Safety Law (LOTTSV 2021) the National e-mobility strategy (ENME 2021) and the National Urban Mobility Plan (NUMP 2022). At the local level, the city counts with Quito's Climate Action Plan (PACQ 2020) and the recently approved Sustainable Mobility Master Plan (PMMS 2024). However, the specific incentives, detailed regulations, tools and capacities needed to reach the ambitious goals set in the policies and plans are not fully in place. Thus, e-mobility in Quito and Ecuador still require a stronger framework for a proper scale-up.

In Quito, the demonstration activities carried out in the context of SOLUTIONSplus aimed to contribute to the advancement of e-mobility in the city in four fronts, i.e., 1) low-carbon urban logistics in the city center, 2) capacity building and technical assistance for the decarbonization of the public transport system, 3) Mobility as a Service and 4) gender and e-mobility.

In this context, Quito's City Roadmap builds on the results and learnings of the SOLUTIONSplus pilot in Quito and aligns with the existing regulatory framework in the city, in particular the Sustainable Mobility Master Plan (PMMS) developed in 2022 and approved by the City Council in 2024 to define the following objectives / action lines to continue the work started by SOLUTIONSplus towards low-carbon, integrated and inclusive mobility in the Metropolitan District of Quito:

1) Consolidate the Zero Emissions Historic Center goal by creating a LEV system for urban logistics in the HCQ
2) Contribute to a clean, efficient and integrated public transport system by introducing optimization tools and models in mobility planning
3) Enhance the intermodality in the transport system in Quito using digital tools such as Mobility as a Service applications
4) Close the gender gap in the transport sector by promoting economic inclusion of women throughout the value chain of the transport sector

The following table summarizes the focus areas that need to be addressed under each action line to achieve the overall goal.

Action line	Focus areas
1. Low-carbon urban logistics in the Historic Center of Quito by the introduction of a Light Electric Freight Vehicle (LEFV) System	1a. Orgware – collaborative governance and business models 1b. Software – optimal design of the LEFV system, i.e., the microhub location and LEFV routing) 1c. Hardware – adequate design and characteristics of LEFVs, microhub and road infrastructure 1d. Policy framework – enabling regulation and policies for the establishment of the LEFV system and its efficient functioning
2. Public Transport electrification (and optimization)	2a. Regulatory framework 2b. Charging infrastructure and interoperability

	2c. Business models 2d. Transport optimization models
3. Mobility as a Service (MaaS)	3a. Regulatory & collaboration framework 3b. Mobility stations to enhance intermodality
4. Gender and e-mobility	4a. Leadership and participation in decision making processes 4b. Economic inclusion 4c. Gender-responsive technology and infrastructure design

This City Roadmap will guide the design and implementation of the follow-up projects:

- E-MOVILIZA (GEF7 – 2023–2026): Support the shift towards low-carbon electric mobility in Ecuador
- ACCESS (2024–2029): Accelerating Access to Low-carbon Urban Mobility Solutions through Digitalization
- E-mobility as a Driver for Change (2023–2026): Towards a Gender Transformative and Just Transition to Electric Mobility
- EBRT (2023–2026): European Bus Rapid Transit of 2030

These projects will be executed in Quito, Ecuador until 2029 with a total budget of approximately 4 million Euros (for the country) and will, therefore, ensure the scale-up of the SOLUTIONSplus action lines to a mainstream phase from 2030 onwards.

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List of Abbreviations

BRT	Buses of Rapid Transit
HCQ	Historic Center of Quito
DMQ	Metropolitan District of Quito
ENEM	National Electromobility Strategy
EPMTPQ	Public Metropolitan Company of Passenger Transport of Quito
EPMMQ	Public Metropolitan Company of Metro Quito
GAD	Decentralized Autonomous Governments
GEF	Green Environment Fund
NDC	Nationally Determined Contribution
PACQ	Quito's Climate Action Plan
PMMS	Sustainable Mobility Master Plan
PNMUS	National Sustainable Urban Mobility Policy
SM	Mobility Secretariat of the Metropolitan District of Quito
SWOT	Strengths, Weaknesses, Opportunities, and Threats Analysis
WHO	World Health Organization
ZEZ	Zero Emissions Zone

Acknowledgements

Purpose	To provide inputs for local and national entities in Quito and Ecuador, as well as for the private sector and other relevant stakeholders to accelerate the transition to low-carbon urban mobility to reduce emissions in the four action lines in which SOLUTIONSplus was active during the 4+ years of the project.
Coordination	Wuppertal Institute (WI)
SOLUTIONSplus partners	- Wuppertal Institute for Climate, Environment and Energy (WI) - The Urban Electric Mobility Initiative (UEMI) - Zaragoza Logistics Center (ZLC) - Municipality of Quito (MDMQ)
Contributors	María Rosa Muñoz B. (WI), Alicia Martínez de Yuso (ZLC), Milos Milenkovic (ZLC), Grace López (UEMI), Alexandra Suasnavas (UEMI), Vanessa Lasso (UEMI), Lorena Saavedra (UEMI), Nicolás Toro (MDMQ)
Reviewers	

1. Background – Where are we now?

1.1. Urban mobility context in selected city

General context, topography and thermal variability

The Metropolitan District of Quito (DMQ) is the capital and the 2nd largest city of the Republic of Ecuador with a population of 2,7 million inhabitants, a similar population than Guayaquil (INEC, 2022). The DMQ covers an area of 4217 km^2, divided in 65 parishes, 33 rural and 32 urban. The urbanized area, however, represents less than 20% of the territory and is the result of three growth phases: until the 1950's it grew in a radial form; from the 1950's until the 1990's it grew longitudinally in north-south direction; and since the 1990's Quito has experienced urban sprawl to the east side of the territory (DMQ, 2020), as it can be seen in Figure 1. It extends over 42 km from North to South and and only 15 km from East to West with an expansive urban development in the valleys of Tumbaco and Los Chillos (DMQ, 2020).

The altitudinal gradient of the Metropolitan District of Quito oscillates between 500 (m a.s.l.) and 4 780 (m a.s.l.), which influences the presence of various climatic floors characterized by average annual temperature of 15 °C throughout its territory. The urban area, however, is situated at an average elevation of 2.850 meters above sea level on a plateau between the Western and Eastern Mountain chains of the northern Andes. Thus, Quito is surrounded by volcanoes and mountainous reliefs that delimit an elongated urban sprawl.

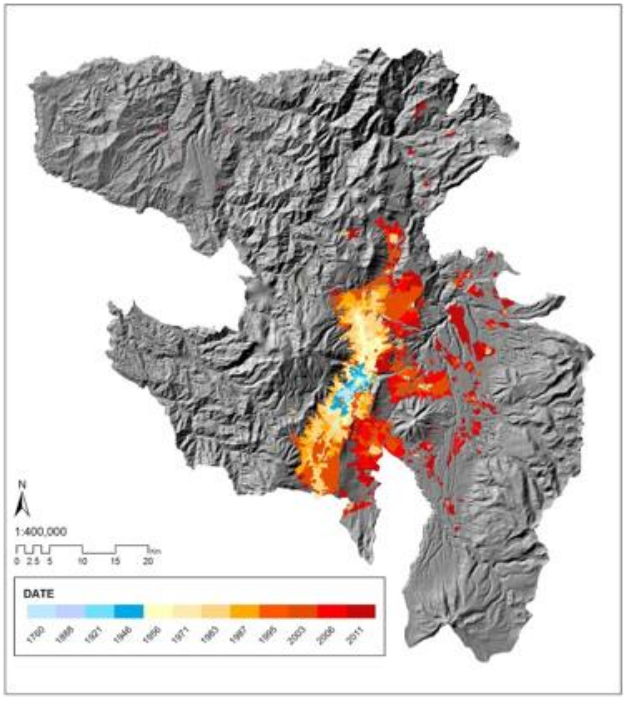


Figure 1. Physical Map of the political-administrative confine of the Metropolitan District of Quito and its urbanized area highlighted.
Source: Territory Habitat and Housing Secretariat (STHV, 2012)

Quito is known for its Historic Centre (CHQ), one of the largest, least-altered, and well-preserved in Latin America, by which Quito was declared World Heritage Site by UNESCO in 1978. The HCQ

comprises an urban area of 376 hectares, with approximately 40.000 inhabitants (DMQ, 2019) Due to its location in a narrow city like Quito, the HCQ is a regular crossing point for the commuters from the southern area of the city that go to the Central Business District (CBD) and it is also a commercial, touristic and mobility hub.

Environment and GHG emissions

The general analysis of air quality during 2020 (DMQ, 2020b) shows that 26% of the days of the year, the air is kept in good condition desirable (under 25% NECA), 71% remain acceptable (under 50% NECA), while in 3% of the days (37), the air quality was reported as in a state of caution (> = to the NECA value). The significant increase in days with desirable air quality and the decrease in days with caution, is due to mobility restrictions caused by the pandemic due to the proliferation of the SARS-Cov-2 virus, which forced a decrease in circulation vehicular from the month of March until the end of the year. This limitation of vehicular circulation caused the concentrations of pollutants PM2.5 and NO2 to reach their lowest values during the months of March and April (the lowest in the last 15 years) and restored according to the release of restrictions and the end of the state of emergency. The Pollutant values have not reached those measured during the first months of the year 2020, before the pandemic.

Herby, are the figures of air quality measured in existing monitoring stations in 2020 (DMQ and C40 2020c):

- PM2.5: 114 (El Camal station), 58 (Carapungo), 40 (Centro), 53 (Cotocollao), 59 (Guamaní), 6 (Los Chillos), 28 (San Antonio), 6 (Tumbaco).
- PM10: 162 Carapungo, 180 San Antonio

On the other hand, the average noise in 2020 in the Historic Center is twice as high as recommended by the WHO Guide (52dB). La Mariscal, La J street, the Historic Center, La Paz (Whymper) and La Jipijapa are the areas with highest noise levels. According to data from the Environmental Secretariat of the Municipality of Quito, in these sectors, the noise emission easily exceeds 65 decibels during the day and 55 at night (El Comercio, 2022). However, the norms in cities like Quito, decibels acceptable in the day range between 65 and 75dB, and in the night from 55 to 70dB, so in comparison the Historic Center would be within the average.

The DMQ GHG emissions inventory, prepared from the base year 2015, reflects an approximate total of 7,611,216 MT CO2e. This accumulated value is obtained from the evaluation carried out in each sector inventoried. In this sense, the highest concentration of emissions of GHG corresponds to the transport sector with close to 40% of total emissions, followed by 26% of total GHG emissions from energy consumption (residential, commercial, institutional and industrial). Likewise, 24% of the emissions are associated with anthropic activities from the AFOLU sector. Finally, 10% of the emissions totals are related to the waste sector (DMQ, 2020). The described data is presented in the following Figure 2.

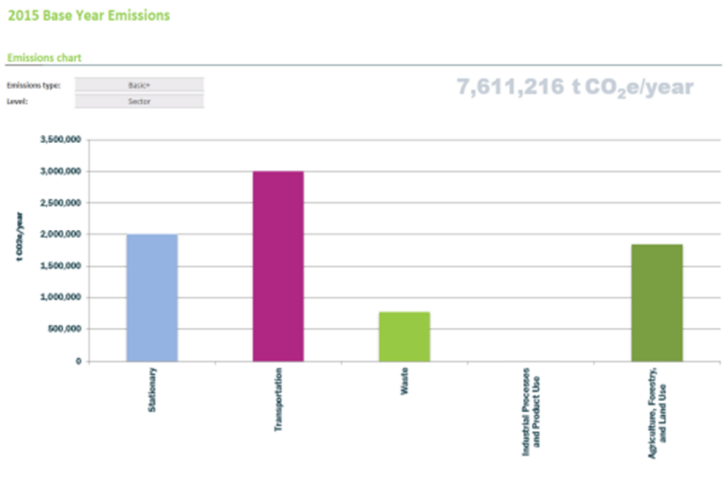


Figure 2. Quito's Net GHG emissions by sector 2015.
Source: Quito's Climate Action Plan (DMQ, 2020)

In terms of subsectors, the roads sub sector represents the main source of emissions in the DMQ with a 39% of the total GHG, caused by the operation of the BRT system and other buses, as well as taxis and private vehicles.

These results are like the nation GHGI, where transport is the sector with the highest energy consumption with 46% of the total amount of oil consumed annually, from which 31% corresponds to diesel oil and 27% to gasoline. The National GHG Inventory of 2012 showed that the energy sector was responsible for 46,3% of GHG emissions from which transport accounted for 45,2%, with a total of 37.6 million tCO2eq. By 2015, land transport consumed 87% of the energy of the subsector, from which heavy freight was responsible for 44% (MTOP, GIZ Ecuador, and B4future, 2018).

Urban Transport - status of urban passenger and freight transport

Most recent data shows that there are 3,9 million trips done daily in Quito. Among these, 7 out of 10 journeys are made using so-called sustainable modes of transport, either in non-motorized ways on a human scale (travels on foot with a 13% participation and in bicycle of less than 1%), or in collective public transport, 27% in conventional public transport and 22% in BRT buses.

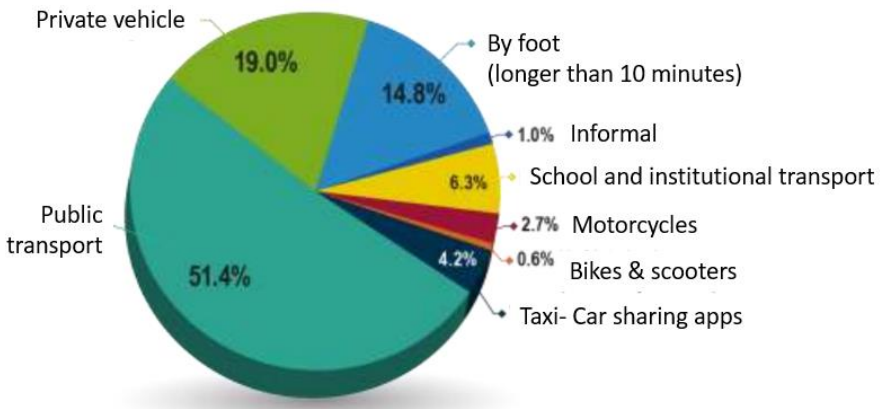


Figure 3. Transport Modal split in DMQ 2022.
Source: Diagnostic Synthesis- Sustainable Urban Mobility Master Plan (DMQ, 2022

National and local policies and plans related e-mobility

The Ecuadorian Government has adopted a series of plans, policies and laws to create the enabling environment to advance towards transport decarbonization countrywide. These include the Nationally Determined Contributions (NDCs), in which the country commits to reducing its GHG emissions by 9% unconditionally, and 21% if additional international resources are made available until 2025 in comparison to 2010. In order to mitigate the emissions of the transport sector, the country will focus on the promotion of efficient and sustainable transport sector such as the first tram line in Cuenca, the first subway line in Quito, and the cable car in Guayaquil (MAATE, 2022).

The Ecuadorian Energy Efficiency Law (LOEE) issued in March 2019 was created in order to guarantee energy sovereignty using environmentally clean technologies and non-polluting and low-impact alternative energies. To this end, Article 14, which refers to energy efficiency in the transport sector stipulates that, that from 2025 on all new public and commercial transport vehicles will have to be zero emissions (Ley Orgánica de Eficiencia Energética, 2019). Nevertheless, given the minimum progress observed between 2019 and 2023, the Energy Competitiveness Law, a reform to the Energy Efficiency Law approved in January 2024, postpones the start of the fleet renewal process to 2030 (Ley Orgánica de Competitividad Energética, 2024). Despite the extension, national experts still doubt the feasibility of 2030 due to the lack of incentives for e-mobility that exist in the country.

In the same context, the 2021 Reform to the *Law on Road Transport, Transit and Road Safety (LOTTTSV)* declares the public interest of e-mobility and exults Municipalities and National Ministries to create the necessary incentives to promote it within their corresponding mandates. In addition, this Reform establishes that electric vehicles should be exempt from the measures to restrict vehicle circulation; that EVs will have free use of paid public parking spaces within the jurisdiction of the municipalities; and that public entities and commercial establishments that offer parking spaces to the public must allocate a minimum percentage of 2% of the total number of parking spaces to EVs (Ley Orgánica de Transporte, Tránsito y Seguridad Vial, 2021).

The National Electromobility Strategy (ENME), a document elaborated in 2021 by the Interamerican Development Bank as technical cooperation for the Ministry of Transport and Public Works (MTOP), refers to the advantage that the country has due to its clean energy generation matrix, to which is added the interest of the National Government to develop electric mobility (BID & Hinicio, 2021). This translates into the existence of incentives in terms of taxes, tariffs and electricity rates, in addition to financing programs from Development Banks, such as the IDB, that are in the negotiation phase with a focus on fleet renewal with electric vehicles of different types (BID, 2024). It is worth noting that the ENME has not been officially adopted by the national government. Thus, the goals and targets set in it are not binding.

In addition to the National Electromobility Strategy, in June 2023 the country launched the National Sustainable Urban Mobility Policy (PNMUS) that establishes guidelines applicable to all the municipal governments of the country so that they can develop and implement strategies and actions in urban areas of different sizes to promote sustainable urban mobility. For these, various cross-cutting and specific guidelines have been issued, which include incentive schemes for the transition to more sustainable modes (MTOP, 2023).

Considering the national framework and in compliance with the international commitments to which the Municipality of Quito adhered in the past years, such as the C40 Clean Air Cities Declaration, the C40 Clean and Healthy Streets Declaration and the Mobilize Your City Global Initiative, in 2020 the Municipality of Quito issued its Climate Action Plan for Quito (PACQ by its Spanish acronym). With the PACQ, Quito commits to reduce GHG emissions by 30% in comparison to 2015 by 2030 and achieve climate neutrality by 2050. Given that the transport sector has been identified as the largest generator of GHG emissions in the city, being responsible for 40% of them, actions to mitigate its impact need to be prioritized. Thus, the PACQ defines the following mitigation actions for a sustainable urban mobility:

- Zero emissions public transport
- Zero emissions Historic Center
- Integrated and efficient public transport
- Active mobility
- Low carbon freight transport

In this context, the Municipality has been working on advancing on various fronts to promote sustainable mobility in general and more specifically electric mobility. On one hand, the municipality has already approved a series of ordinances to advance towards the sustainable mobility goals proposed in the PACQ, such as the Ordinance No. 017 (2020) for the integration of all the public transport subsystems of the city, the Ordinance No. 0194 (2017), which regulates the different modes of transportation in the city and its circulation priority with a strong focus on walking and cycling. Moreover, the Municipality advances in the discussion of a Draft Ordinance for the Gradual Decarbonization of Public and Private Transport, and Promotion of the Use of Clean Technologies, and a second one on the regulation of Light Electric Vehicles (LEV).

On the other hand, the Mobility Secretariat finalized the Sustainable Mobility Master Plan 2022 – 2042 (PMMS due to its acronym in Spanish), an in-depth study that will be a reference guide for the management of the development of the Metropolitan Sustainable Mobility System in the next 20 years, which was officially approved by the City Council in February 2024 under Ordinance No. PUC-001-2024. The PMMS is an important input for Quito, since it contemplates fundamental principles and public policies as well as strategic guidelines, programs and projects that make up an accessible city with universal equity, in accordance with the vision of urban development established in the Metropolitan Land Use Plan (SecMov, 2023b).

The main references for the development of the document are the current Integrated Public Transport System (SITP by its Spanish acronym), which has the first subway line inaugurated in December 2023 as the backbone of the mobility system, the public transport subsystems; and all of this is legally defined under a physical and fare integration scheme towards an Integrated Public Transport System and other components such as commercial transport -taxis, school, institutional, tourism- (SecMov, 2023b).

According to the PMMS, the five key goals established for the mobility of the city are:

1. Reduction of 75% in emissions from transport sector until 2042
2. Improvement of travel experience based on passenger perception
3. Shift in modal split (see figure 4)
4. Introduction of alternative funding sources in 25% of mobility projects
5. Increase of road safety by the reduction of 50% in casualties

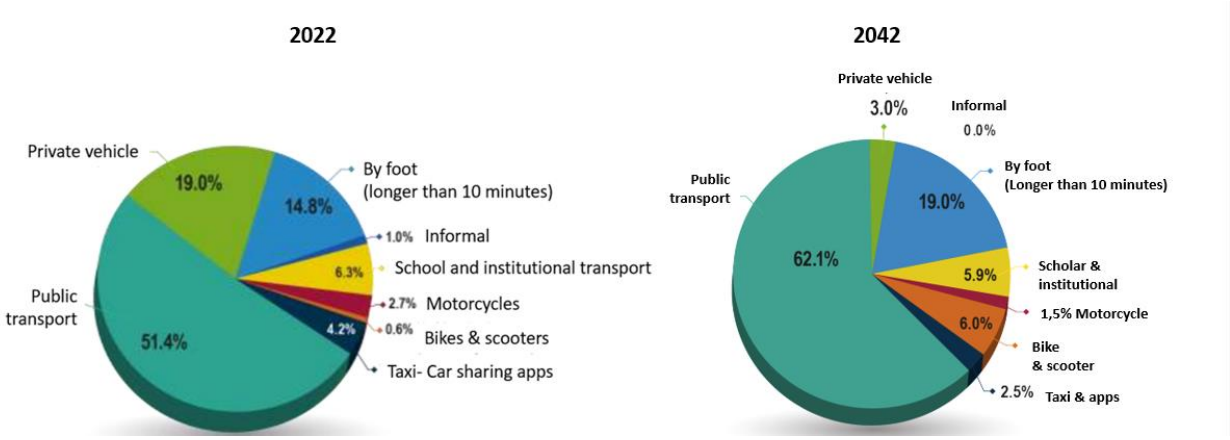


Figure 4. Modal split shift 2022-2042
Source: Diagnostic Synthesis- Sustainable Urban Mobility Master Plan (DMQ, 2022)

The total investment of the PMMS is presented below, separated by time horizon and specified by each Complementary Plan, which adds up to $7,510,311,863 in 20 years. This amount of investment in mobility is consistent in the medium term with the investments stipulated in the local development plan (PMDOT) 2021-2033 (DMQ,2022). The PMMS developed 9 complementary plans, 33 programs and 139 projects that will have to be carried out until 2042 to achieve the plan's goals.

Table 1. Total Investment Plan

N°	Complimentary Plan	Inmediate (2022-2023)	Short term (2023-2027)	Mid term (2027-2032)	Long term (2032-2042)	Total estimated cost
I	Public transport plan	$ 1.646.706	$ 281.055.022	$ 1.236.658.743	$ 5.266.112.666	$ 6.785.473.138
II	Commercial vehicle plan	-	$ 1.850.000	$ 2.100.000	$ 1.600.000	$ 5.550.000
III	Shared mobility plan	-	$ 824.277	$ 786.184	$ 1.110.551	$ 2.721.012
VI	Commercial freight plan	$ 30.000	$ 2.700.000	$ 10.030.000	$ 30.000	$ 12.790.000
V	Sustainable transport, active and micromobility plan	-	$ 25.545.268	$ 16.724.176	$ 19.805.845	$ 62.075.290
VI	Traffic management plan	$ 70.303	$ 715.656	$ 51.833.090	$ 24.520.000	$ 77.139.049
VII	Road provision and maintainance plan	-	$ 35.614.901	$ 250.088.470	$ 235.489.916	$ 521.193.287
VIII	Road safety plan	$ 1.799.437	$ 10.229.092	$ 9.797.186	$ 18.794.372	$ 40.620.086
IX	Trip demand management plan	$ 400.000	$ 2.350.000	-	-	$ 2.750.000
	Total	**$ 3.946.446**	**$ 360.884.217**	**$ 1.578.017.850**	**$ 5.567.463.350**	**$ 7.510.311.863**

Source: Sustainable Urban Mobility Master Plan, 2022

Table 2 shows the list of 33 programs included in the PMMS and marks the ones directly related to the 4 prioritized action lines that will be addressed in this City Roadmap.

Table 2. Programs of the PMMS

#	PROGRAMS	LINKED PLAN/S
1	Zero emissions Historic Center	IX, I
2	Connectivity and accessibility improvement at the zone level	VII, I
3	Connectivity and accessibility improvement at the sector level	VII, I
4	Connectivity and accessibility improvement at the metropolitan level	VII, I
5	Implementation of new road infrastructure to improve conflict zones and reduce travel time	VII
6	Road infrastructure management	VII
7	Maintenance of road infrastructure	VI, VII
8	Identity corridors	V
9	Institutional arrangement for the operation of the SITP	I
10	Implementation of alternative financial mechanisms for mobility	IX, VI
11	Smart mobility	I, VI
12	Optimization of public transport infrastructure	VII, V
13	Integrated Public Transport System (SITP)	V, I
14	Active mobility for an active city	V
15	Taxi in the DMQ: a trip friend	II
16	Enhancing tourism through transport	II
17	Complete streets	V
18	Differential services	I
19	Sustainable mobility culture for acknowledging different road users	I
20	Demand management measures	III, IX, VI
21	School mobility	II, III, VIII
22	Sustainable mobility culture and promotion	V
23	Last mile logistics	IV
24	Optimization of the logistics value chain and reduction of associated externalities	IV
25	Mobility data	V, VI
26	Sustainable mobility culture for acknowledging different road users	VIII
27	Road safety as a priority criterion for road interventions	VIII
28	Speed management and traffic calming program	VIII
29	Control and supervision	VIII
30	Care for victims	VIII
31	Safe vehicles in the public sector	VIII
32	E-mobility	V
33	Sustainable Mobility Oriented Development (DOMS)	V

1.2. The SOLUTIONSplus project in Quito

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 Quito, the city demonstration aimed to contribute to the advancement of e-mobility in the city in four fronts:

- Component 1, the main component of the demonstration is the Multimodal e-mobility hub in the Historic Center of Quito (HCQ). This pilot aimed to contribute 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. For this, the project allocated seed funding to three SMEs for the development of prototypes and subsequent assembly of different types of LEVs, both passenger and cargo. The implementation of the pilot was planned to be executed in two phases. The first phase of the pilot was completed at the beginning of 2023, by testing 10 e-cargo bikes in four different operating schemes in the HCQ. Once the pilot ended, the vehicles were given in permanent custody to the logistics operators that obtained the best results. The 4 e-mini vans and 4 e-quadricycles for the second phase are ready and will be tested by courier companies in the context of the follow-up project E-MOVILIZA (GEF7 Ecuador).
- Component 2 contributed to enhancing the capacities and providing technical assistance on e-buses and trolleybuses to the municipal staff working in the field. Several representatives of Quito's mobility secretariat and municipal PTO were able to participate in conferences, site visits and training in Latin America and Europe.
- Component 3 focused on the development and use of Mobility-as-a-Service (MaaS) solutions. Specifically, in the context of the project, Pluservice developed a MaaS App during 2020 and 2021 with the permanent participation of the Mobility Secretariat, the Municipal PTO and the Subway operator to ensure that the app is in line with the local needs of the PT system. The app was tested between November and December 2022 with a group of university students helping them plan trips and pay for public transport.
- Finally, Component 4, closing the gender gap in the (e-)mobility sector and contributing to a just transition is an element that was added during the project implementation as the gender gap in the sector became visible.

Along with the pilot implementation, the SOLUTIONSplus team has been working with the city of Quito and other relevant stakeholders in the corresponding impact assessment, capacity development,

business models and policies that will enable the replication and scale-up of the demonstration, all which are summarized in Figure 5:

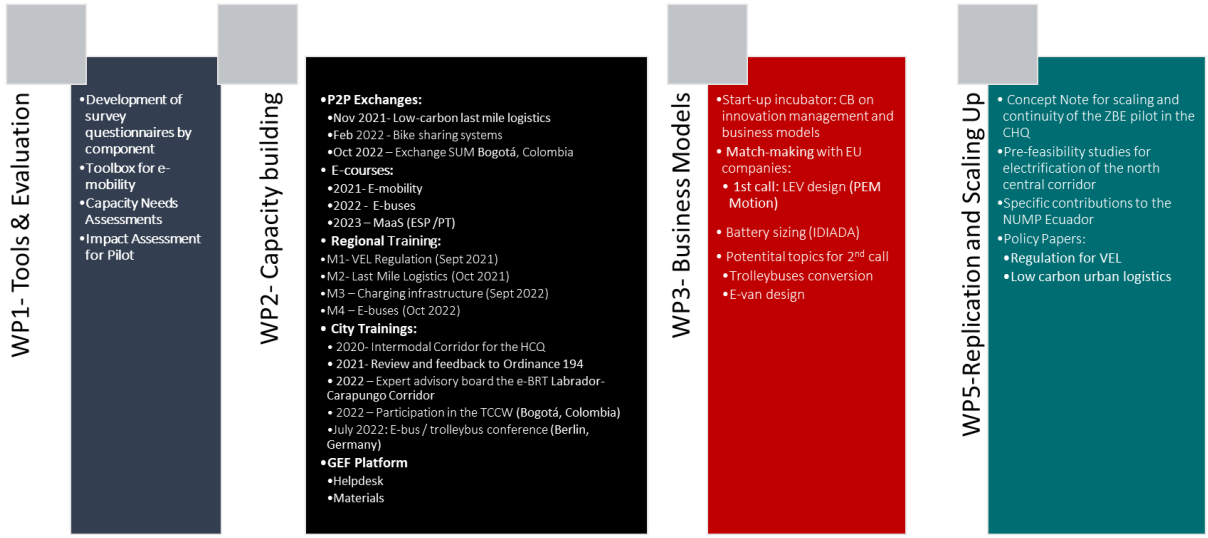


Figure 5. Contribution of SOLUTIONSplus work packages to the Quito demonstration
Source: SOLUTIONSplus

As it is shown in Figure 5, during the 4 and a half years of the project, Quito benefited from several capacity building and technical assistance instances tailored to their needs and requests. As a matter of fact, a total of four learning modules were carried out virtually in the context of the Regional Training Programs of 2021 and 2022, addressing the gaps identified in the Technical Needs Assessment: 1) low-carbon urban logistics, 2) LEV regulations, 3) charging infrastructure, and 4) e-buses. Quito not only benefited from the content presented but was able to share initiatives that public and private actors are pushing forward in the city (e.g.: Zero Emissions Zone and locally manufactured e-bus).

Between July 18th and August 3rd, 2022, a SOLUTIONSplus delegation (WI, FIER and UEMI) joined the local team and held a series of meetings and workshops, where topics such as e-buses, charging infrastructure, MaaS, LEV and urban logistics were discussed with members of national and local entities, as well as with private stakeholders.

In November 2023, an expert from the SOLUTIONSplus partner ZLC was on-site to present the results of the logistics model and recommendations developed to all the relevant stakeholders, including the municipal authorities, logistics operators and to the Mathematical Modelling Centre (ModeMat) of the National Polytechnic School (EPN), the entity in charge of carrying on the modelling beyond SOLUTIONSplus.

In March 2024, a multistakeholder delegation of 14 people from Quito, representing the Municipality, the Municipal PTO, LEV manufacturers and logistics operators participated in the Latin American e-Mobility Forum 2024 (LAEMF) in Bogotá, Colombia. The LAEMF, organized by SOLUTIONSplus and the GEF7 Regional Platform, summoned approximately 100 participants from the region and provided the opportunity to learn in situ from one of the countries leading the transition to e-mobility in Latin America, both in public transport and in urban logistics.

Figure 6. Quito's delegation in the Latin American e-Mobility Forum - Bogotá, Colombia 2024

Additionally, Quito benefited from its participation in other SOLUTIONSplus capacity building activities, including virtual and on-site peer-to-peer exchanges, site visits, e-courses, expert advisory boards and international conferences related to e-bike sharing systems, low-carbon urban logistics, last-mile connectivity, e-cargo bikes, e-buses, e-BRT, trolleybuses, MaaS, batteries, Eco-driving and the Low-Carbon Mobility Management (LCMM) Tool from T-Systems.

2. Approach – Methodology

The work conducted by SOLUTIONSplus in Quito during the past 4 years (2020 - 2024) included not only the demonstration activities, but also impact (and scale-up) assessment, capacity building, technical assistance, business models, policy development and the identification of funding sources. Thus, this City Roadmap will build on the results of this work and align with the existing regulatory framework in the city, in particular the Sustainable Mobility Master Plan (PMMS) developed in 2022 and approved by the City Council in 2024, focusing on prioritized action lines to advance towards low-carbon, integrated and inclusive mobility in the Metropolitan District of Quito. The four action lines are:

1. Low carbon Last Mile Logistics by introducing (locally produced) Light Electric Vehicles (LEV) for urban logistics
2. Public transport electrification (&optimization)
3. Mobility as a Service aimed at serving as a tool to complement the Integrated Payment System (SIR by its Spanish acronym), consolidate the integration of the PT system and promote intermodality by adding other sustainable modes to the platform
4. Gender and (e-)Mobility is a cross-cutting issue identified during SOLUTIONSplus, mainly with regards to the inclusion of women in a male-dominated sector

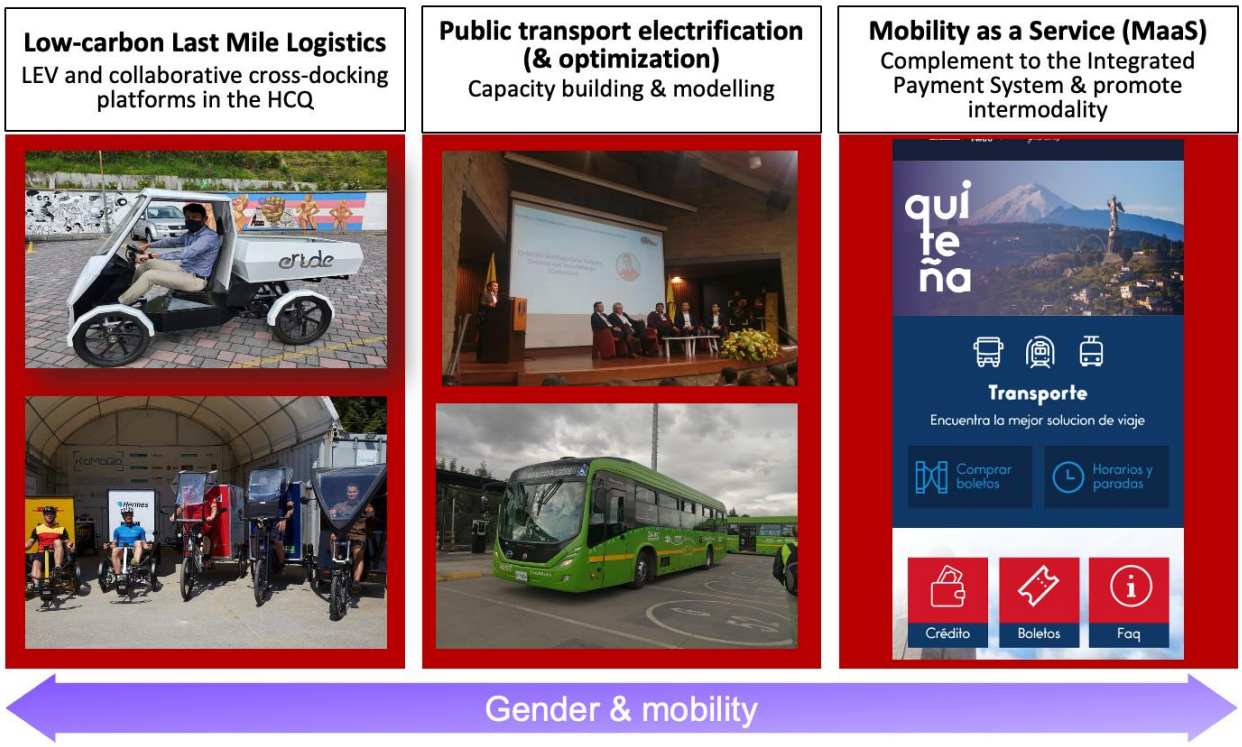


Figure 7. Action lines City Roadmap

A strong relationship between the action lines prioritized in this city roadmap and the PMMS has been identified and aims to be strengthened through the development of this city roadmap. Out of the 5 objectives of the PMMS, this city roadmap will be relevant for 3, i.e.:

- Objective 1: To mitigate GHG emissions from the transport sector
- Objective 4: To promote a high-quality public transport system that prioritizes low/zero-emissions transport modes, as well as resilient and sustainable infrastructure
- Objective 5: To generate an integrated transport system focused on multimodality

The methods

In order to elaborate this city roadmap, the following quantitative and qualitative methods were used:

- **Data collection** before and after the implementation of the pilots was carried out to understand the baseline situation, the impact of the pilot and the scale-up potential
- **Extensive literature review** focusing on the existing gaps in the national and local policies and regulations that need to be addressed to accelerate the transition to low-carbon mobility in each one of the four work streams identified. It also included a comprehensive review of the current trends in sustainable urban mobility, worldwide and in Latin America.
- The work conducted by SOLUTIONSplus in Quito during 4 years allowed the regional and local teams to **observe and document** the main challenges to scale-up the pilots in each work stream. All these learnings are reflected in this document
- **Expert interviews** to local policy makers, transport operators and vehicle manufacturers were conducted to understand the main barriers that they identify for the scale-up of the solutions piloted and the best way to address them. A total of 14 interviews were conducted manly with representatives of the Mobility and Environment Secretariats of the Municipality of Quito.

- **Case studies** from other cities, mainly Latin American ones, are integrated in the document to showcase how the focus areas could be implemented in Quito using good examples as a reference and inspiration.
- A **Stakeholder workshop series** was conducted in January 2024 with policy makers, private sector, academia and civil society organizations to discuss the challenges and opportunities in each one of the four work streams. A total of 75 representatives of these sectors participated in person and 135 online. Table 1 shows the number of participants by type. The goal of this series of workshops was to understand the diverse needs and perspectives of all stakeholders and to ensure that all actors are actively involved in the construction of Quito's City Roadmap. The ownership generated by such a collaborative process is key for the actual implementation of the measures proposed in this city roadmap to advance in the transition to low-carbon urban mobility in Quito.

Table 3. In person Participants' Summary in the SOLUTIONSplus' workshops in January 2024

Type of organization	Number of participants	Rate of participation
Public (Quito's municipal organization)	6	8%
Private sector	4	6%
Academia	21	28%
Civil Society	44	58%

The City Roadmap Workshop Series

In order to ensure that Quito's City Roadmap was built in a participatory manner, a workshop series was held from January 16 to 18 in the premises of the National Polytechnic School (EPN). The workshop were organized jointly by the SOLUTIONSplus regional and local teams and the Municipality of Quito with the support of the EPN and gathered more than 200 (75 in person and online) representatives of municipal entities, transport operators, mobility service providers, academia and civil society organisations. Through participatory design workshops connected by Miro's app and scenario planning exercises, SOLUTIONSplus facilitates a creative and inclusive process where diverse perspectives converge to generate actionable recommendations for the Urban Mobility Road Map. The session started with the presentation of the SOLUTIONSplus results, followed by the work being carried out by the municipality and other public and private actors in each one of the action lines and finished with a discussion with all the participants about the challenges, opportunities and ways forward on the topic: (i) implementing low-carbon last mile logistics, (ii) electrifying and optimizing Public Transport, and (iii) exploring technological solutions for the Integrated Public Transport System (SITP) that enhance multimodality with a specific focus on Mobility as a Service (MaaS). Gender was addressed as a cross-cutting issue in each one of the sessions.

Figure 8. City's Road Map Workshops in January 2024, taken from the SOLUTIONSplus Data Base

3. The Roadmap – Where are we going?

3.1. Vision

In 2024, urban mobility cannot be understood without considering the new mobility trends, of which electric vehicles are just one. Shared mobility, digitalization, new operating and business models are here to stay. In addition, the emergence of new mobility concepts and the widespread use of smartphones worldwide have led to the emergence of a significant number of mobility applications and services aimed at improving the efficiency of urban mobility, both for freight and passenger transport. Therefore, this City Roadmap embraces all these new mobility concepts and trends, linking them to the experience of the demonstration activities carried out in Quito in the context of SOLUTIONSplus and to the available policy framework, in order to propose contextualized, realistic solutions that require thinking outside the box in order to be implemented. In this context, this City Roadmap would like to use the new mobility pyramid proposed by PRIF (2021), which includes not only passenger transportation, but also freight transportation beyond the use of heavy-duty vehicles. A mobility system that integrates micro and light electric vehicles for people and goods, and one that takes into account shared mobility services and is gender-inclusive from the conception.

The Metropolitan District of Quito (MDMQ by its Spanish acronym) leads the transition to low-carbon urban mobility in Quito by implementing innovative solutions that not only contribute to the city's GHG emissions reduction goals, but also to the consolidation of a safe, efficient, integrated, inter-modal and inclusive transport system. Therefore, Quito becomes a frontrunner in Latin America in terms of the transition to low-carbon mobility. This is directly in line with the Sustainable Mobility Master Plan (PMMS), approved by the City Council in 2024, which will serve as the main policy document to guide the development of this city roadmap.

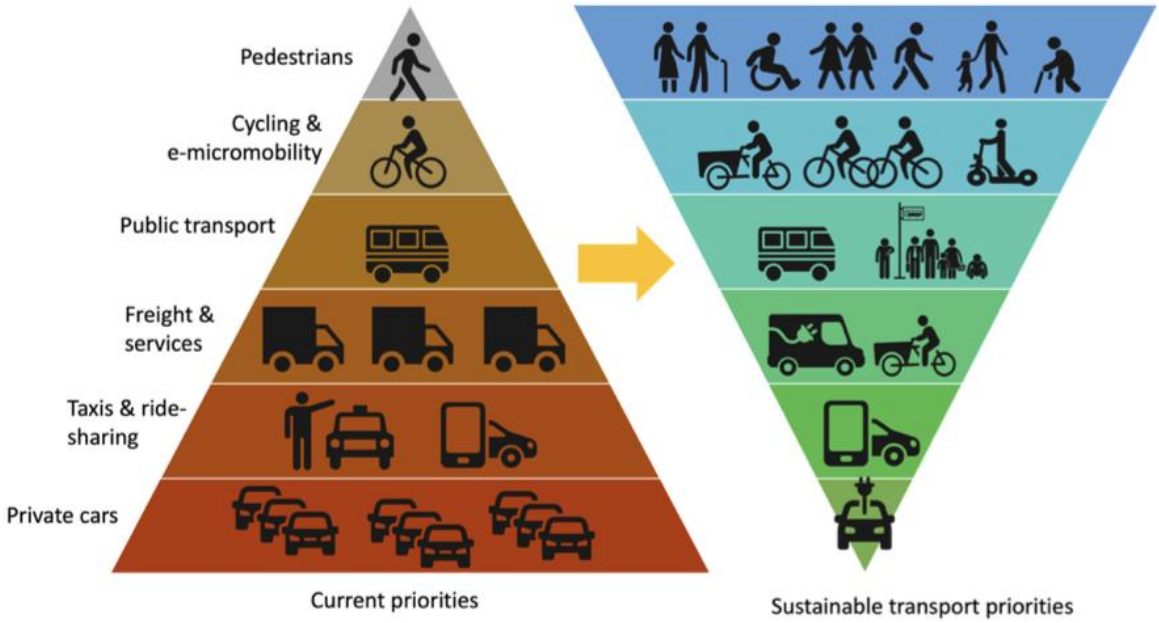


Figure 9. Shift from a car-oriented paradigm to a people-first one. Source: PRIF (2021)

3.2. Objectives

Following the approach mentioned in the previous section and the learnings and priorities from the SOLUTIONSplus Project, the objectives of these City Roadmap are the following:

1) Consolidate the Zero Emissions Historic Center target by introducing a LEFV system for urban logistics in the HCQ
2) Contribute to a clean, efficient and integrated public transport system by introducing optimization tools and models in mobility planning
3) Enhance the intermodality in the transport system in Quito using digital tools such as Mobility as a Service applications
4) Close the gender gap in the transport sector by promoting economic inclusion of women throughout the value chain of the transport sector

These objectives will be addressed in the City Roadmap as Action Lines.

3.3. Stakeholders

Figure 10 presents the stakeholders that need to be involved for achieving the objectives defined in this City Roadmap.

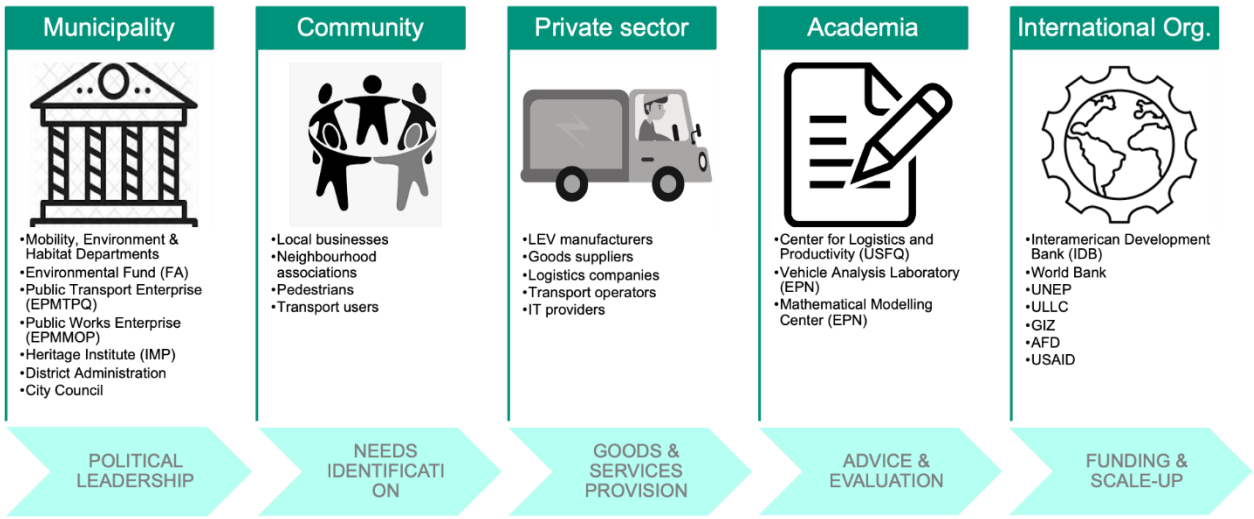


Figure 10. Stakeholder map and roles

Action line 1: A LEV system for urban logistics in the HCQ

4. Action line 1: A LEV system for urban logistics in the Historic Center of Quito (HCQ)

4.1. Current Policy Framework and Market Readiness for deployment of low-carbon last mile logistics in the HCQ

The Historic Center of Quito (HCQ)

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.

Despite the provisions of Ordinance No. 147, which regulates logistics in the Historic Center, night loading and unloading schedules are not compatible with the business dynamics of the territory, and the infrastructure is deficient (IMP, 2019). According to a survey conducted in 2018, which had the residents and business owners in the HCQ as the target group, 58% of respondents identified congestion problems as the main barrier for provisioning for their businesses, a circumstance aggravated by the fact that 93% gets supplies at least once a week, and 28% in fact receives merchandise daily (Secretaría de Movilidad, 2018).

Moreover, due to its location in the center of a long and narrow city like Quito, the HCQ is an obligatory crossing point for many commuters from the southern area of the city that go to the Central Business District (CBD) to work and study. However, the colonial urban structure, which remains unchanged, cannot withstand the current flows of vehicles, generating high levels of congestion and air and noise pollution. The air pollutants and the constant vibration threaten not only the health of the people that work and live in the area but also the vulnerable structures of the old colonial buildings (MIDUVI, 2013).

This situation, together with the commitments made by Quito to contribute to the mitigation of the global climate crisis, led to the decision of turning the area into a Zero Emissions Zone (ZEZ) by 2030 and thus starting the pedestrianization of several streets in the core of the HCQ (Secretaría de Ambiente, 2020). As a result, in 2019 nine streets in the main area of the HCQ were turned into pedestrian streets, on which 280,000 people walk on weekdays and 315,000 on weekends. Moreover, the concentration of air pollutants such as PM2.5 and CO decreased by 30% and 60%, correspondingly, after the pedestrianization (Carvajal, 2019). Despite the improved accessibility, road safety, and air quality experienced by pedestrians, however, this measure has made the distribution of goods difficult in the area (La Hora, 2019). Additionally, with the launch of the first subway line in Quito in December 2023 and the San Francisco Station in the core of the HCQ, the receives 16% of the total trips made by subway among the 15 stations, i.e., approximately 20,000 daily trips (Metro de Quito, 2024).

In the CHQ area, 76,038 private vehicles, 1,233 buses, 65 conventional bus lines and 16 feeder lines circulate daily. This situation has led to high levels of vehicle congestion, reducing traffic speed to 3 km/h at peak hours, when the average in the city is 25 km/h. The most important means of

mobilization in the Historic Centre are public transport (72%) and pedestrian transport (19%). Due to the topography of the territory, there are areas of difficult pedestrian access, as there are slopes that exceed 30% (IMP, 2019). Also, walkability is complex as well since pedestrians must share the road with heavy congestion and lack of safety and pedestrian routes are not well connected either. This is the situation that led to the pedestrianization of further streets in the core of the HCQ and the decision of turning the area into a Zero Emission Zone (ZEZ).

Hence, the current setup in the HCQ poses challenges for logistics, but it creates important opportunities to transform the high pollutant, disruptive and inefficient logistics in the area. It is in this context that the SOLUTIONSplus project had as its main component in Quito the implementation of an e-mobility pilot and complementary measures aimed at contributing to the last-mile logistics of the HCQ. Accordingly, the SOLUTIONSplus Team led by the Wuppertal Institute (WI), the Zaragoza Logistics Center (ZLC) and the Urban Electric Mobility Initiative (UEMI) have put together in this section the steps forward for the consolidation of a LEV System for urban logistics in the HCQ.

The local policies

As mentioned previously, in 2015 Quito joined the C40 Climate Leadership Group and signed the Declaration of Green and Healthy Streets and the Declaration of Cities with Clean Air. Through the first, it commits, among other actions, to "lead by example through the acquisition of zero-emission vehicles for our urban fleets as quickly as possible" and "Collaborate with suppliers, fleet operators and companies to accelerate the change to zero emission vehicles. The second one assumes the commitment to implement regulations and policies focused on the significant reduction of air pollution and integrates measures with a high potential for reducing emissions, such as the creation of Zero-Emission Zones. This international commitment was integrated into Quito's Climate Action Plan with the goal of materializing a Zero-Emission Historic Center by 2030.

In terms of local regulations, Ordinance No. 0194 was issued by the Municipality of Quito in 2017 to regulate the modes of transportation in the city and its circulation priority. In 2019, however, the need to include other modes besides cycling and walking was detected, so the Municipality decided to develop an ordinance project for personal, electric, and mechanical mobility vehicles. The document was developed in February 2020 with the support of a consulting firm.

Also relevant to this action line is the Integral Plan of Development of the Historic Center of Quito (2018), which outlines four strategies to face the main problems identified in the area. These include the creation of a sustainable multimodal mobility and public space network and the promotion of local capacities and economic activities in the HCQ (IMP, 2018).

The Integral Plan establishes a model for mobility based on the organization by super blocks ("supermanzanas"), which foresees a rearrangement of vehicular traffic, based on a study of redistribution of public and private transport, as well as mechanisms of mitigation and adaptation to climate change, for a continuous improvement of environmental quality (IMP, 2018). Furthermore, the Plan states that the regulatory framework to be developed should prioritize the use of electric transport in the HCQ to reduce the negative impacts produced by air and noise pollution. The proposed Plan for the Integral Development of the HCQ foresees the introduction of electric freight and passengers' vehicles (IMP 2018).

Subsequently, based on the types of vehicles proposed by the SOLUTIONSplus project and the proliferation of new types of 2 and 3-wheel internal combustion vehicles during the pandemic, the need arose to broaden the scope to include the regulation of freight vehicles and other types of vehicles, and the Municipality requested the experience of SOLUTIONSplus members to make the necessary modifications. As a result, the amending ordinance proposal broadens the scope so that it does not refer only to electric vehicles for personal mobility, but rather the concept of light sustainable mobility was introduced, which covers Light Electric Vehicles (transportation of people and cargo) and the Non-Motorized Mobility. The proposed regulation covers everything that is internationally grouped under the name Light Electric Vehicles, for which a recategorization of all vehicles was carried out using the ABC categories of Electric Mobility Passenger Vehicles and the L category for passenger and cargo vehicles. bigger size; and aspects of equipment and safety for light electric vehicles and circulation conditions by type were added.

The PMMS establishes Objective 1 "Mitigate the emissions of Greenhouse Effect Gases generated by the transport sector". As it was mentioned, it defines 139 projects grouped into 9 programs linked to the PMDOT and detailed in 9 Complementary Plans, one of which is Plan IV: Commercial Freight Plan. This plan, which has an estimated budget of almost USD 13 million, includes 2 relevant Programs (MDMQ, 2024):

- Last mile logistics
- Optimization of the logistics value chain and reduction of associated externalities

Moreover, Plan IX: Trip Demand Management includes one specific Program for the Zero Emission Zone in the Historic Center.

Within the projects, Plan IV contemplates:

- Freight consolidation hubs
- LML in non-motorized or cero emissions transport in the HCQ and other areas of the city
- Implementation of loading and unloading areas and update of the corresponding regulations

The logistics dynamics in the Historic Center of Quito

Between July and September 2021, SOLUTIONSplus conducted a data collection process 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. A second data collection process was conducted in February 2023 by the local consultancy firm Oikonomics funded by the Interamerican Development Bank (IDB) to identify the scale-up potential of the SOLUTIONSplus pilot project to a control group. A total of 101 businesses, 106 drivers conducting deliveries and 6 representatives of large logistics companies active in the HCQ were surveyed. The methodology and questionnaire used mirrored the one from 2021. In comparison to the first one, this process also surveyed the supply side, which contributed additional information to the research. The results of these 2 data collection processes are used here to present the main characteristics of the logistics in the HCQ.

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 11) 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.

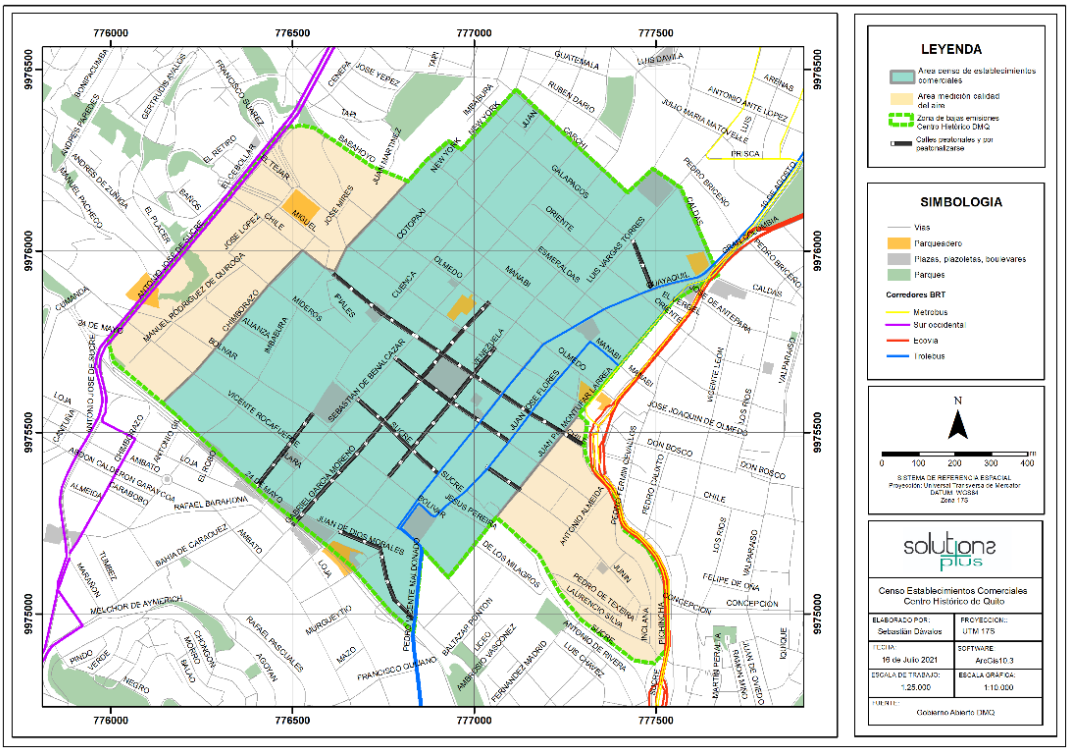


Figure 11. Defined Area

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.

As it was mentioned before, the HCQ is characterized by a high density of commercial activities (Figure 12).

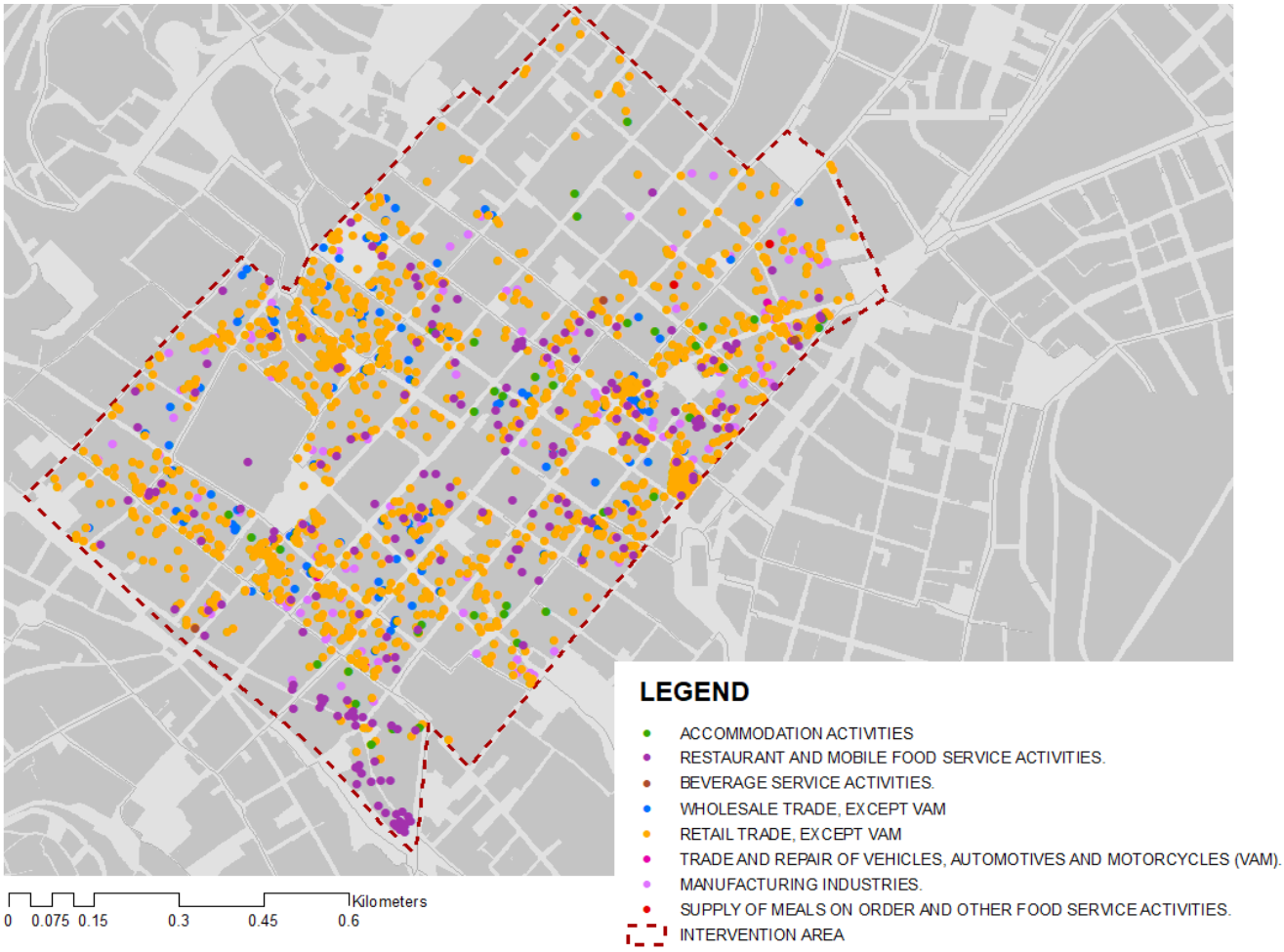


Figure 12. The size of the potential market. Source: MDMQ, 2019

The business and products structure in the HCQ

As it can be seen in Figure 13, the main economic activities in the HCQ identified in the survey are related to retail (48%), the HoReCa sector (28%) and the wholesale sector (25%), confirming the commercial and touristic character of the area. In particular, the five activities that are predominant in the economic structure of the HCQ are restaurants and food service (26%), wholesale and retail trade of clothing (19%), retail sale in non-specialized stores (16%), non-specialized trade with a predominance of food, beverages and tobacco sales (7%), retail sale of pharmaceutical products (7%). These activities represent 75% of the surveyed businesses, the remaining 25% corresponds mainly to retail and wholesale of various articles and hotel and lodging activities.

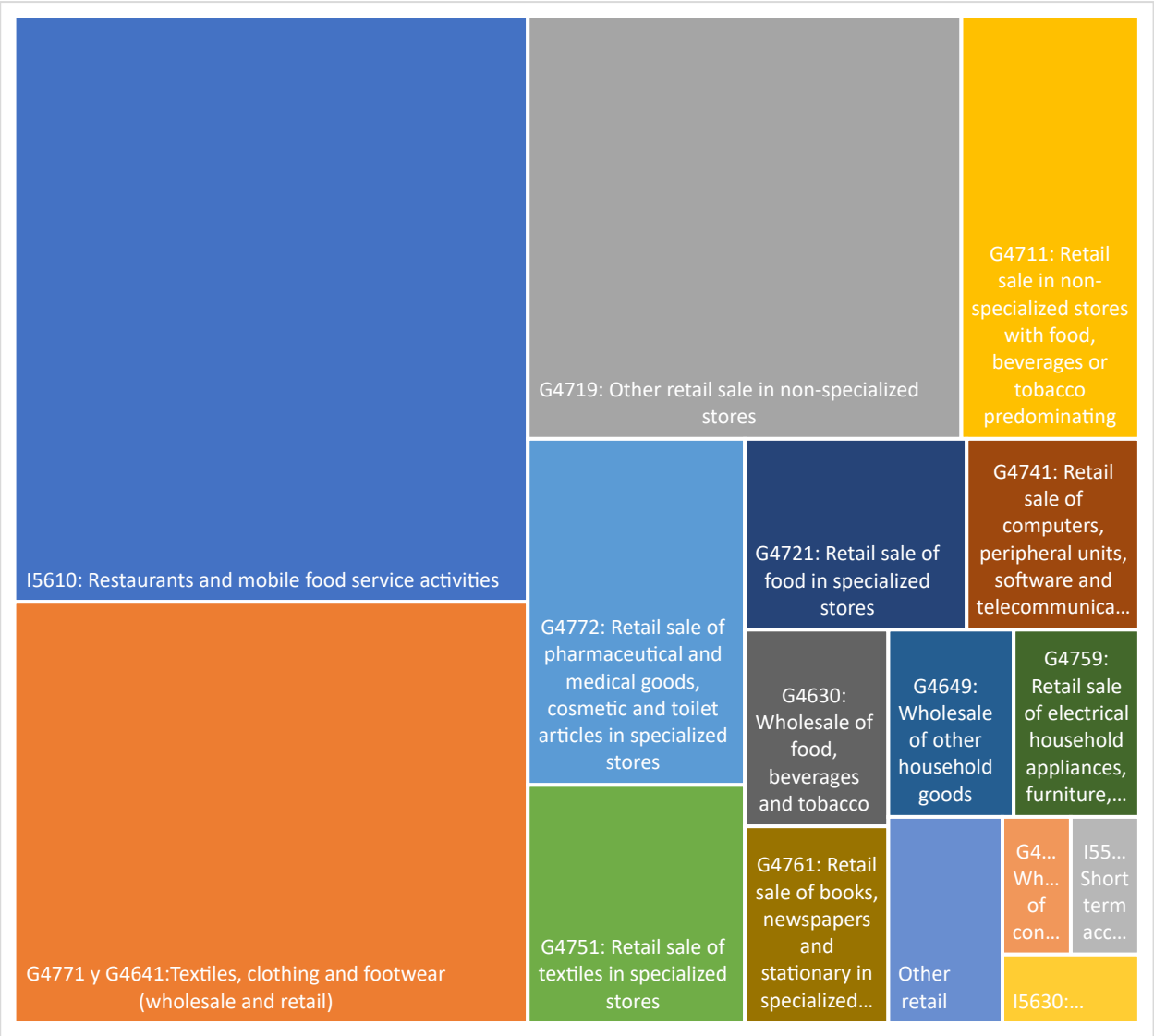


Figure 13. The economic structure of the HCQ

With regards to the products supplied in the HCQ, 73% are textiles, leather and leather products (23%), beverages and tobacco (17%), paper and cardboard (9%), meat products (8%), chemicals (8%), other agricultural products (4%) and other food products (4%). All these products have their own specificities in terms of volume, mass, opportunity cost and special handling/carrying requirements which have implications on the main characteristics of LEFVs. This product structure enables a high level of consolidation and LEFVs fleet mix composed mostly of single compartment vehicles. However, it is important to mention that some of the products, such as meat, might need refrigerated boxes to be transported using LEFVs.

The provision

Regarding the form of supply, 43% of the business in the HCQ obtain the goods from direct suppliers, 25% do the provision themselves and 32% that use both forms of supply. Regarding the frequency of supply, 63% of the businesses in the HCQ receive provisions at least once a week, showing the high level of deliveries to which the HCQ is exposed on a daily basis. Figure 14 shows that most of the

provision (60%) happens in the morning between 8am and 1pm. There is, however, an important 19% of deliveries still happens between 1pm and 5pm.

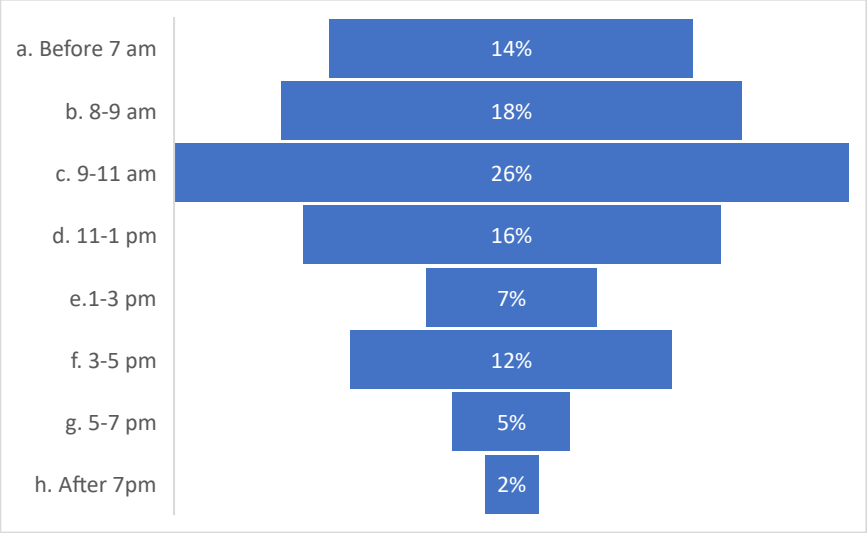


Figure 14. Supply share by time

Most businesses get their products delivered in small trucks (30%), followed by light-duty vehicles (20%), vans and pickup trucks (15%), and large trucks (11%). 8% use non-motorized means, such as wheelbarrows (7%) and bicycles (1%), as it can be seen in Figure 15.

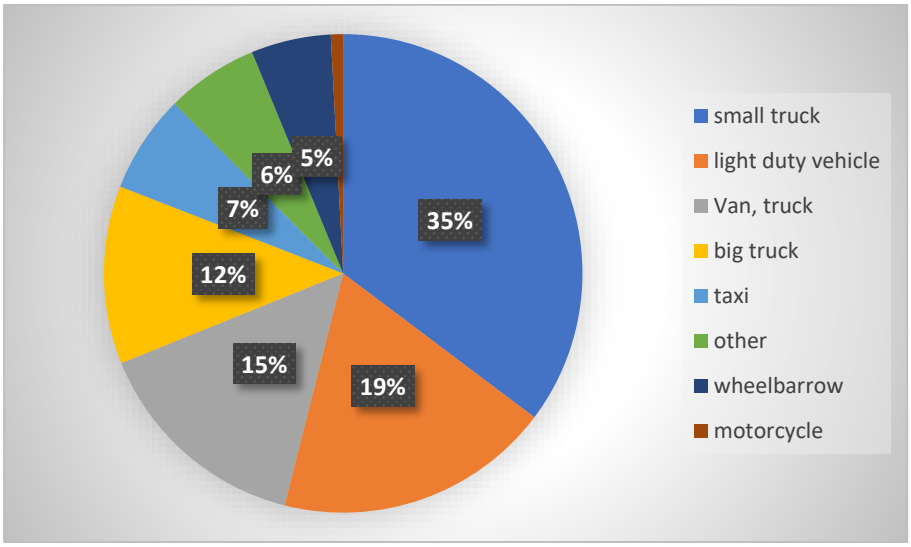


Figure 15. Types of vehicles used for LML in the HCQ

When it comes to the places in which the vehicles park to make the deliveries, 59% park on the sidewalk, followed by 11% that use either public or private parking buildings and only 5% use the loading and unloading bays provided by the Municipality. Moreover, 62% of all businesses do not have storage capacity requiring more frequent deliveries. Figure 16 presents the disruptions heat map conducted through observation as part of the data collection process. The main disruptions occur on the Streets Vargas, Cuenca, Sucre, Rocafuerte, Montúfar and Olmedo.

Figure 16. Disruptions heat map

These data show the lack of compliance with loading and unloading regulations in the HCQ and at the same time indicate that there is an opportunity for coordination with public parking lots to improve logistics in the area and reduce traffic caused by improper parking.

The suppliers

The number of suppliers per business varies from 1 to more than 100. 49% of businesses have up to 5 suppliers. The main suppliers can be seen in 17, where direct sellers are involved in 31% of deliveries, 20% of deliveries are made by Coca Cola, 11% come from the Market San Roque and 9% by food service company Pronaca, Cervecería Nacional and Pepsi. A total of 15% of the deliveries come from the local Markets, 11% from Mercado San Roque and 4% from Mercado Central.

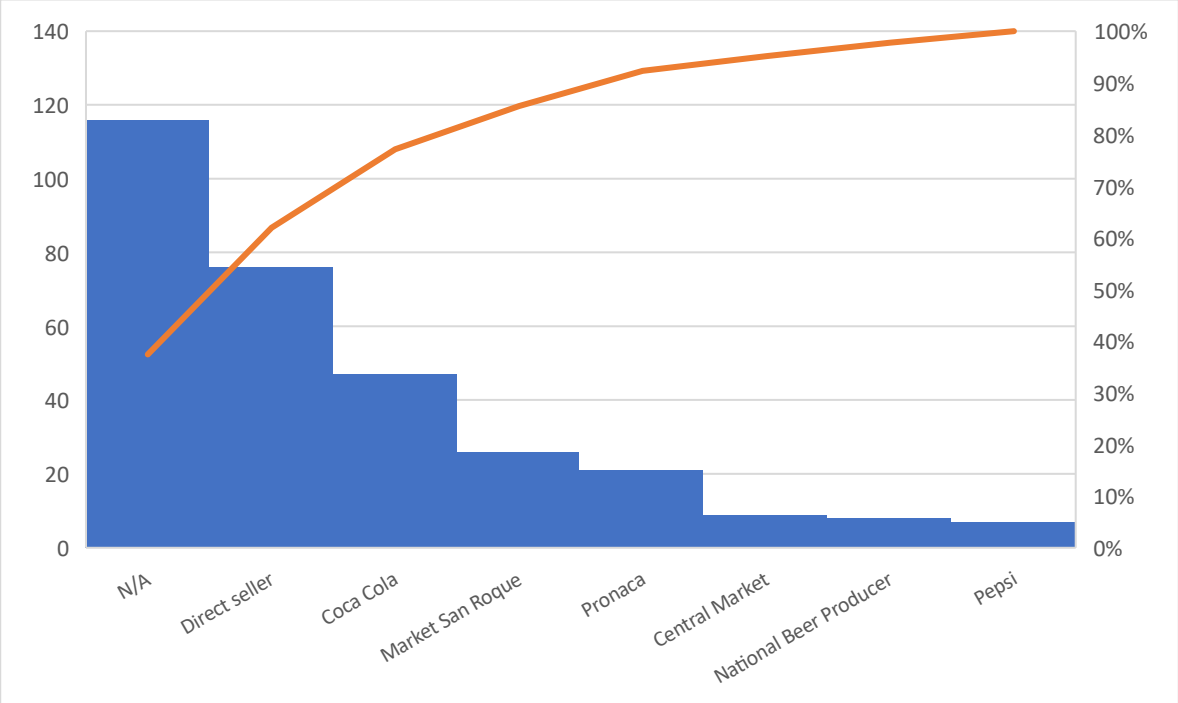


Figure 17. The structure of suppliers.

4.2. The Demonstration actions

The main component of the project in Quito, the multimodal e-mobility hub in the HCQ 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.

4.2.1. 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. Table 4 shows the 6 different types of vehicles locally designed and manufactured in the context of SOLUTIONSplus. 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.

Table 4. Locally designed and assembled SOLUTIONSplus LEVs in Quito

Vehicle	Characteristics
	**Vehicle type:** Long John e-cargo bicycle **Manufacturer:** Bixicargo **Loading Capacity:** 100kg **Power:** 500W – 13 A **Maximum speed:** - **Autonomy range:** - Battery recharge: Full charge in 4 to 5 hours **Charging connector type:** Type A for 110V **Turning radius:** 3000 mm **Dimensions:** Width: 790mm - Height: 1000mm - Length: 2450mm

	**Vehicle type:** Rear load e-tricycle **Manufacturer:** Bixicargo **Loading Capacity:** 100kg **Power:** 500W – 13 A **Maximum speed**: - **Autonomy range:** - **Battery recharge:** Full charge in 4 to 5 hours **Charging connector type:** Type A for 110V **Turning radius:** 3000 mm **Dimensions:** Width: 790mm - Height: 1000mm - Length: 2450mm
	**Vehicle type:** Front load e-tricycle **Manufacturer:** Bixicargo **Loading Capacity:** 75kg **Power:** 500W – 13 A **Maximum speed:** - **Autonomy range**: - **Battery recharge:** Full charge in 4 to 5 hours **Charging connector type:** Type A for 110V **Turning radius:** 3000 mm **Dimensions:** Width: 790mm - Height: 1000mm - Length: 2450mm
	**Vehicle type**: L6 **Manufacturer:** Sidertech **Net weight:** 180 kg **Loading Capacity**: 400kg including driver **Power:** 6.5 kW - 135 A **Maximum speed:** 32 - 40 km/h **Autonomy range:** 60km **Battery recharge:** Full charge in 4 to 5 hours **Charging connector type:** Type A for 110V **Turning radius:** 3000 mm **Tires:** 100/80 R17 **Dimensions:** Width: 840mm - Height: 1620mm - Length: 2500mm
	**Vehicle type:** L7 **Manufacturer:** Grupo Miral **Number of seats:** 2 **Battery recharge:** Full charge in 5 to 7 hours **Net weight:** 1050 kg **Loading Capacity:** 600 kg **Power:** 5kW **Autonomy range:** 60 - 90 km **Maximum speed:** 52 km/h **Tires:** 165/70 R12 **Dimensions:** Width: 1345mm - Height: 1765mm - Length: 3600mm **Truck bed dimensions:** Width: 2650mm - **Height:** 1000mm - Length: 16170mm

	**Vehicle type:** L7-CP **Number of seats:** 4 = 1 driver + 3 passengers **Battery recharge:** Full charge in 5 to 7 hours **Net weight:** 1050 kg **Loading Capacity:** 600 kg **Power:** 5kW - 60v **Autonomy range:** 60 - 90 km **Maximum speed:** 52 km/h **Tires:** 165/70 R12 **Dimensions:** Width: 1345mm - Height: 1765mm - Length: 3600mm

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.

4.2.2. The pilot design

The first contribution to the Zero Emission Zone was a conceptual proposal for an intermodal corridor for the Historic Center developed in 2021 by the Design Studio of the Technical University of Berlin (TUB), a member of the SOLUTIONSplus project. The proposed corridor integrates the area's 3 markets and the main public transport stations to enable low-carbon last mile movements. This proposal was socialized and validated by the various municipal entities (SM, SA, STHV, AdmZ MS and IMP) in 2021 and despite being conceptual, the proposal helped the local team to start the conversation with the relevant stakeholders. This was followed by site visits to the area with the relevant municipal entities in 2021 and 2022.

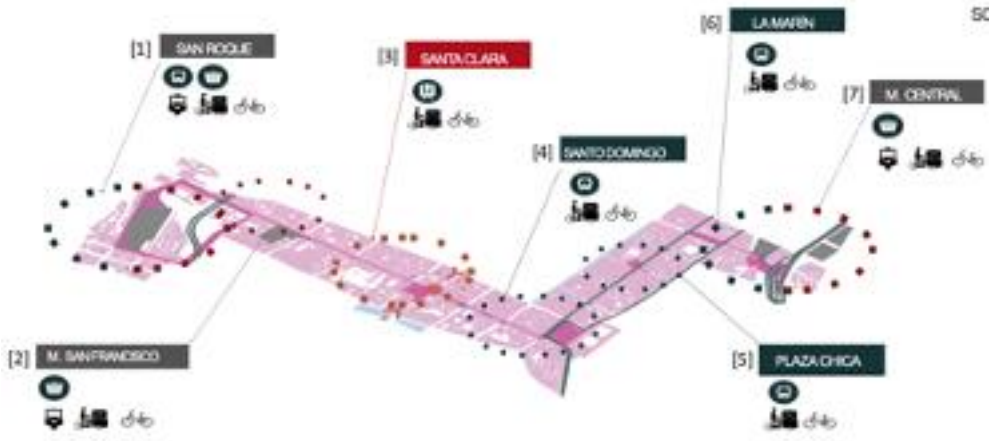


Figure 18. Conceptual proposal of an intermodal corridor in the HCQ
Source: TUB Design Studio (2021)

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 19). 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. These included the former prison Penal García Moreno, an old colonial house in San Marcos, two municipal plots in the surroundings of La Marín multi-modal station and the municipal parking buildings Yaku, La Ronda and San Blas. Yaku was identified as the best option for the temporary installation of a micro hub in the HCQ due to its location, available infrastructure and reduced occupation. An in-depth analysis of the 3 municipal parking buildings is presented in Section 4.4.5. 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.

SCHEME 1

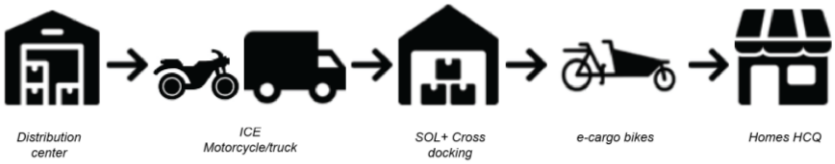
Operators: Bike messengers and Central Market stevedores
Use case: Food distribution from local markets and shops to restaurants and hotel

SCHEME 2

Operator: San Ignacio Restaurant
Use case: Restaurant with its own storage point in the HCQ

SCHEME 3

Operators: Urbano Express, Grupo Entregas and ASEMEC
Use case: Courier and postal services



SCHEME 4

Operators: Recycling Associations ASOREUN and ASOBEP and Municipal Waste collection company (EMGIRS)
Use case: Collection of recycling materials

SCHEME 5

Operators: Moderna de Alimentos / Grupo Entregas
Use case: Large food & beverage distribution companies

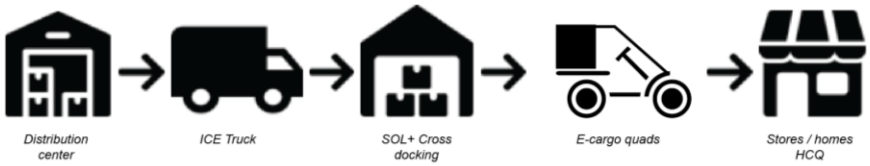


Figure 19. Five operating schemes

Furthermore, with the aim of strengthening the local capacities and knowledge about the topic, SOLUTIONSplus has provided various training and capacity-building opportunities from which the local 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 which was targeted to all actors involved in the logistic pilot's design. 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.

4.2.3. 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 4 e-mini vans, 2 for cargo and 2 for passenger transport, and 4 e-quadricycles for the second phase are finalized and will be tested by Courier Companies and the Municipal Companies, Empresa de Pasajeros (Municipal PTO) and EMGIRS (Waste Collection Company).
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
    i. Mobile air quality sensors were installed in all e-cargo bikes to collect information on air quality, delivery routes and distance travelled
    ii. 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:
    i. Logistics operators
    ii. Drivers
    iii. 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 19. The overall results of the operation of the 10 e-cargo bikes during 2 months in the HCQ can be seen in Figure 20.

Figure 20. Overall results of the pilot

The results by operating scheme (Figure 21 and 22) 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.

SCHEME 1

Operators: Bike messengers and Central Market stevedores
Use case: Food distribution from local markets and shops to restaurants and hotel

RESULTS:

- 81% ↑ Income per hour
- 43% ↓ Working hours
- 75% ↑ Packages per hour
- 563 kms Total distance
- 18 kms Daily distance

SCHEME 2

Operator: San Ignacio Restaurant
Use case: Restaurant with its own storage point in the HCQ

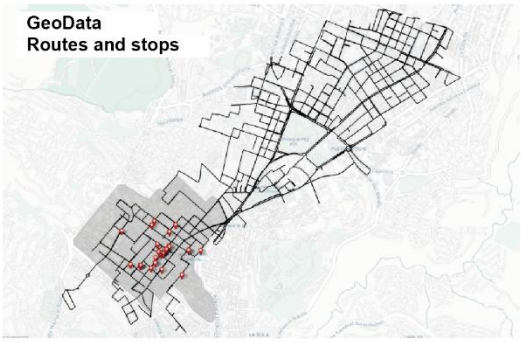
RESULTS:

- 100% ↑ Volume transported
- 50% ↓ Working hours
- 100% ↑ Packages per trip
- 359 kms Total distance
- 13 kms Daily distance
- 50% ↓ Trips

Figure 21. Results of schemes 1 and 2

SCHEME 3

Operators: Urbano Express, Grupo Entregas and ASEMEC
Use case: Courier and postal services



Before

After

RESULTS:

From 8 to 35 Packages delivered — from the beginning to the end of the pilot.

526 kms Total distance

16 kms Daily distance

13% Packages per hour

SCHEME 4

Operators: Recycling Associations ASOREUN and ASOBEP and Municipal Waste collection company (EMGIRS)
Use case: Collection of recycling materials

Before

After

RESULTS:

25% Income per hour

56% Working hours

125% Packages per trip

432 kms Total distance

14 kms Daily distance

Figure 22. Results of schemes 3 and 4

With regards to the routes, Figure 23 presents the streets that were used more frequently during the curse of the pilot. From North to South the 2 streets that were used regularly were the Streets Flores and Guayaquil. From East to West on the other hand, the streets that were used the most were the Bolívar and Rocafuerte Streets, as well as the 24 de Mayo Avenue. This despite the high slopes that characterizes them.

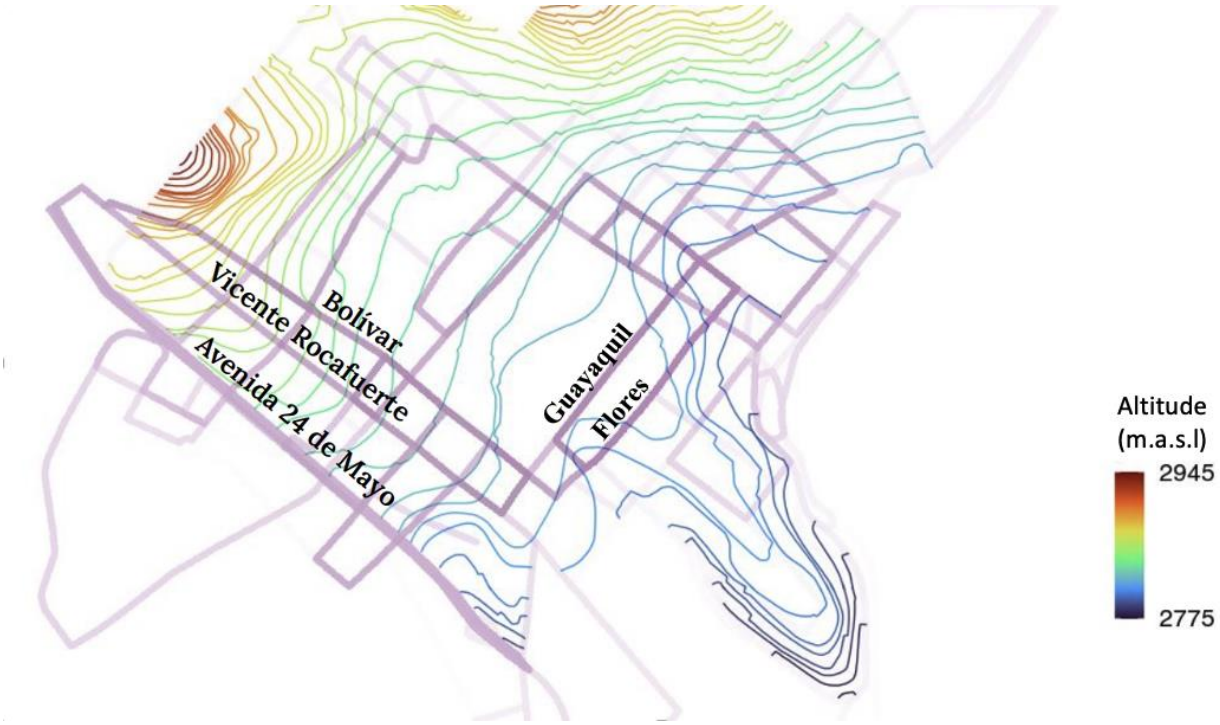


Figure 23. Most common delivery routes during the pilot
Source: BID (2023)

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.

The 4 e-mini vans that were assembled by Grupo Miral following an open call launched by the Municipality of Quito in 2022, were finalised and handed over to three municipal entities to enhance last mile logistics, connectivity and tourism. These entities are the municipal PTO (EPMTPQ), the district touristic administration La Mariscal, and the Municipal Waste Management Company (EMGIRS).

The 4 e-quadricycles, on the other hand, were handed over to the E-MOVILIZA Project (GEF7), which is the SOLUTIONSplus sister and follow-up project, also implemented by UEMI, and has as one of its components a LML pilot in the HCQ. In June SOLUTIONSplus launched a Call for EoI to companies to understand their interest in piloting the 4 e-quadricycles. A large food distribution company and 4 courier companies through their association (ASEMEC) applied to the call. The pilot is being designed with these companies and will happen in the context of E-MOVILIZA between September and November 2024. Afterwards, the vehicles will remain in the E-MOVILIZA EV Pool to be tested by at least 16 companies during 2025.

4.2.4. Scale-up potential

Based on the survey conducted in 2021, an scale-up assessment was conducted. The 240 businesses surveyed, revealed that they receive an average of 1.7 vehicle deliveries per week or 0.24 per day. The proportions of vehicles used to conduct the deliveries are presented in Table 5.

Table 5. Vehicles used for deliveries in Quito (Baseline survey)

Type of vehicle	Proportion of deliveries
Small truck	30.2%
Light vehicle or motorbike	20.9%
Van	14.8%
Large Truck	11.0%
Pushcart or bicycle	6.9%
Taxi	6.7%
Other	9.4%

Based on these data, we posit an assumption that every day, roughly 145 small trucks, 96 light vehicles or motorbikes, 71 vans, 53 large trucks, and 32 taxis enter the HCQ area for deliveries. Therefore, if zero-emission logistics were implemented in the HCQ, it would result in a significant reduction of 397 internal combustion engine (ICE) vehicles entering HCQ daily, which would be replaced by electric logistics vehicles.

Thus, on the ground of these estimations, if all ICE logistics vehicles in the HCQ were replaced by electric, approximately 600t CO2 emissions would be avoided every year.

4.3. Main barriers and opportunities for scale-up

What are the main issues in Quito's central area from the aspect of policy makers and freight stakeholders?

The following barriers have been identified during the survey conducted among the potential users of LEFV service in the historical center of Quito:

- End user barriers: insufficient knowledge related to the benefits of electromobility;
- Economic barriers: associated with a high cost of investing in LEFVs, investing in new infrastructure and developing new routines for which the time, capacity and motivation by most actors are required;
- Operational barriers: low number of demonstrative experiences that show results associated with electromobility;

These barriers can be overcome in the following ways:

- With regard to economic barriers, it is identified that in order to solve the high cost of electric vehicles, it is necessary to promote innovative business models and carry out studies of the cost-benefit of the implementation of electric vehicles and TCO analysis (Total Cost of Ownership) as well as funding opportunities to cover the acquisitions;
- In terms of operational barriers, there is a need to promote the implementation of **Monitoring, Reporting and Verification (**MRV) systems in electromobility projects to quantify the environmental and economic benefits of these;

- In terms of end-user barriers, the need for initiatives to socialize the benefits of adopting new technologies and the implementation of test-drives to overcome the fear of electromobility is required.

Besides these identified barriers, there are also barriers related to the environmental conditions such as:

- Topography: steep hills drain batteries faster and cause significant reductions in speed;
- Weather: cyclists are exposed to poor weather which can have a variety of impacts on how jobs are carried out, winds can make LEFVs more tiring to use, reducing both speed and range.

These barriers can be addressed by careful planning of LEFVs' energy capacities and supporting infrastructure as well as by appropriate design of LEFVs.

Addressing/Lowering these barriers will also have a positive impact on developing customer loyalty and on the speed of acceptance of the new last mile distribution system in Quito.

Main interests, motives and barriers from the aspect of introducing the LEFV system?

Figure 24 summarizes the willingness to pay for in Quito´s historical center. For different types of LEFVs, there is a significant share (having in mind that it is a launching stage) of customers who would be willing to pay a specific amount for the delivery service or for renting vehicles. To have a cost-efficient and effective last-mile solution it is needed to conduct a cost analysis including all relevant cost aspects into account and derive the unit cost of using each type of LEFVs. Owning, operating and maintaining costs should be considered. Some of the most important variables of influence operational costs are the number of stops, the distance between stops and number of parcels per stop. Based on the detailed cost estimation the cost-efficient and effective service can be planned and the level of subsidies (in case they are needed for some market segments) can also be determined. Some businesses consider the option of buying a specific LEFV. Incentives can also be an effective instrument for popularizing this option.

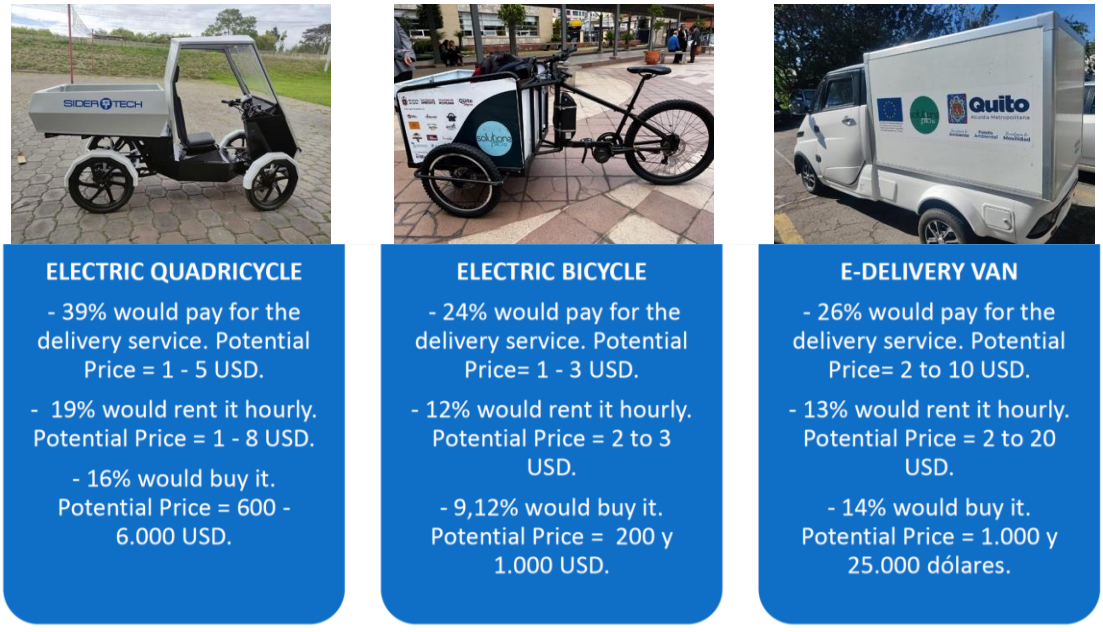


Figure 24. Willingness to pay for LEFVs in the HCQ.

In order to have a clearer picture about all the factors that positively and negatively influence Quito' commercial actors' desire and ability to invest in and use LEFVs, it is needed to conduct an in-depth evaluation during the Pilot operation. An in-depth evaluation will measure how successful this Pilot stage is at encouraging businesses in Quito historical center to switch to LEFVs, understand the barriers and motivations for businesses and impacts on freight levels. The evidence from this evaluation will inform recommendations for how LEFVs can be scaled up across Quito and provide learnings for local and national policy makers.

To address this, an impact assessment survey was made to logistics operators, drivers and customers involved in the pilot in Quito. The analysis of the results will be available soon and will illustrate the factors influencing the satisfaction and the intention to adopt LEFVs in the operations of the main actors in Quito.

The rule of the public sector is to promote sustainable urban distribution by balancing the economic costs and the impacts of freight transport on behalf of all stakeholder groups.

What are the trends on supply side?

Transformation of supply in urban transport of Quito central area will have a significant impact on sustainable mobility in the future and will facilitate or compete with LEFV system. Smart mobility solutions enabled by ICT contribute to cleaner, cheaper, safer, and more efficient transport.

In terms of innovation on the logistics service supply side, the courier companies are taking the lead, for example, the representatives of FEDEX in Ecuador, a company named Grupo Entregas has started making pilots with LEFVs in the Central Business District of Quito (with their own e-cargo bikes) and the Historic Center of Quito (in the framework of the SOLUTIONSplus project).

Special attention is given to existing measures oriented toward sustainable urban distribution in Quito, those currently active and planned. The focus was on the following categories of measures:

- Regulatory measures: time-based restrictions, volume or weight restrictions, emission-based restrictions;
- Market based measures: congestion charges, subsidies;
- Land use planning measures: zoning of activities;
- Infrastructure measures on-street loading and unloading bays;
- New technologies: vehicle technologies, ICT and ITS;
- Management and other measures: freight consultation forums, single windows for urban freight transport, urban consolidation centers (retail consolidation centers, construction consolidation centers, etc.), facilitating night time deliveries.

One of the most critical issues identified in terms of policies to enable the replication and scale-up of the pilot in Quito, has been the specific national and local regulations related to LEVs. The table below summarizes the main challenges and opportunities to advance the introduction of LEVs to improve Last Mile Logistics and Connectivity, primarily in the Historic Center of Quito, but with the goal of replicating the model in other areas of the city which could strongly benefit from it, such as the CBD.

4.4. Implementation plan - How do we get there?

In order to advance in the goal of Zero Emissions Historic Center included in the PACQ (2020) and the PMMS (2024) in an area with such a high commercial and touristic density, this City Roadmap proposes the establishment of LEV System for urban logistics, based on the results of the pilot and the recommendations of the Zaragoza Logistics Center (ZLC).

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. Policy framework as the fourth pillar should provide a solid base for an innovative value proposition.

Orgware perspective includes organizational improvements related to building a cooperative network between all actors directly and indirectly involved in the city distribution system. 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.

Software perspective is related to the optimal design of the LEFVs system. This includes building a model for determining the optimal location of transshipment points – hubs, as well as the design of vehicle routes supplying customers from these depots. The results of this phase should identify the effects of implementing the new solution compared to the existing scenario. Therefore, 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 of the relevant variables (travel speed, mass of load, slope of streets, etc.).

Hardware perspective should result in optimal design of LEFVs, micro-hub/s location and infrastructure for the safe circulation of LEFV. In this phase, existing experiences from other locations should be considered. For example, in the case of Amsterdam[1] identified barriers to using LEFVs are:

- Cargo capacity (in weight and volume)
- Battery charging time
- Availability of charging infrastructure
- Range
- Maintenance
- Possibility to cool/freeze

[1] https://www.amsterdamuas.com/urban-technology/shared-content/projects/general-projects/levv-logic.html

- Too large turning radius
- Allowance of parking

Specific barriers should be identified for the designed area (these and other that can arise from the market analysis – survey conducted) for the acceptable design of cargo vehicles, the micro-hub and the adequate road infrastructure.

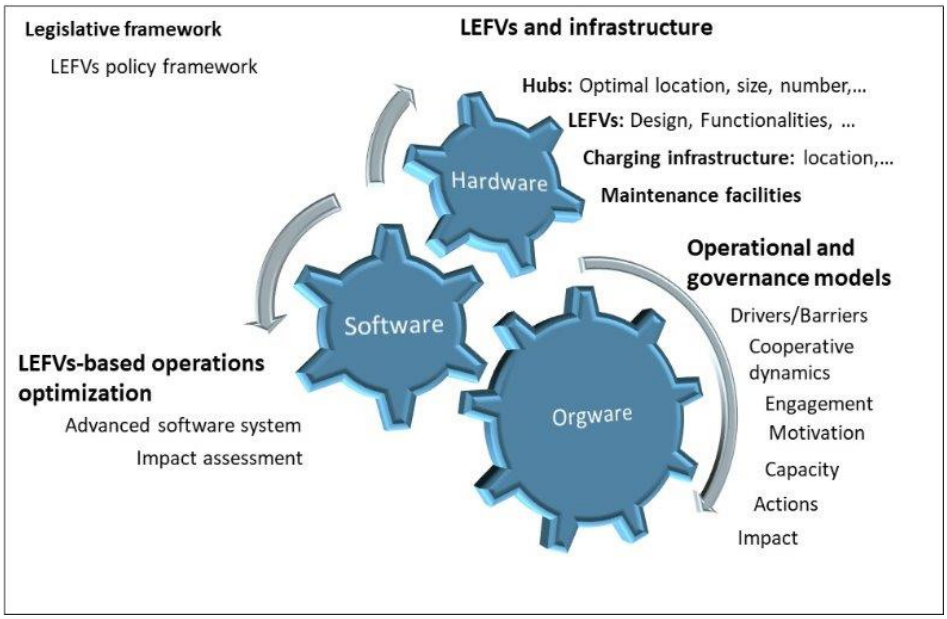


Figure 25. Framework for development of last mile distribution system.

The existing **policy framework** related to conventional vehicles needs to be assessed and the need for additional policy measures regarding LEFVs examined. This will result in a set of recommendations related to the policy framework tailored for the designed area.

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

4.4.1. Focus Area 1: Orgware

Since the urban freight transport activity in the HCQ is a multi-stakeholder activity, the only successful way to introduce a new mode of freight transport is through the involvement of all actors and stakeholders in the development of a consensus-based strategy. No single stakeholder is capable of finding a collectively accepted solution, which will overcome all barriers to acceptance of LEFVs mode.

More specifically, urban freight transport is characterized by a number of different stakeholders, those indirectly involved in freight transport (public authorities, residents and tourists/visitors) and the transport of goods (transport operators). The intensity of interaction between different stakeholders each with different interests and own perceptions increases the complexity of transition towards the solutions which will contribute to a more efficient and sustainable urban distribution.

In most cases, conflicts arise between the interests of residents and transport operators and public authorities frequently intervene to try to balance the interests of both sides. There are also conflicts between residents and tourists/visitors as consumers. The latter want goods to be available in shops whereas residents complain about traffic congestion, noise, and environmental pollution.

Motivating factors that positively influence commercials' desire and ability to use LEFVs are as follows:

- *Climate and environment*: LEFVs represent a solution for more sustainable and environmentally friendly urban logistics;
- *Increased accessibility*: issues related to accessibility and parking in densely populated areas can be addressed by LEFVs;
- *Economic benefits*: LEFVs represent potential time and money savers;
- *Public support*: support from public entities (municipalities for example) may influence the choice to use LEFVs;
- *Promotion and branding*: the use of LEFVs can be considered as good marketing.

The urban freight transport system is complex as it is influenced by different factors such as many stakeholders with different motives, barriers, and values that they identify with a potential redesign of existing freight transport service design.

Table 6 presents the main opportunities and challenges regarding the Orgware dimension in Quito.

Table 6. Opportunities and challenges in the governance and business models in Quito

GOVERNANCE & BUSINESS MODELS	
Opportunities	**Challenges**
High interest from the private sector • Small e-mobility initiatives have been implemented (e-buses in Guayaquil, e-taxis in Loja and Cuenca, LML pilots in Quito and Cuenca, etc.) • Since 2019, 2 e-scooter sharing companies operate in Quito (Torres, 2022). • The sales of LEV have increased significantly. In 2021 the number of imported LEV between January and July doubled the one in 2020 (Torres, 2022). • There are an important number of Logistics companies with sustainability plans aiming at	• The scalability of the mentioned initiatives will be limited until the necessary regulations are in place. • Despite interested, some logistics companies are still reluctant to conduct the necessary changes in their operations in order to profit from the potential efficiency gains of introducing LEV in LML operations. • LEV, at least the cargo bikes tested in the first phase, cannot be insured, which becomes a limitation for the large companies aiming to integrate LEV in their operations to decarbonize. The proper regulations,

decarbonizing their operations by introducing (L)EV, such as Grupo Entregas, DHL, Urbano Express, among others. • Non-motorised vehicles that have been used for decades in the informal sector could be electrified to improve working conditions and income. • Formal and informal businesses have shown interest in adopting LEV in their operations. As a matter of fact, SOL+ received 20 EoI to participate in the pilot and test the SOL+ LEV. The EoI came from a huge variety of companies, going from large food and beverage distribution and courier companies to stevedores from the local market.	recognising LEV as a possible logistics vehicle are needed. • The results of the first pilot phase show that the efficiency and economic gains (reduced working time and increased income) obtained from the introduction of LEV in the operations of informal / low-income businesses shows the huge potential of scaling them up. However, it will only be possible with the proper credit lines. • Several (multinational) delivery platforms have entered the Ecuadorian market offering employment opportunities for many. Their business model however, does not promote the use of sustainable vehicles. As a matter of fact, there is a growing number of conventional bicycles converted to ICE vehicles to increase speed, but highly pollutant.
Business models and financing • Renting is legal in Ecuador under Regulation for the functioning of vehicle renting companies by the National Transit Agency (ANT) from 2013 • SOLUTIONSplus results showed efficiency and economic gains in all operating schemes, even the ones related to informal actors. The financial indicators are positive.	• However, the renting regulation states that rented vehicles can only be used by private users and never as public or commercial transport. • Without the proper business models or access to loans, not all use cases will be able to access the LEV that will help them improve their logistics operations and contribute to the emissions reduction goals of the city

Therefore, 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 e-cargo distribution network**. Proposed business model, for the sake of successful lunching, 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 26* presents a decision-making process for the introduction of the LEFV system.

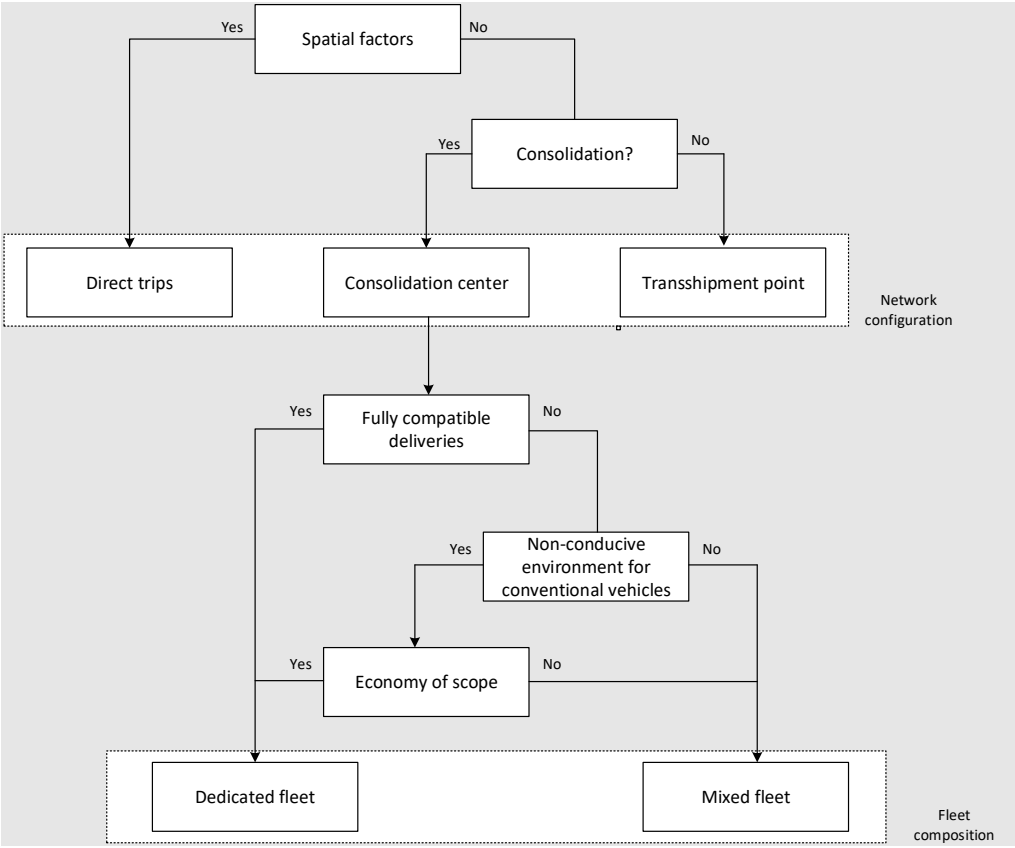


Figure 26. Decision making process for the introduction of LEFV system.

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. Table 7 contains a brief description of each of the activities, responsible parties and their roles.

Table 7. 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.

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 27 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**.

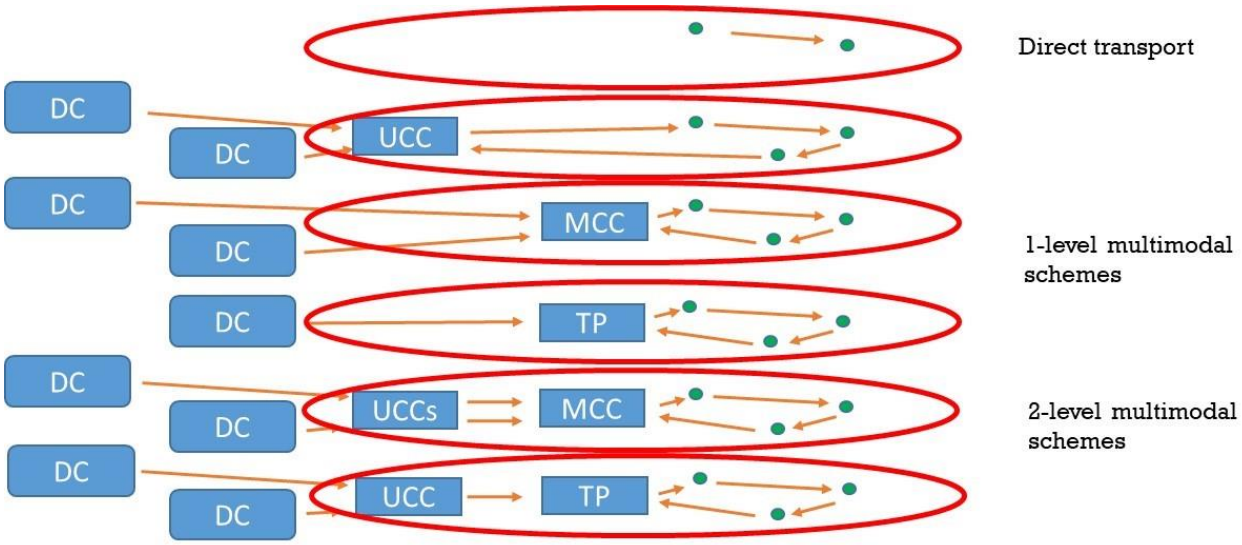


Figure 27. Classification of multimodal schemes integrating LEFVs according to level and consolidation principle.

Multimodal scheme 1: Direct transport system

The first scheme in Figure 27 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.

Business models

This City Roadmap 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 City Roadmap we address only the *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 the 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. For more information about the Supplier and the Courier business models (SBM & CBM), please check the SOLUTIONSplus Urban Logistics Policy Paper (SOLUTIONSplus, 2024.

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.

Key Partners Municipality (administration)	**Key Activities** Pick-up and delivery service	**Value Proposition** Delivery on time offering reliable	**Customer Relationships** Cooperative and client-centric	**Customer Segments** B2B and B2C

<table>
<tr>
<td>Network coordinator
LEFV service providers
Freight transport operators (such as DHL, FedEx)
Suppliers
LEFV repair service</td>
<td>Key Resources
Urban Consolidation center (UCC)
Employees & LEFVs
Routing and assignment software
Cooperative platform</td>
<td>performance
More efficient service for last mile delivery
Less congestion, emissions
Better environment for pedestrians
Air quality
Job creation</td>
<td>Channels
Internet/telephone
Subcontractor to express delivery companies</td>
<td>Express deliveries
Parcel delivery for mail orders and e-commerce businesses
Parcels delivery for local shops
Fresh product delivery</td>
</tr>
<tr>
<td colspan="3">Cost Structure
Employees’ wages, running and maintenance costs of LEFVs, rent of facilities</td>
<td colspan="2">Revenue Streams
Customers pay for the service (senders), depending on volume, frequency, destinations; advertisement</td>
</tr>
</table>

Figure 28. Conceptual framework of GBM based cooperative network.

A cooperative business network of GBM looks as in Figure 29.

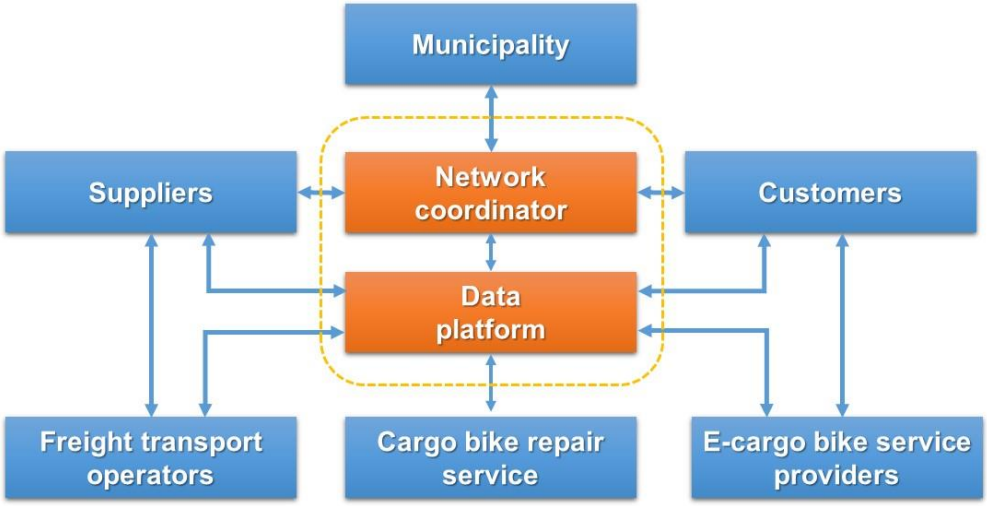


Figure 29. GBM based cooperative network for LEFV system.

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 30 presents a contractual framework for governing the transactions in the proposed relationship.

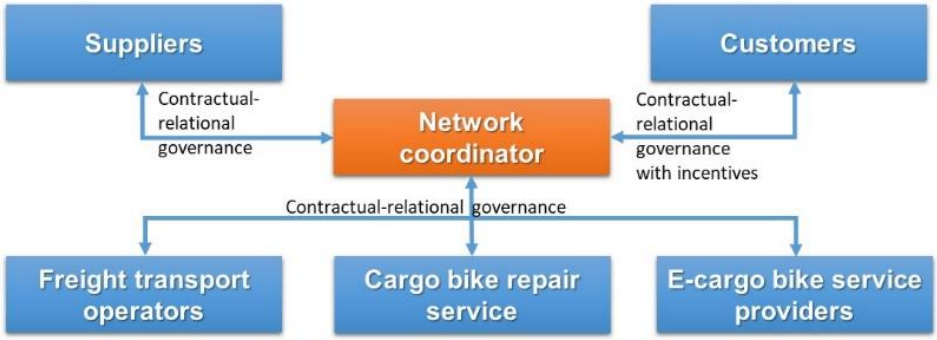


Figure 30. Contractual governance of proposed LEFV business network.

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 31 presents the flow of information between the actors in the proposed LEFV network – inside the established entity and with external actors.

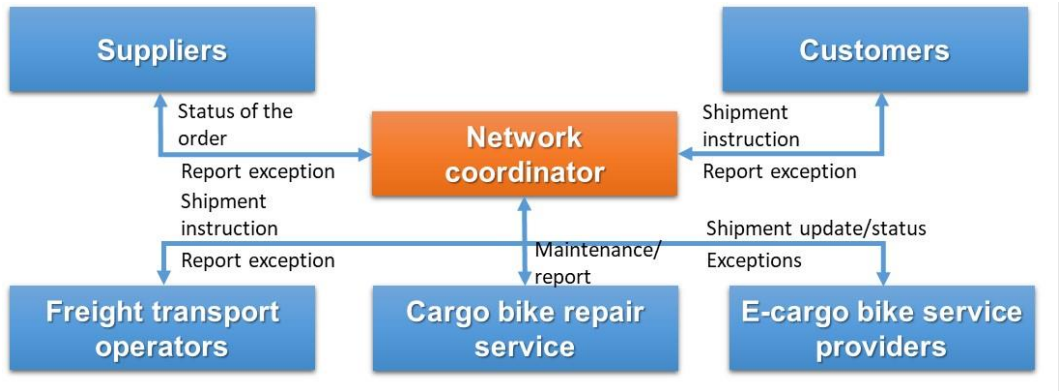


Figure 31. Information flow in proposed LEFV business network.

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 a 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.

4.4.2. Focus Area 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 the delivery 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 transhipment 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.

Optimal micro hub location (software perspective)

The problem of finding optimal locations for transhipment 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 transhipment 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.

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.

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;

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 32). The user can change the inputs to adapt the solution to its specific purpose.

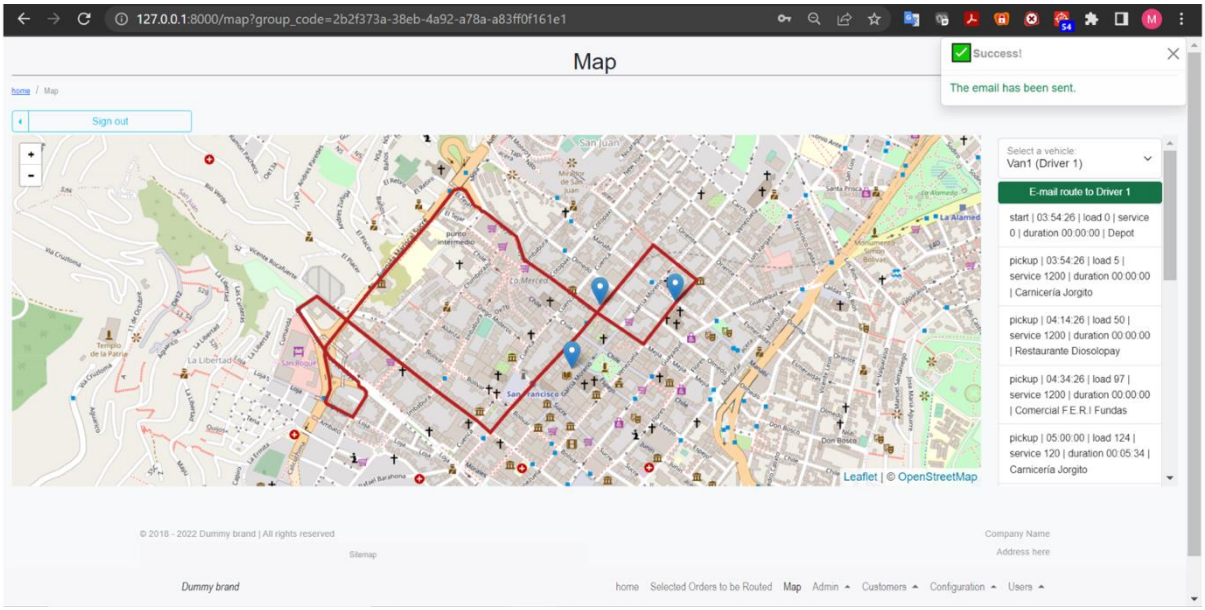


Figure 32. Routing solution for selected set of orders. Source: Milenkovich et al. (2024)

4.4.3. Focus Area 3: Hardware

"Hardware" stage includes the design of LEFVs and the sizing of micro hubs. Both of 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.

Table 8.Opportunities and challenges in terms of Vehicles & Infrastructure (Hardware)

VEHICLES & INFRASTRUCTURE (HARDWARE)	
Opportunities	**Challenges**
<u>Available road infrastructure</u> • Cycling infrastructure: at present Quito has 125km of bike lanes available, 25km of which were added in 2020 during the COVID-19 pandemic. • Important streets in the HCQ have become pedestrian areas.	• There's a dispute between road users about if LEV users should be able to use cycling infrastructure and under which conditions. The corresponding ordinance in discussion.
<u>Local design and assembly of LEV</u> • Most of the national regulations refer to imported vehicles, making the regularization of locally produced LEV extremely difficult.	• There are no insurance products for e-cargo bikes / tricycles, meaning that companies wanting to transition to micro-vehicles for last mile distribution won't be able to insure them. • The import taxes and the customs clearance on parts for the local manufacturing LEV • The National Agency of Sanitary Regulation, Control and Surveillance (ARCSA by its Spanish acronym) requires all vehicles that transport food or medicines to have a license plate, completely excluding the possibility of large formal food and medicine distribution companies using micro vehicles. What should be controlled is the transport box depending on the type of good, not the vehicle as such.
<u>Micro hubs / cross-docking platforms</u> • Several businesses in the HCQ have storage units in the area from where they transport the goods to their premises. • There are 7 municipal parking buildings in the HCQ. At present, Yaku, La Ronda and San Blás are not being used to their full capacity. Moreover, with the recent launch of the subway station in San Francisco / La Ronda and the Zero Emissions restrictions to ICE vehicles, the number of people coming by car to the HCQ will be reduced. Thus, there's a huge opportunity.	• There's no proper regulation for micro-hubs in Quito. The PMMS, however, talks about consolidation 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 1) and the one from Express Logística in Buenos Aires (Case Study Box 2).

LEFVs design

Light Electric vehicles (LEVs) 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 the maximum speed 45 km/h. This is broad definition that covers from electric micro-mobility to all vehicle types in the L-category. The different categories and types of vehicles that fall under this definition can be looked up in the LEV Regulations for Latin America SOLUTIONSplus Policy Advice Paper (SOLUTIONSplus 2024b).

In particular, Light Electric Freight Vehicles (LEFV), 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).

LEFVs can be of different design and characteristics. Figure 33 shows some of the models being deployed in Europe. LEFVs 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 for other cyclists. It is worth noting that quadracycles in Europe 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.

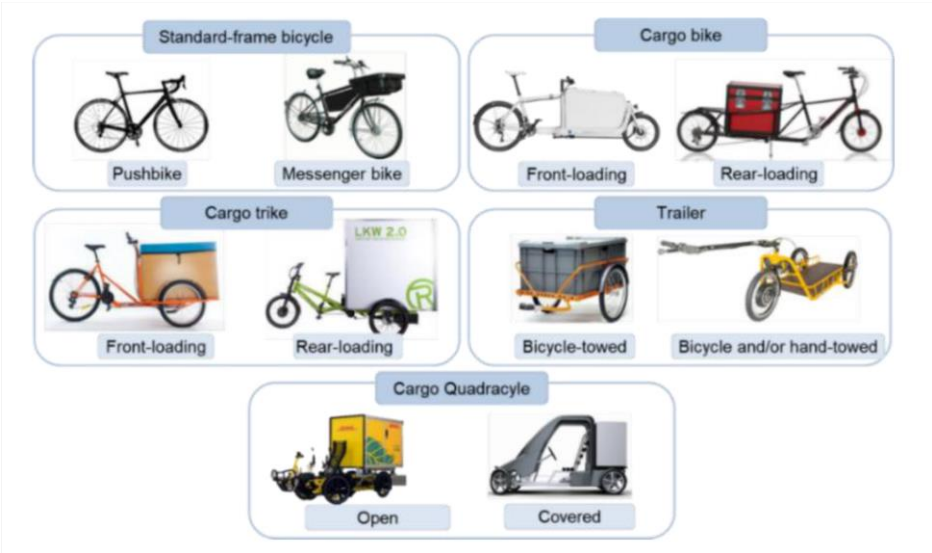


Figure 33. Cargo bikes offer on London's market.

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 LEFV 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);
- Longer economic life, lower maintenance costs, manufacturer' guarantee of LEFV is expected
- 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.

A total of 3 LEV manufacturers received seed funding for the local design and assembly of e-cargo bikes, e-quadricycles and e-mini vans in the context of SOLUTIONSplus. Accordingly, 16 LEFVs (plus 2 passenger e-mini vans) in 5 different LEV models that can be adapted to the needs of a wide variety of users were manufactured. The 5 LEFVs models with their specific characteristics were shown in the Table 4 (Section 4.2. The Demonstration action).

In August 2022, a public event with the support of the Municipality and academia (USFQ-CATENA and EPN) took place to socialize the prototypes of SIDERTECH and Bixicargo and allow potential users to provide feedback regarding design, ease of drive and accessories.

Figure 34. Socialization event of the LEV prototypes
Source: SOLUTIONSplus

The feedback provided in this instance was used as an input for the final design of the vehicles. Moreover, users' perception surveys were conducted among all the logistics operators and drivers that participated in the first phase of the pilot. Figure 35 shows how the 6 logistics operators and 9 riders participating in the first phase of the pilot rated the different characteristics of the e-cargo bikes.

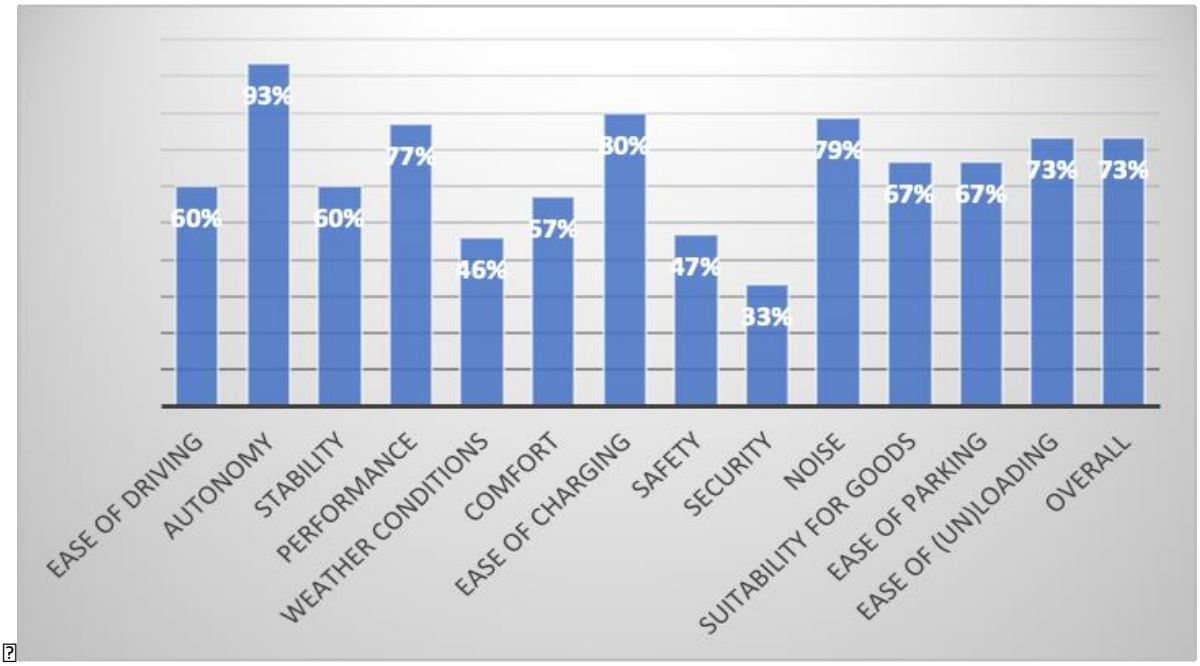


Figure 35. % of riders / logistics operators that rate the vehicle characteristic as satisfactory or very satisfactory

As it can be seen in Figure 35, autonomy, ease of charging, noise and vehicle performance are the characteristics with which more than 75% of the vehicle users were satisfied. In terms of suitability of the vehicles for the transported goods and ease of parking, almost 70% of the users rated them as satisfactory. Meanwhile, with regards to ease of driving, stability and comfort only 50% to 60% of respondents rate them as satisfactory and when it comes to security, safety and suitability for adverse weather conditions the percentage is below 50%. These 6 vehicle characteristics still require improvements by the manufacturer in order to provide solutions that fully respond to the needs of the operators. Nevertheless, it is worth noting that overall 73% of the riders and logistics operators participant in the pilot were satisfied with the solution and have continued using it for the past 1,5 years.

Micro hub location/size (hardware perspective)

There are two main services that LEFV can 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 LEFV logistics companies typically do both services.

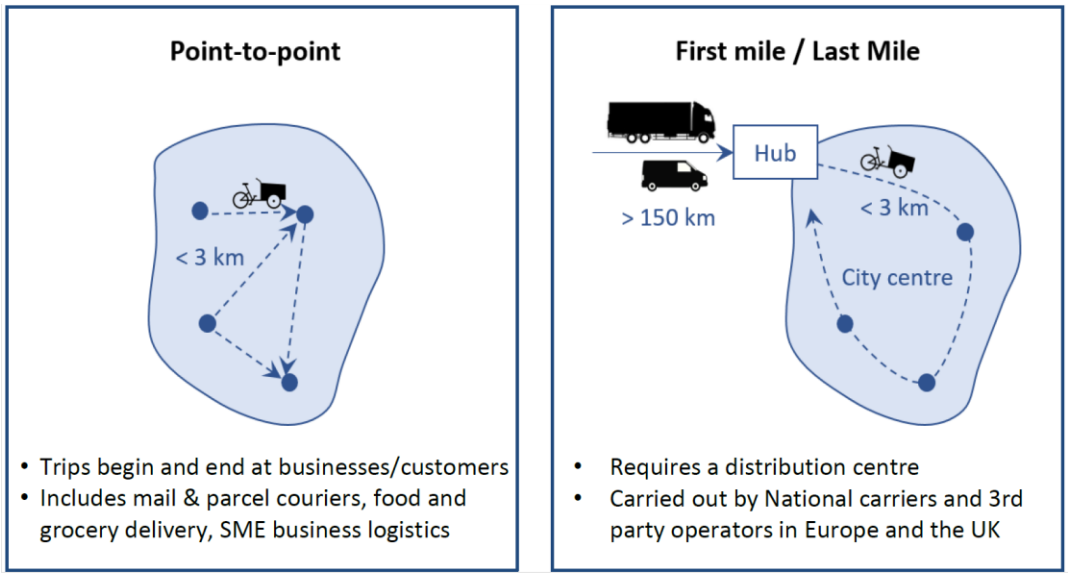


Figure 36. Main LEFV services.

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 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[2]) 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).

In the Historic Center of Quito there are 7 municipal parking buildings, as it can be seen in Figure 37. While parking buildings such as Cadisán and Montúfar 1 and 2 are at their full capacity most of the time, parking buildings such as Yaku, La Ronda and San Blas are not used at their full capacity and could therefore devote some of the available space for a collaborative micro-hub, in which the vehicles are safely stored at night, charged and a transshipment point from small and large trucks to LEFVs.

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

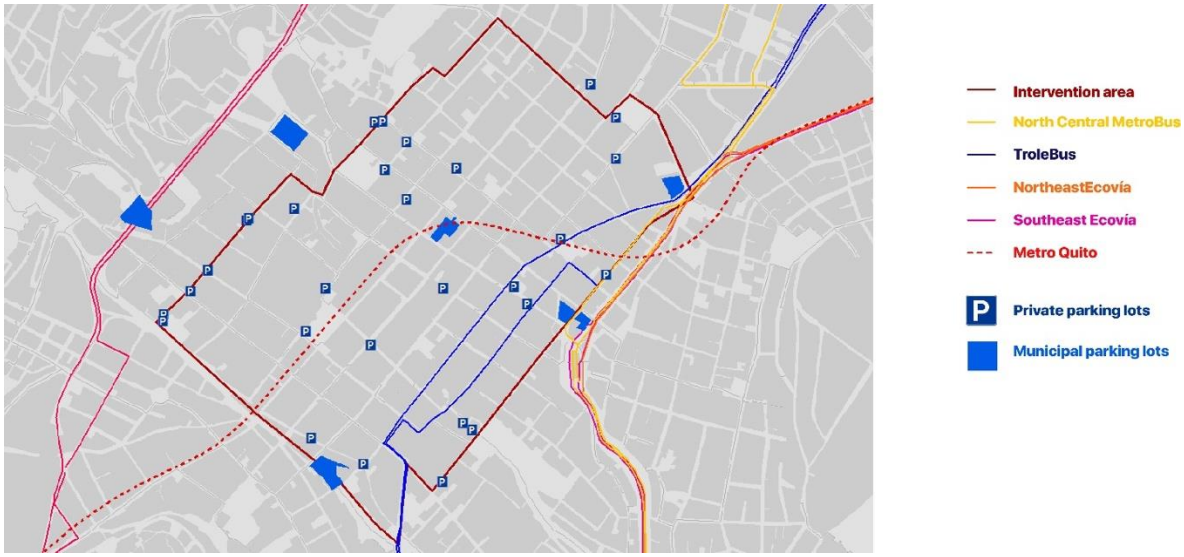


Figure 37. Parking buildings in the HCQ

The location of the 3 municipal parking buildings mentioned is also interesting, as they are located in the peripheral area of the HCQ and are accessible by main roads, such as Av. Mariscal Sucre, Av. 10 de Agosto and Av. 24 de Mayo. Thus, small and large trucks wanting to reach them will not have to pass through the HCQ and will therefore not create more / be affected by congestion. The following data sheets show the results of an analysis conducted by the SOLUTIONSplus team and Pedram Jahanian (2024) in the context of the TUB Design Studio.

Municipal parking building Yaku

Ubication map.

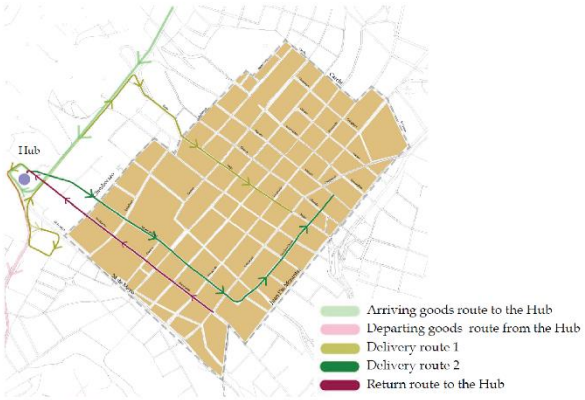
Technical information:

Location: Simón Bolivar Str., El Placer. Quito - Ecuador.
Type: Municipal parking lot
Infrastructure:
This parking lot is a block built upwards and also has a few open parking spaces. The maximum height of its mezzanines is 2.85 meters.

Network concept proposal:

The small and large trucks will arrive (light green) and leave (light pink) the Hub in Yaku directly via Mariscal Sucre Avenue, without entering the HCQ. Thus, the Hub could have a significant impact in reducing congestion and pollution in the area. To distribute the goods from the Hub to the stores in the HCQ, 2 delivery routes have been defined. Route 1 (olive green) focuses on large parcels of clothing and white goods to be delivered using e-mini vans. For this type of deliveries, the e-mini vans will leave and return to the Hub using Mariscal Sucre Avenue and Bolivar Street. Delivery route 2 is designed for the transport of smaller parcels using e-cargo bikes and e-quadricycles.

Due to the narrowness and direction of the streets, the delivery and return routes must be different. Accordingly, the goods will arrive to the businesses via Bolívar Street (dark green) and return empty to the Hub via Rocafuerte Street. An alternative to avoid the usual congestion of the latter could be Loja Street, which has much less traffic than Rocafuerte Street



Jahanian (2024)

Satelital image:

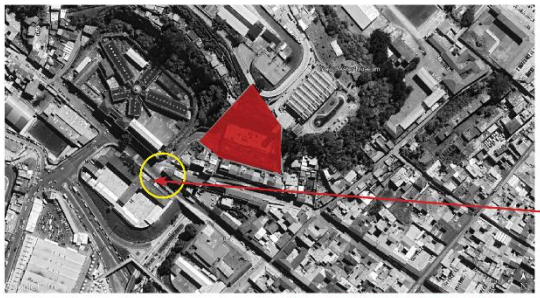


Image recovered from Google Earth.

Access:

Image recovered from Google Street View.

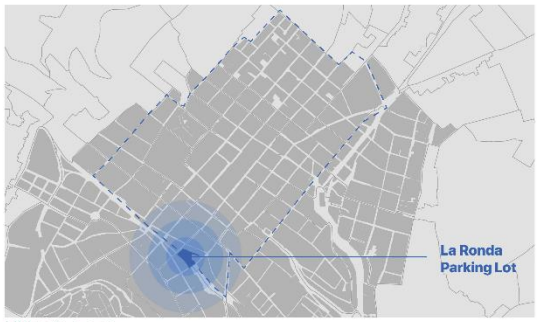
Vehicular and pedestrian entry is from Simon Bolívar Street.

SWOT Analysis:

S	W	O	T
Since most of the delivery points are located in the west of the site, it is close to them, which reduces the delivery time.	• Possible traffic at Av. Mariscal Sucre • Weak accessibility rate for driving in 15 min	Great accessibility routes for future developments.	Some legal obstacles.

Figure 38. Municipal parking building Yaku. Source: TUB Design Studio.

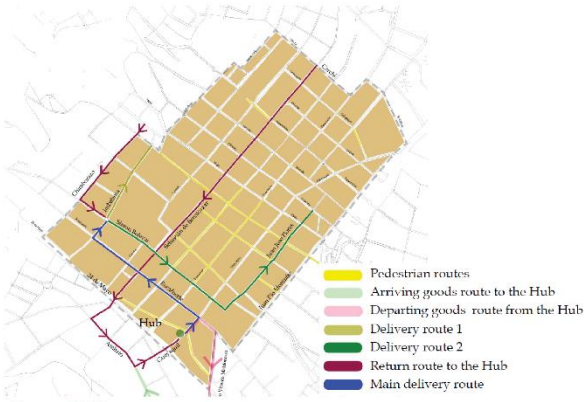
Municipal parking building La Ronda



Ubication map.

Technical information:

Location: Guayaquil Street, La Ronda. Quito - Ecuador.
Type: Municipal parking lot
Infrastructure:
The parking lot is underground and does not have any open space.
The maximum height of its mezzanines is 2.85 meters.



Jahanian (2024)

Network concept proposal:

The small and large trucks will arrive (light green) and leave (light pink) the Hub in La Ronda directly via Rocafuerte Avenue, without entering the HCQ. Thus, the Hub could have a significant impact in reducing congestion and pollution in the area. To distribute the goods from the Hub to the stores in the HCQ, 2 delivery routes have been defined. Route 1 (olive green) focuses on large parcels of clothing and white goods to be delivered using e-mini vans. For this type of deliveries, the e-mini vans will leave and return to the Hub using 24 de Mayo Boulevard and Bolivar Street. Delivery route 2 is designed for the transport of smaller parcels using e-cargo bikes and e-quadricycles.

Due to the narrowness and direction of the streets, the delivery and return routes must be different. Accordingly, the goods will arrive to the businesses via Juan Simon Bolivar and Jose Flores Street (dark green) and return empty to the Hub via Rocafuerte Street.

Satelital image:

Image recovered from Google Earth.

Access:

Vehicular from Guayaquil Street.

Vehicular entry from Av. 24 de Mayo.

Image recovered from Google Street View.

SWOT Analysis:

S
1. Suitable accessibility rate
2. Clear network delivery
3. Closely located to the most local business
4. Closely located to the main local streets.
5. There is no traffic around the hub

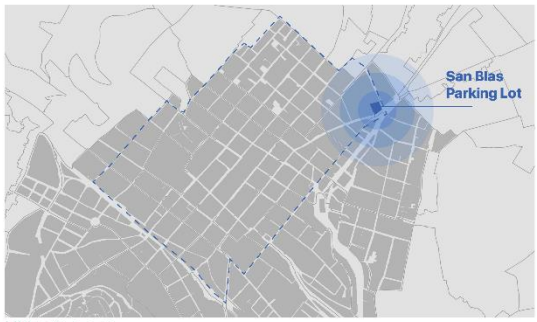
W
The size of parking building looks smaller than others

O
1. Great accessibility routes for future developments
2. Enough space to develop the building

T
Heights of the building, as it is underground it might have some complications with big trucks.

Figure 39. Municipal parking building La Ronda. Source: TUB Design Studio.

Municipal parking building San Blas



Ubication map.

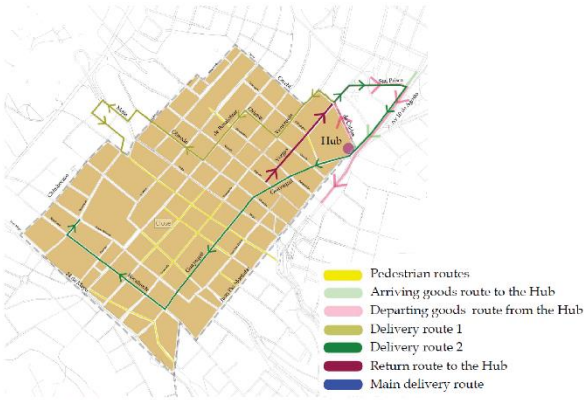
Technical information:

Location: Guayaquil Str. and Francisco de Caldas Str., Quito - Ecuador.
Type: Municipal parking lot
Infrastructure:
The parking lot is part of an existing building. Is totally closed.
The maximum height of its mezzanines is 2.85 meters.

Network concept proposal:

The small and large trucks will arrive (light green) and leave (light pink) the Hub in San Blas directly via Guayaquil street, without entering the HCQ. Thus, the Hub could have a significant impact in reducing congestion and pollution in the area. To distribute the goods from the Hub to the stores in the HCQ, 2 delivery routes have been defined. Route 1 (olive green) focuses on large parcels of clothing and white goods to be delivered using e-mini vans. For this type of deliveries, the e-mini vans will leave and return to the Hub using Guayaquil street and Rocafuerte Street. Delivery route 2 is designed for the transport of smaller parcels using e-cargo bikes and e-quadricycles.

Due to the narrowness and direction of the streets, the delivery and return routes must be different. Accordingly, the goods will arrive to the businesses via Guayaquil street an Rocafuerte street secuence (dark green) and return empty to the Hub via de olive green route. An alternative to avoid the usual congestion of the latter could be Vargas Street but there is usually traffic at morning and in the afternoon.



Jahanian (2024)

Satelital image:

Image recovered from Google Earth.

Access:

Vehicular and pedestrian entry is from Francisco de Caldas Street.

Image recovered from Google Street View.

SWOT Analysis:

S
1. There is a relatively modern building.
2. Located near width streets like 10 de Agosto.

W
1. Reachable from inside area only through Vargas street which would lead to increasing traffic.
2. Weak accessibility rate for driving in 15 min
3. Located far from most of commercial locations which would increase delivery time and also traffic

O
Enough space to equipe the hub.

T
Increasing traffic around the hub at peak traffic time that leads to delay in delivery time

Figure 40. Municipal parking building San Blas. Source: TUB Design Studio.

As it can be seen in Figure 37, there are also several private parking lots that could be used as micro-hubs, as it was the case of the SOLUTIONSplus pilot. However, it is recommended that the municipality supports and supervise this type of activities, contributing directly to the consolidation of the Zero Emissions Historic Center and obtaining financial resource for the rent of the space. In the course of the SOLUTIONSplus project, site visits to Yaku and La Ronda, as well as to other public spaces in the HCQ were conducted with different municipal entities to assess the feasibility of using the mentioned areas as micro-hubs. Other areas considered include the former prison, Ex Penal García Moreno, and some municipal plots in the surroundings of La Marín Multi-modal PT Station.

In the case of Bogotá, Grupo Nutresa rented a municipal unused space of 350 m2 in the South Bus Terminal of the city for the installation of the micro-hub to distribute to the products in the Southern Area of the city. The implementation of this micro-hub reduced the daily distance travelled of 36 ICE vans in 24km, saving an important amount of CO2 emissions, contributing to reduce the congestion in the city and improving the working conditions of the logistics operators (See all details in Case Study Box 1). In Buenos Aires, on the other hand, Express Logística, the largest distributor of Quilmes beer and other beverage brands, following the changes in the Building Code explained in Case Study Box 2 was able to install micro hubs in regular private building garages in central neighbourhoods such as Recoleta and San Telmo.

Case Study Box 1: 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 41. 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 1: Grupo Nutresa, Colombia

Figure 42. 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)*

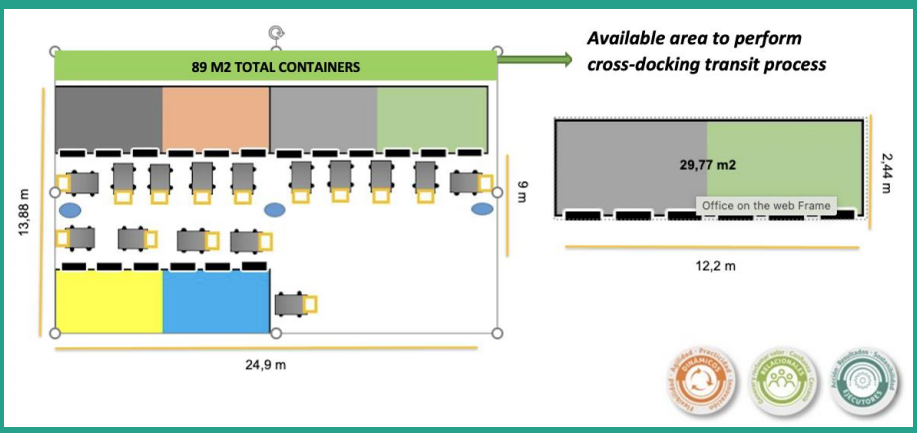


Figure 43. Microhub distribution. Source: Comercial Nutresa, 2024

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.

Adequate 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 44 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.

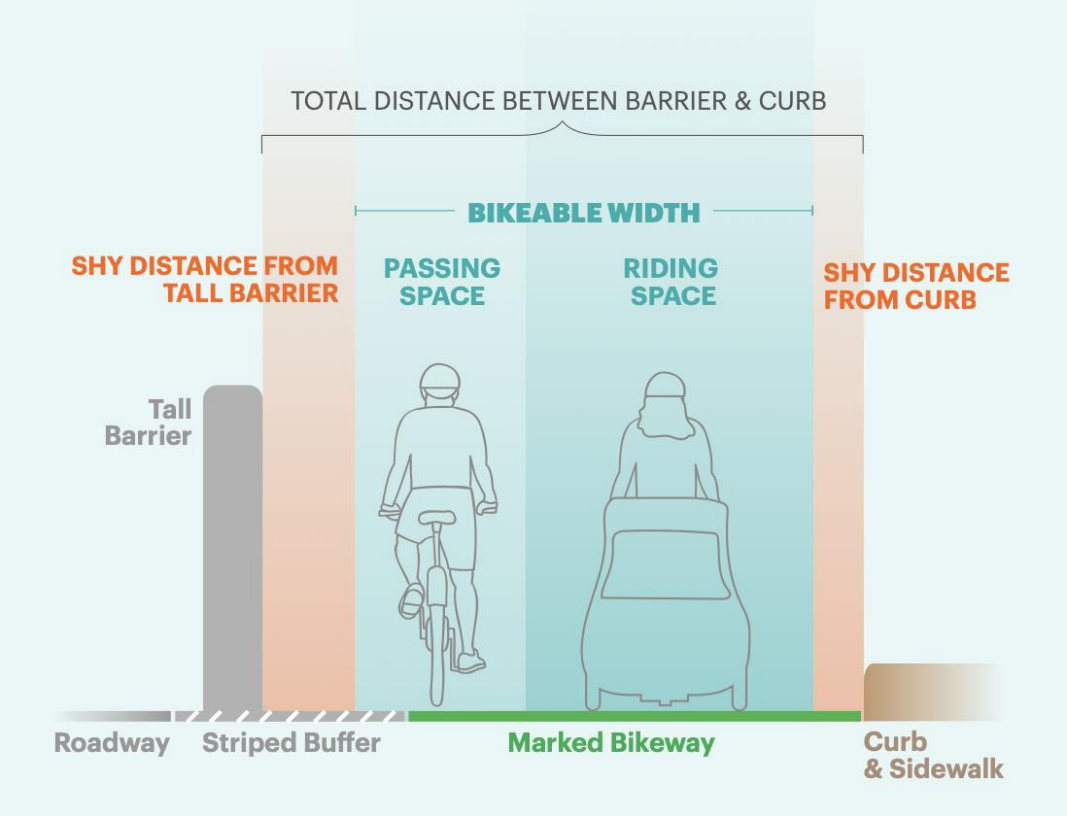


Figure 44. Example of how infrastructure for LEVs can be designed as per NACTO guidance

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 45. 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 46).

Current situation Proposal

Figure 46. Proposed urban design for a LEFV System in the HCQ. Source: Design Studio TUB (2021)

4.4.4. Focus Area 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, coordinate, facilitative, 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 transhipment can also be coordinated by the government. Municipalities can share real-time local traffic data to transport management system providers.

The stipulative role relates to financial incentives for purchasing cargo bikes. 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 organise 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 electric bikes and other light vehicles by the municipalities for their activities.

The facilitative 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.

As it was stated in section 4.1 there are several regulatory barriers at the national and local levels that need to be addressed for the scaled-up implementation of a LEFV system in the Historic Center of Quito that is replicable in other areas of the city such as the Central Business District (CBD), which not only contributes to efficient logistics in a Zero Emissions Area, but also to the economic development by promoting the use of locally designed and manufactured vehicles. Table 9 summarizes the progress done in the regulatory framework and the gaps that still exist for the uptake of a LEVs system for urban logistics in the HCQ.

Table 9. Policy framework: Opportunities and challenges

POLICY FRAMEWORK	
Opportunities	**Challenges**
<u>National regulations, plans and guidelines include electric mobility as a priority</u> • The Energy Efficiency Law (2019) establishes that from 2025 on all new PT vehicles will have to be zero emissions (Ley Orgánica de Eficiencia Energética, 2019) • The Reform to the LOTTTSV (2021) declares the public interest of e-mobility and exults Municipalities and National Ministries to create the necessary incentives to promote it	• The regulatory framework, however, does neither consider LEVs and LML as priorities to achieve the country's decarbonization goals, nor considers the local production of LEVs and the corresponding incentives in its policies. • The experience gathered by SOLUTIONSplus is that the import taxes for LEVs parts were extremely high.

(Art. 214A) (Ley Orgánica de Transporte, Tránsito y Seguridad Vial, 2021)
• Incentives for electric vehicles for private use, public transport and cargo, chargers for electric stations, batteries and chargers for electric vehicles.
  • IVA 0% (2019)
  • ICE 0% (2019)
  • Trade Agreement with PR China, in force since May 2024, will enforce the expansion of the general supply with a 0% of ad valorem tax.
  • No applicable mobility restriction in city of Quito
• Law of Energy Competitiveness (2024), understanding the challenges to comply with the 2025 goal of the Energy Efficiency Law, extends the horizon to 2030 and includes commercial vehicles.	

<u>National (and local) regulations, plans and guidelines already address new vehicle and mobility types</u> • The LOTTTSV (2021) determines that municipal governments are responsible for regulating e-scooters and other micromobility vehicles, but does not specify which. • The National Guide for Cycling Infrastructure and Micromobility (2022) refers to micromobility as small (<100kg & <120cm width), slow (max speed 25 km/h), clean (non-motorized or electric assisted) and healthy (physical activity required) vehicles that can circulate in cycling infrastructure (MTOP, 2022). • NTE-INEN 2656 (2016) provides the description and classification of all L-category vehicles in their ICE and electric versions. • The PMMS (2024) defines micromobility vehicles as small vehicles with a maximum speed of 25 km/h.	• There is not a clear / unified definition of micromobility in the national regulation, plans and guidelines. • The term Light Electric Vehicles, which is the term widely used in English literature to refer to electric micro vehicles (e-scooters, e-bikes, etc) and small vehicles (L-category vehicles) does not exist in Spanish. • The vehicles included under the micromobility category in the Guide (MTOP, 2022) include mostly non-motorized vehicles. The only electric vehicle included is an e-bike, leaving even e-scooters and other personal e-mobility vehicles out. However, according to the study conducted by (Torres, 2022), 6 different types of Light Electric Vehicles (LEV) were observed circulating in Quito's bike lanes in 2021. • The available national norms are outdated: do not include in the vehicle classification vehicles smaller than a motorcycles, like bicycles and new micro vehicle types out.
<u>Important progress in terms of local regulations, plans and measures to advance towards sustainable urban mobility in Quito</u> • Ordinance 194 (2017) regulates the circulation priority of different modes with a focus on active mobility • Quito's Climate Action Plan (PACQ, 2020) has sustainable urban mobility as one of the	Very relevant ordinances for the adoption of e-mobility are still pending approval, such as: • Ordinance for the gradual decarbonisation of transport since 2018 • Micromobility ordinance is under discussion since 2021. The original version included only personal mobility vehicles,

main lines of work. Among the specific measures, it includes: 1) Zero Emissions Historic Center, 2) Active Mobility, 3) Low-carbon urban freight, among others. Moreover, SOLUTIONSplus was included as one of the projects working on contributing to the achievement of the SUM goals (Secretaría de Ambiente, 2020). • PMMS (2024) focuses on improving PT infrastructure and strengthening non-motorized modes, active and micromobility.	excluding micro-mobility vehicles for the transport of goods and people.
<u>Zero emissions Historic Center by 2030</u> • This policy is included in several city plans (PACQ, PMMS, etc.). • In 2019 9 streets in the core area of the HCQ were pedestrianised, converting it in the ideal area to test zero emission alternatives. • It forces businesses operating in the area to change / adapt / innovate. • The results of the SOL+ pilot will shed light on the potential of scaling up the pilots in the HCQ and in the city.	• Despite it being mentioned in important policy documents of Quito, there's not an ordinance that declares the HCQ as a low-/zero-emissions zone yet. • There is a strong resistance from certain sectors in the HCQ. However, the introduction of LEFV in the context of the SOLUTIONSplus project, showcased a possible way out to the vehicles restrictions for their logistics operations. • There is no clarity about the areas in which LEV can circulate. The local regulations should define that.

<u>Local policies and regulations for LML</u>
• Ordinance No. 147 (2012) stipulates that heavy-duty freight vehicles are banned from the HCQ, medium freight vehicles are restricted by a specific schedule (20:30 – 06:30), and light duty vehicles are required to use loading and unloading areas for their operations. LEVs are not specifically mentioned in the ordinance.
• The PMMS (2024) doesn't only include a Commercial Freight plan, but also relevant programs and projects such as:
  ○ Programs
  ▪ Last Mile Logistics
  ▪ Optimization of the logistics value chain and reduction of associated externalities
  ○ Projects
  ▪ Freight consolidation hubs
  ▪ LML in non-motorized or cero emissions transport in the HCQ and other areas
  ▪ Implementation of loading and unloading areas and
	• Ordinance No. 147 was drafted more than a decade ago and needs updating to respond to the current situation in the HCQ and the new regulations that have been approved recently.

	update of the corresponding regulations	

In summary, the national and local regulations should move forward in the following way:

- National regulations
  - LEV should be considered in the national legislation and recognized as a safe and efficient mode of transport for urban logistics, so that incentives for manufacturing that type of vehicles are available, as well as products and permits for “traditional” logistics vehicles, e.g.: vehicle insurance and large-scale transport of food and medicines (ARCSA restrictions. Without this, large companies aiming at shifting to a low-carbon mobility system will not be able to formally integrate LEV in their operations.
  - The administrative processes for the homologation and the import of parts for locally manufactured LEV should become faster and easier, so that local SMEs could produce such vehicles in a smaller period of time responding to the offer
  - Renting / leasing of LEV is one of the business models that has been observed as successful in other case studies, such as Lola te mueve in Colombia. Thus, the renting regulation in Ecuador should include this type of vehicles.
- Local regulations
  - The goal of the Zero Emissions Historic Center has been included in several policy documents and international commitments of the Municipality of Quito (PACQ, PMMS, Plan Integral CHQ, etc.). However, for it to enter into force, an ordinance declaring the HCQ as a Zero or Low emissions Zone is required, as it was the case in Medellín and Bogotá (see Case Study Box 3). This ordinance should include guidelines for the use of LEV for logistics in the HCQ.
  - The micromobility ordinance including a broader spectrum of vehicles, i.e., not only covering personal mobility vehicles (VMP by its Spanish acronym), but also micro- and L-category vehicles for the transport of passengers and freight should also be included and approved in order to formalize and regulate the circulation of LEV in the city.
  - The possibility of renting / leasing under-used public or private spaces as micro-hubs should be formalized and integrated in the urban logistics plan in Quito. In the case of Buenos Aires, for example, the municipality included that possibility in the Building and Transit Code of 2020 together with loading and unloading areas attached to it as it is explained in Case Study Box 2.

Case Study Box 2: 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 47. Micro Hub Express Logística, Buenos Aires, Argentina. Source: SOLUTIONSplus Repository

The results in Buenos Aires show that the CO2 emissions per 100 liters transported can be reduced 25% - 30% when introducing a LEV system (GCBA, 2022).

Case Study Box 3: 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 48. Business in ZUMA Bosa – Apogeo and Southern Terminal Consolidation Center

Action line 2: Public Transport electrification (and optimization)

5. Action line 2: Public Transport electrification (and optimization)

5.1. Current Policy Framework and Market Readiness for deployment of e- mobility

In terms of public transport, the city's transport system is divided between the Metrobus-Q subsystem that includes the two corridors operated publicly and one operated privately; and in the conventional subsystem there are private operators receiving authorization to operate on routes. The following Figure 49 details the classification and numbers of units and routes available in each category.

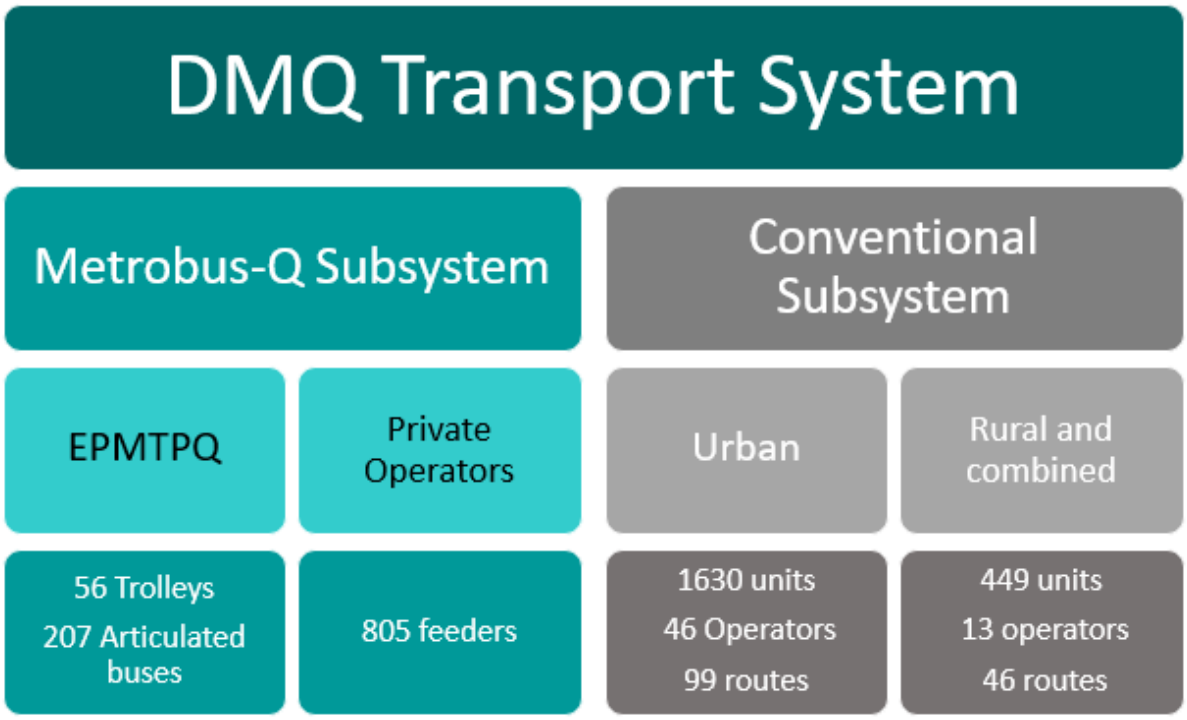


Figure 49. Classification of the DMQ Transport System
Source: Estudio de actualización del Modelo de Demanda del DMQ. TRN Taryet, (EPMMQ, 2018)

Quito is the second city in Latin America to have implemented a BRT system, which has been expanded over time, increasing the served area and number of passengers. At present, the system is composed of 5 BRT lines, which cover 136 km with exclusive lanes that cross the city in a north-south direction, completing 1 million trips on a regular working day (Havela Rodríguez 2019).

The first BRT line -Trolebús- was implemented in 1995 with 113 trolleybuses running on 37 km of exclusive lanes connected to the electricity grid. This is the only BRT line, which runs on electricity. However, the diesel engines supposed to be used only in case of emergency, are being used more frequently than needed. Furthermore, due to the age of the trolleybuses running on this line, many have been replaced by diesel buses. In the past years, 80 biarticulate (18m) diesel buses were bought to replace some of the oldest buses and increase capacity (Bravo 2017).

Currently, the BRT system counts on 324 buses (feeder buses not included), from which 87 are 21years old or older and 37 are 17 years old. These represent 38% of the total fleet of the BRT system. Moreover, there are 2.380 diesel buses that make part of the public transport system, which are run

by private operators and conduct a total of 1.6 million trips on a regular working day (El Comercio 2019).

The current public transport system in Quito has already reached capacity and has not been able to provide safe and comfortable travels to its passengers, generating an important shift towards private cars in the past years. Thus, in 2010 the municipality decided to build the first subway line. The works started in January 2016, and it started operating commercially in December 2023. It is a 23 km long line with 15 stops and costed USD 2 billion. The line crosses the city from north to south, serving a similar route than the one done by the BRTs. However, the subway line is not planned to replace the BRT system, but to complement it. Accordingly, the whole public transportation system is being restructured to integrate the new subway line in the most efficient way possible.

According to Mobility Secretariat (DMQ, 2020c) the main problems in the public transport service of the DMQ are:

- ***High degree of redundancy of routes on roads:*** It refers to the superposition unnecessary routes along the largest percentage of routes, generating various negative effects such as: individual competition between the different providers of the transport service between the operators of the same or other companies, since there is no global integrated common cash operation, generating the so-called “run-ins” (competition for exceeding between transport units to capture more passengers) or "held" (arrests deliberate to also attract more passengers); road safety as a product of the above; operational deficiencies evidenced in low productivity; and environmental effects due to the pollution generated by the emissions that, above all, are evidenced specially where there is greater agglomeration of units in the same road section. All these shortcomings end in a common denominator: low quality of service.
- **Congestion due to saturation of the roads and road insecurity in the main road network:** This is a consequence of the problems described in the preceding point, where the magnitude (number and volume) of public transport units (buses) is very significant.
- **No network of complementary public transport services:** transport services, instead of forming a complementary system make up a transport network of individual routes throughout the Subsystem Conventional Urban and partially between the corridors of the Subsystem Metrobús-Q.
- **Elementary business organization of the operators:** Although, the provision of public transport services is exercised by delegation of the authorities corresponding to the organizations legally formed according to the provisions in national and local regulations (cooperatives, companies or companies), which implies a corporate provision, in practice the service is done individually, since the income that corresponds to each operator comes directly from the collection of fees to users in each transport unit.
- **Failure to comply with schedules and frequencies**: Around 50% of the routes of the conventional services do not comply with the schedules or frequencies established in the enabling titles. One of the causes is that the operation of the buses is performed by a single driver who works up to 16 continuous hours, which is extremely strenuous, against labor norms. Consequently, operational indicators are not met (Mobility Secretariat, 2016).
- **The minimum comfort indicator is not me**t: 80% of the transport offer public has an average occupancy rate of 8 passengers per m2 in the peak hours, exceeding the maximum allowable limit of 6 passengers per m2 internationally recommended (Mobility Secretariat, 2016). This condition is dissuasive to the use of public transport services and encourages the use of the private vehicle to those who have it and the acquisition of those who do not have it yet, a situation totally opposite to the policies sustainable mobility of the MDQ.

- **Deficit of capacities in the supply of Passenger Transport (TP) Services**: The deficiency is notorious in most of the services of the integrated corridors, in terms of their capacity, where users must wait for up to three or four articulated units to be able to enter and move comfortably. Although, on the one hand, they comply with a good speed of movement when traveling in segregated lanes, its capacity leaves much to be desired, even in the so-called valley hours. The same way this problem is evident in most of the conventional services subsystems. This deficit derives in the use of informal transport services.
  On the other hand, it can also be observed that there is a group of conventional transport routes that has low occupancy, making evident the oversupply there**.**
- **Increasing supply of informal transport:** Given the lack of coverage and the deficient TP service, informal transport services have emerged and increased continuously, coexisting in parallel with regular services. One of the main causes for the deficit is the current regulatory framework for public transport, which has not allowed to establish regular procedures to increase the supply against a justified demand. These informal services are carried out with units outside the current regulations, even charging fees above the authorized, especially to cover trips to peripheral sectors.

Therefore, the current system is neither competitive nor attractive compared to the private vehicle, which, despite a complex economic situation of the population, continues increasing its automobile fleet to the detriment of public transport. Consequently, working towards an integrated transportation system where each component contributes to the integrity of urban mobility is unavoidable, both from the social point of view, as well as the economic and environmental one.

The transport sector is a major contributor to global climate change. It is a significant source of CO2 emissions, generating about a quarter of total emissions, with 18% coming from road transport. Therefore, decarbonising transport represents one of the main challenges to meet the reduction targets defined by countries through their nationally determined contributions in the context of the Paris Agreement. The electrification of transport systems is presented as a powerful action to transform our mobility and, at the same time, improve our quality of life.

One of the global climate goals is e-mobility and is the next step for public transport mobility in many countries in Latin America. There are possibilities to apply for green funds offered by the fleet replacement process, because there would be significant savings in greenhouse gas emissions during the implementation of electrification, transition and alternative to fossil fuels projects. ON their path, CAF and IDB are involved in strengthening sustainable transport policies and are part of the Sustainable Transport Group of development banks and the UN Secretary General's High Level Advisory Group on Sustainable Transport.

Figure 50. Mobility Secretary of Quito. Strategical Alignment of the PMMS presented on the City's Road Map Workshops on January 2024

The city of Quito pioneered electric mobility in Ecuador when it implemented the Central Trolley BRT corridor in 1995. The Ecovía was inaugurated in 2002; it has 38 bus stops, 2 transfer stations and an average of 229 thousand passengers per day. Currently, the integrated fare system includes the regular USD 0.35, reduced USD 0.17, and preferential USD 0.12 fares.

Currently, there are five BRT corridors operating along the city, Central or Trolleybus, Oriental (Eastern) or Ecovía and Occidental (Western), operated by the Municipal PTO (EPMTPQ by its Spanish acronym) and Central-North Corridor and South-Western corridor operated by private operators. These corridors have several organized routes operated with articulated and bi-articulated buses on more than 71 kms of segregated bus lanes.

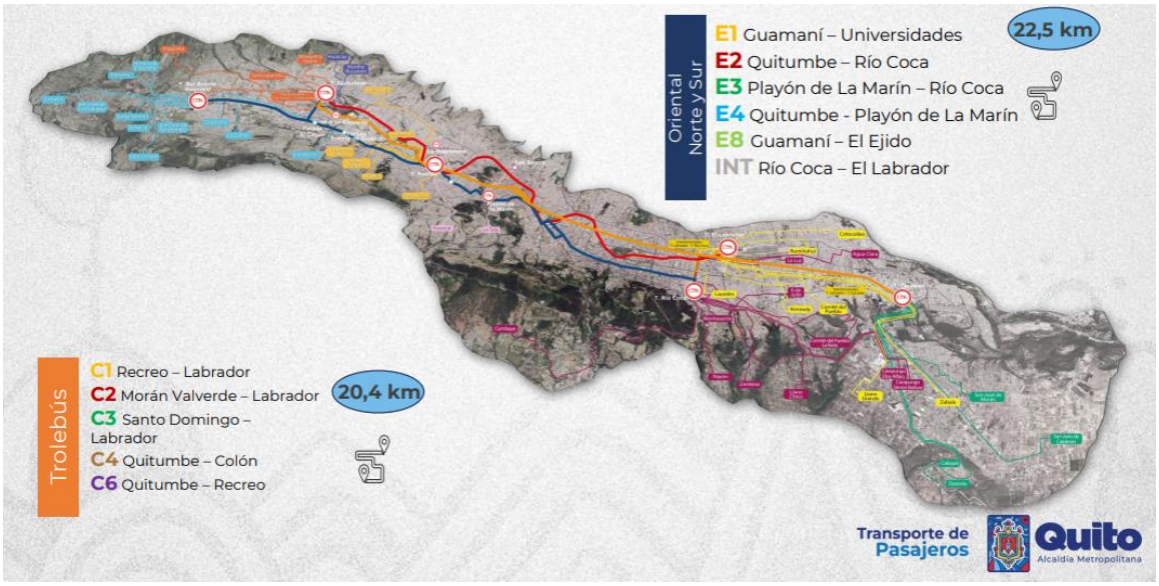


Figure 51. Mobility Secretary of Quito. BRT corridors presented on the City's Road Map Workshops on January 2024.

As a member of C40, Quito is committed to replacing all diesel buses in the city starting in 2020. Furthermore, the trolleybus and part of the Ecovía fleets must be withdrawn from service because of their useful life. In 2020, the C40 Cities Finance Facility (CFF) provided technical assistance for the substitution of approximately 200 articulated diesel buses, 90 trolleybuses and 300 12-meter buses for electric buses and new trolleybuses, by resorting public-private operations models.

Nowadays, the operative infrastructure and capability of the EPMTPQ is limited due the demand of use, which is approximately without fare integration, the Trolleybus and Ecovía corridors transport around 360,000 passengers a day, while with fare integration, it is around 330,000 passengers a day.

Figure 52. Mobility Secretary of Quito. Operative Management presented on the City's Road Map Workshops on January 2024.

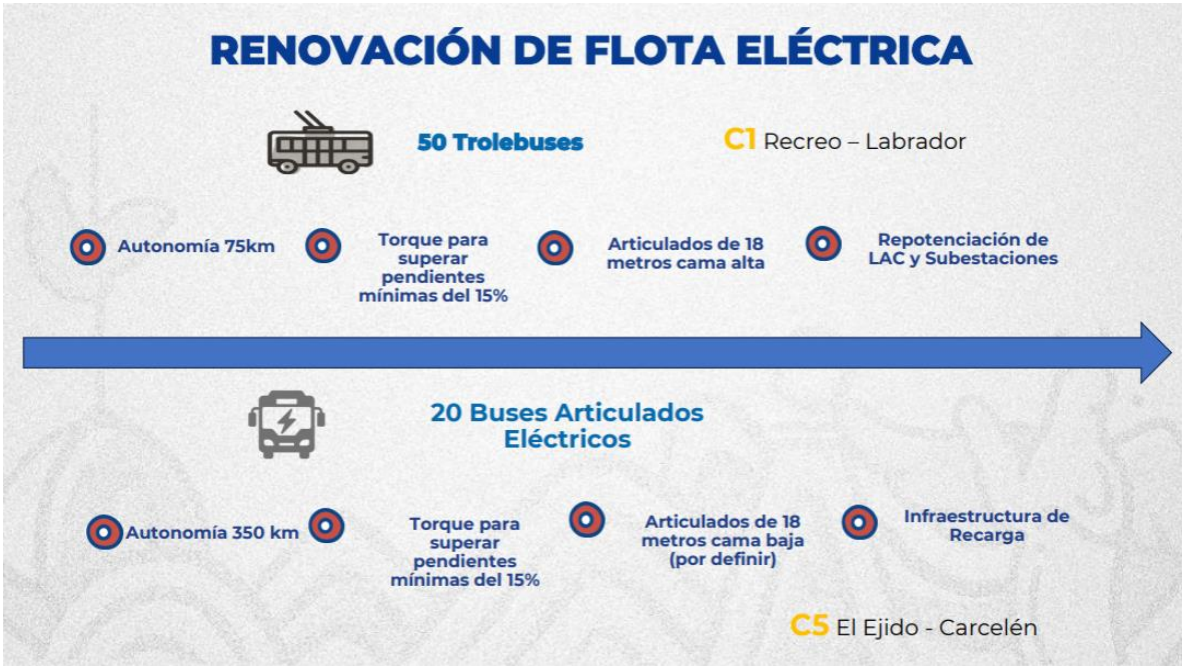


Figure 53. Mobility Secretary of Quito. Renew objective. presented on the City's Road Map Workshops on January 2024.

Transport projects ongoing

The most relevant transport project of the city is the construction and startup of the First Line of the Subway which has a length of 22,6km, 18 trains and 15 stops and which aims to transport 377 000 passengers daily. The Metropolitan Public Enterprise Metro Quito (EPMMQ) was created for this purpose. The works are finalized, and the private operator has already been contracted. The project is currently in the socialization phase, and in parallel is finalizing management, operation and connectivity plans. It is estimated that full operation might start in the second semester of 2023.

On the other hand, the Metropolitan Public Enterprise of Passenger Transport (EPMTP) is responsible for the operation and management of the public transport service of the 4 (out of 5) municipal BRT corridors of the Metropolitan District of Quito and is implementing the following transport projects:

Table 10. Strategic Projects in execution by the EPMTPQ

Project	Starting year	Ending year	Expected Progress by Dec- 2022
Repowering of infrastructure corridors managed by the EPMTPQ	2021	2024	48%
Implementation of Communicational Campaigns regarding the coexistence and the transformation of the public transport system	2021	2024	77%
Implementation of zero-emission units	2021	2031	82%
Implementation of Intelligent Transport Systems (SIR - SAE – SIU)	2021	2031	10%
Adaptation of parking spaces for other modes of ecomobility within the stations and terminals of the EPMTPQ	2021	2022	

Source: Strategic Plan EPMTPQ 2021-2024 (EPMTPQ, 2021)

In addition, the Mobility Secretariat has been developing the project for Construction of the Labrador-Carapungo BRT Corridor. It is the first self-sustaining public transport corridor in Ecuador through an ecological operation system. The stops will have solar panels, ramps for access by people who use wheelchairs, floors, tactile podo, information screens, etc. The Labrador – Carcelén section includes 14 stops (south-north direction and vice versa); that is, 28 in total, and 2 transfer stations, in Labrador and Carcelén (SecMov, 2023a).

Scenarios on future transport demand / growth / modal split

Aside the modal split shift, the recently finalized Sustainable Mobility Plan also includes short-, mid- and long-term scenarios for transport demand, which are summarized in the following table:

Table 11. Future Public Transport Demand Scenarios

Subsystem	Route restructure + new projects	Route restructure + new projects	Route restructure + new projects
	Esc07 2027	Esc08 2032	Esc09 2042
	Passengers/ day	Passengers/ day	Passengers/ day
BRT	606.707	685.316	719.772
Metro	384.242	587.728	627.060
Cable	-	60.282	66.578
Other Urban Services	1.402.000	1.419.783	1.464.833
Regional	628.285	637.274	678.663
Feeders	1.308.644	1.228.958	1.286.319
Secondary lanes	205.762	194.701	199.518
Total	4.535.639	4.814.041	5.042.743

Source: Sustainable Urban Mobility Master Plan, (DMQ, 2022)

5.2. The Demonstration actions

5.2.1. Mathematical Modelling and optimization

In the context of the SOLUTIONSplus project and the Urban Living Lab Center (ULLC), the Research Center for Mathematical Modeling (MODEMAT) from the National Polytechnic School (EPN) has been developing mathematical models for the optimization of fleet allocation and investments for the transition to electric mobility. After discussions with the Municipality of Quito, specifically with the Mobility Secretariat and the EPMTPQ, it was decided to focus the data analysis in two ways:

1) Operational: use the statistics that the EPMTPQ generates regularly from its operations, such as gait diagrams to create models and automate the process, with regard to the allocation of units to cover scheduled trips, as well as, later, in the allocation of shifts to drivers.

2) Strategic: use the demand data available in the Origin Destination Surveys (EOD) carried out for the Sustainable Mobility Master Plan (PMMS) to implement models for optimizing routes and frequencies of public transportation that guarantee adequate coverage of transportation demand. The goal is to adjust with statistical models to take into account the global growth in demand. Below are some of the models in which the EPN has worked on and their preliminary results.

Vehicle Scheduling in the Bus Rapid Transit (BRT) System in Quito

The model considers Bus Rapid Transits (BRT) Systems as a proven cost-effective alternative for urban public transportation in Latin America. MODEMAT has been working on the fleet assignment optimization of Quito's BRT system composed by a heterogeneous fleet of more than 150 high-

capacity buses driving among dedicated tracks, which carry around 380,000 passengers on more than 1,900 trips during a usual working day. The initial research has worked specifically with the Trolleybus and Ecovía Corridors with the objective of reducing the number of units and the waiting time on platforms between trips, focusing on the C4 and C6 closed cycle routes during weekdays with 222 scheduled trips using 26 transport units.

The research uses integer programming models for solving a multi-depot vehicle scheduling problem. Feasible bus routes to serve the trips must comply with several additional constraints, such as having durations that are compatible with the driver assignment, which is solved as a following phase in the operational planning of the system. The solved model included 6020 constraints and 542.646 variables, with a resolution time of 13 minutes and 43 seconds. The following three optimization scenarios were analyzed:

- **Scenario 1:** Minimization of Dead Time, where the 26 units were maintained with a dead time reduction of 1052 minutes (17.53 hours).
- **Scenario 2:** Unit Minimization, using the same number of units and similar downtime reduction as Scenario 1
- **Scenario 3:** Minimization of Downtime and Units Used, achieving a reduction of 1052 minutes in dead time while maintaining the same 26 units used.

The future analysis will incorporate more circuits (C1, C2 of Trolleybus and E1, E2, E3, E4, E1M, E8 of Ecovía). It will also consider the fleet in different depots with different characteristics, incorporating fleet-travel compatibility criteria, and calibrate costs and redefine downtime and unit availability. Moreover, since the Mobility Secretariat aims to gradually replace the bus fleet with electric buses in the next years, the next models must also accommodate the possibility of considering battery charging times within the routes. The results of the first instances solved indicate remarkable optimization potential for the waiting times of vehicles between scheduled trips, when compared to the current bus schedules. The proposed pilot model has demonstrated significant improvement in reducing platform idle time without increasing the number of units. The optimized results suggest potential improvements in operational efficiency for Quito's transportation system.

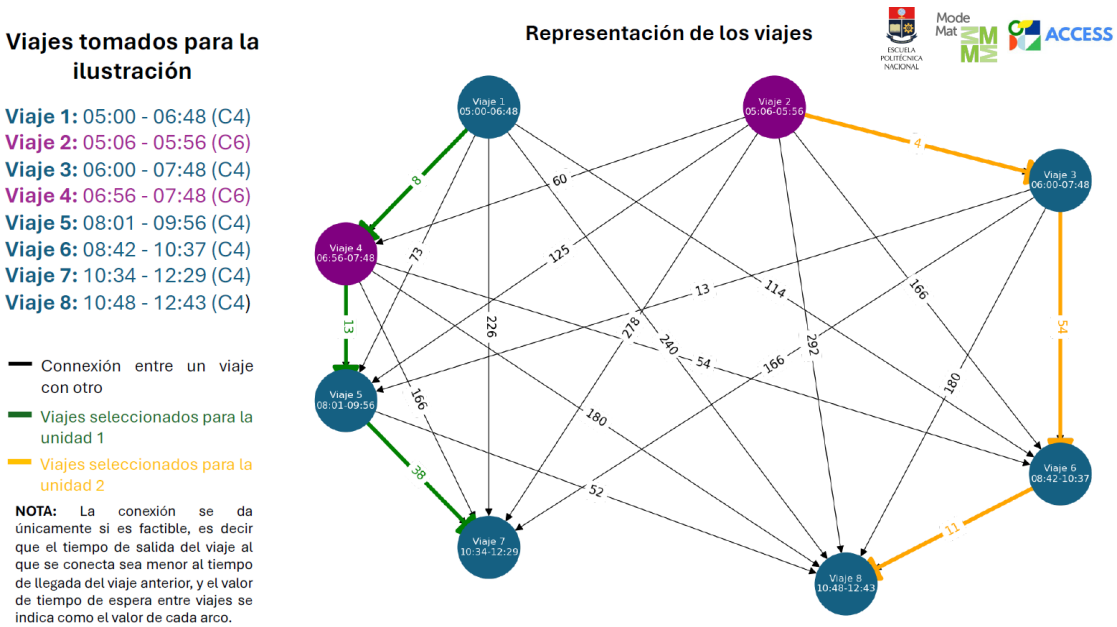


Figure 54. Example of mathematical optimization of travels with data provided by EPMTPQ.

Models for the transition to electric public transport fleets

The purpose of this research is to create mathematical integer linear programming models to support the transition to an electrified and decarbonized public transport fleet in various scenarios. Specifically, it seeks to develop an optimization-based decision support tool that addresses the complex fleet replacement problem, taking into account a variety of economic and infrastructure considerations. Decision variables include annual investment costs for both vehicle acquisition and charging infrastructure implementation of various possible technologies, along with projected operating costs. The goal is to develop optimal transition plans that achieve fleet electrification and emissions reduction goals in a cost-effective manner.

The MODEMAT has worked on a model for optimizing investments in the transition to electric mobility in bus fleets, based on the work of Pelletier et al. (2019), which compares the cost of three types of buses: diesel, hybrid and electric, highlighting the lower operating cost of electric buses in the long term. The model seeks to plan the purchase of electric buses and charging infrastructure, determine the number of buses sold and retired in each period, and estimate the associated costs. The objective is to minimize the total investment cost required for the transition. The optimization model needs the following input data:

Current Fleet: Characteristics, age, useful life, and purchase options (new buses and chargers).

Operations: Number of buses needed and compatibility between bus types and routes.

Charging Infrastructure: Costs, energy consumption, current quantity and compatibility with electric buses.

Costs: Cost of operation, maintenance, fuel and purchase of electric buses.

The model also considers the following control parameters: budget available in each period, maximum number of chargers per depot, maximum charging capacity in the network, bus demand per period, average age of the fleet and time horizon for complete transition. The EPN has proposed to replicate the model in Quito, Ecuador, incorporating an emissions reduction dimension. Some of the data required to apply the models for Quito is the following: fuel cost forecasts in Ecuador, charges for electric power demand, information on routes and current fleet (technical characteristics and age), costs of new buses, chargers, batteries and maintenance, local data on autonomy and performance, incorporation of emissions which means establishing restrictions for emissions ceilings or include a cost for emissions in the objective function. It also implies identifying zero-emission routes operated exclusively by electric buses.

Low Carbon Mobility Management App (LCMM)

The EPN has been working with the LCMM App developed by T-Systems, a tool that measures driving behavior, fuel consumption and CO2 emissions. It also performs analysis of speed profiles from GPS smartphones, evaluating driving performance by comparing trip data to reference cycles. On April 2024, a group of students from EPN gathered information from different BRT route profiles, they collected time measurements during peak and off-peak hours on the following routes:

- E1: 15 cycle measurements from 3/4/24 to 11/4/24.
- C1: 27 measurements of the South-North and North-South sections from 3/4/24 through 11/4/24.
- Recreo-Solanda: 5 cycle measurements from 9/4/24 to 12/4/24.

- Labrador-Carcelén: 10 measurements of the South-North and North-South sections from 9/4/24 to 11/4/24.

The analysis has shown significant differences between travel times during peak and valley hours, which is critical for fleet planning and optimization. Peak hour routes tend to have longer times due to higher traffic and passenger demand. The data collected can be used to adjust frequencies and bus assignments, improving operational efficiency and reducing wait times.

Specific measurements for each stretch and schedule will allow for better scheduling and fleet distribution, tailored to actual demand. The identification of demand peaks and travel times will allow a better allocation of resources, optimizing the use of buses and personnel. It will be possible to reduce the number of units in circulation during off-peak hours, reducing operating costs without affecting service. The collection of this type of data for passenger transportation operations is useful for implementing adjustments to bus frequencies based on demand data and travel times to improve service efficiency. Additionally, the continue monitoring and data collection is important to keep information up to date and be able to respond to changes in demand patterns.

In summary, the permanent collection of data is useful for long-term strategic planning, considering possible route expansions and infrastructure improvements. The research done by EPNT presents a detailed compilation of travel times on various routes of Quito's transport system, highlighting the importance of this data for optimizing fleet allocation and improving operational efficiency. The conclusions point towards better resource management and more accurate planning based on actual user demand. Further analysis are being done with a gender perspective to define if there is differences in ecodriving practices between men and women drivers.

Labrador-Carcelén: Sur-Norte, 09/04/2024, 09h17-09h36| Hora Valle

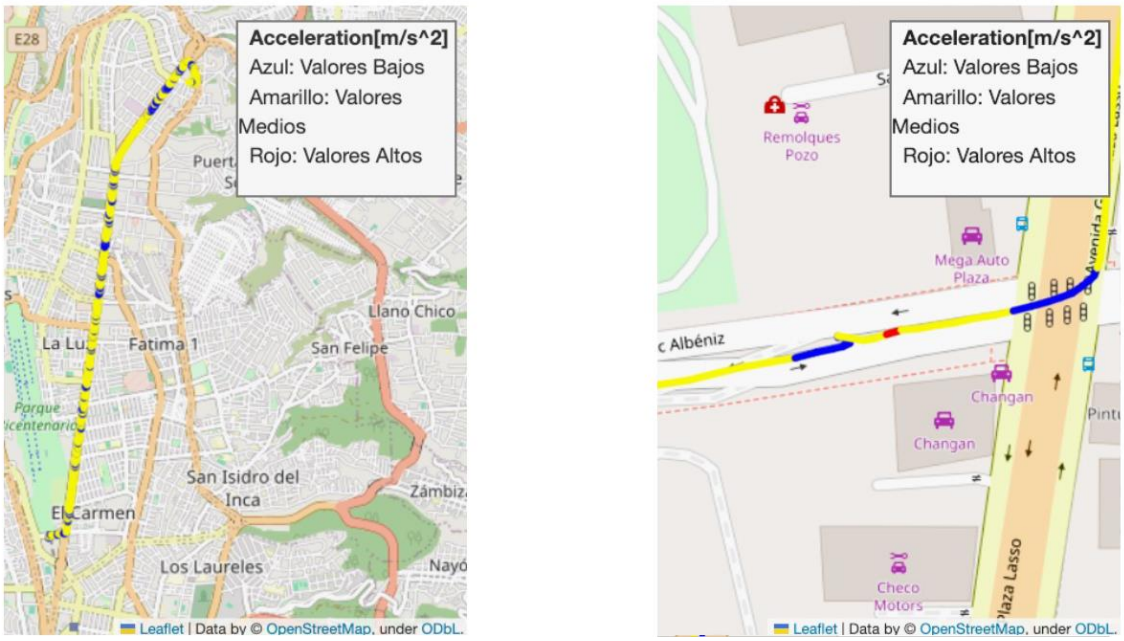


Figure 55. Example of data collected by the EPN students with the LCMM App.

5.3. Main barriers and opportunities for scale-up

Below are some of the key challenges and needs that must be addressed to ensure the successful implementation of an eBRT system in the future in Quito. Overcoming these obstacles—ranging from coordination among diverse operators to infrastructure gaps and training requirements—will be crucial for kickstarting the transition to eBRT.

Coordination among diverse operators: Ensuring cohesive action and strategy among competing bus operators requires robust coordination mechanisms.

Transition plan for the conventional buses and absence of regulations for retrofitting: The municipal public transport operator (PTO), Empresa Pública Metropolitana de Transporte de Pasajeros de Quito (EPMTPQ), has been exploring the retrofitting option for the 200 conventional buses, but there is no regulation yet to support the process. Moreover, a recent technical assistance made by USAID for the EPMTPQ concluded that retrofitting is not a feasible option for Quito, and it recommends gradually acquiring new electric buses to replace the obsolete fleet.

- **Renting of BYD buses:** The EPMTPQ has also been analyzing the feasibility of renting BYD buses, checking the regulations. EPMTPQ considers renting as an alternative in the long-term, but existing regulations on vehicle depreciation present challenges to this option.
- **Infrastructure gaps**: The need for suitable charging infrastructure and the transition of 200 conventional buses to electric counterparts require substantial technological and infrastructural development.
- **Comprehensive planning for feeder routes**: Currently, there is no specific plan for the electrification of feeder routes, necessitating comprehensive planning to ensure systemic efficiency.
- **Training for the personnel of public transport operator (PTO):** The EPMTPQ also highlighted the importance of training the personnel for the transition to e-mobility (e.g., handling smart charging systems). The public company needs to define new staff profiles and provide capacity building for the current employees.
- **Energy management models:** There is also interest in understanding strategies for managing the energy demand and supply effectively, specifically, optimizing the use of energy during periods of low demand (low-peak times) throughout the day. This could involve various management models that aim to make the most efficient use of available energy while maintaining a reliable charging infrastructure for e-buses.

In this context, the electrification technical feasibility seeks to show aspects of the city of Quito, describe its transport system, the characteristics of the demand and user profile, the possible integration with Urban Mobility Vehicles (UMV), and how to prepare the infrastructure for the implementation of electric buses. The analysis conducted points out the financial difficulties faced by the City of Quito, including a situation of low transport demand that represents a major financial risk for the bus operating companies.

The problem was even more critical as there has been no fare increase over 13 years, while inflation has accumulated to 56% over the same period (2006-2019). It is understandable that decisions to adjust fares are difficult, but the results depend on these decisions. In the absence of political decision

around fares, various studies had made the recommendations that consultants believe are the most appropriate. Technical feasibility is also part of these barriers.

Specifically, the acknowledgement of a consistently evaluated tariff formula and the implementation of a long-term subsidy policy are crucial in the field of research. From an expert perspective, professionals recognize the significance of establishing a tariff formula that undergoes regular reviews to ensure its effectiveness and alignment with evolving market conditions. Additionally, the implementation of a permanent subsidy policy is essential to provide consistent financial support and incentives for various sectors. This approach allows for a more comprehensive and sustainable approach to managing tariffs and subsidies, contributing to the overall success and growth of industries.

To foster a competitive regulatory framework that enhances the collaboration between public and private entities, it is imperative to establish a research-based approach from an expert perspective. This approach aims to optimize the operational efficiency and effectiveness of the public/private operation. By implementing a pro-competitive regulatory environment, professionals can ensure fair competition, promote innovation, and drive economic growth.

In order to encourage stakeholders and users to actively contribute to the enhancement of the transport service, it is essential to establish a comprehensive set of incentives and disincentives. These measures can effectively drive positive changes and ensure the success of the transportation system.

One key incentive is the introduction of an electronic fare payment system. This system offers numerous benefits, such as convenience, efficiency, and security. By adopting this technology, stakeholders and users can enjoy faster and more streamlined payment processes, eliminating the need for physical tickets or cash transactions. This not only enhances the overall user experience but also reduces the risk of fraud and theft. Additionally, the electronic fare payment system can be integrated with loyalty programs or rewards schemes. This allows stakeholders and users to earn points or receive discounts based on their frequency of travel or loyalty to the transportation service. These incentives can motivate individuals to choose the service more frequently and actively participate in its improvement.

On the other hand, disincentives can be employed to discourage behaviors that hinder the improvement of the transport service. For instance, penalties or fines can be imposed on individuals who engage in fare evasion or disruptive behavior. By implementing strict consequences for such actions, stakeholders and users are deterred from engaging in activities that negatively impact the overall quality of the service.

Furthermore, regular monitoring and evaluation of the transport service can be conducted to identify areas of improvement. Stakeholders and users can be actively engaged in this process through surveys, feedback mechanisms, or focus group discussions. By actively involving them in decision-making and improvement initiatives, their sense of ownership and responsibility towards the service is heightened.

In conclusion, the establishment of an electronic fare payment system, coupled with a range of incentives and disincentives, can effectively empower stakeholders and users to contribute to the enhancement of the transport service. By providing convenience, security, and rewards, individuals are motivated to actively participate in the improvement process, while penalties discourage behaviors that hinder progress. Regular monitoring and engagement further strengthen the bond between stakeholders, users, and the transport service, ensuring its continuous improvement.

5.4. Implementation plan - How do we get there?

5.4.1. Focus area 1: Regulatory framework

The development of infrastructure and equipment for a public passenger transport system is framed within a context of sustainable economic growth, competitiveness and employment. Public passenger transport is a basic strategic public service whose availability has a direct impact on the productivity and economic dynamics of any city, and which currently represents one of the factors of high pollution in the city, due to the use of fossil fuels.

The transport service is a fundamental element for the development and competitiveness of cities, and as such is an important component of investment budgets. They also generate effects on the population, including impacts on their health and the environment, especially when their use is based on non-renewable fossil fuels, as is the case in the Metropolitan District of Quito.

So on in this wide context, the SOLUTIONSplus project offers the Municipality the opportunity to acquire charging equipment for electric buses at a discounted rate, depending on the progress of the public transport fleet electrification process in the DMQ. This section analyses the legal framework in force both at the national level and at the level of the Metropolitan District of Quito, as well as the institutional framework for the management of public passenger transport.

Recent experiences suggest that the most suitable bus procurement model involves buses being owned by an independent investor separate from the operation. This setup ensures that buses do not become problematic during the renewal of operation concessions, as bus contracts align with the bus's lifespan. Although the separation between the investor and the operator results in higher costs, cities where this model was adopted have found that the ease of management outweighs these expenses. The increased costs arise from bus owners taking on risks that were previously mitigated by the operator to some extent. Moreover, bus owners may face penalties for bus unavailability, whereas operators view such unavailability as "non-compliance" and may incur fines that are often not fully paid due to the company's financial balance.

Leasing, on the other hand, represents an alternative form of fleet financing. Articulated, bi-articulated, and now electric buses lack a broad market that facilitates easy fleet reallocation for other operations. Consequently, contracts must align with the bus's lifespan, introducing the risk of the administration defaulting on contract payments. The investor's risk assessment influences the "spread" over the investment interest rate. In Ecuador, as it was said, leasing is not part of the public procurement.

On the other hand, recognizing the financial constraints of many prospective buyers, the scaling-up model offers flexible financing options with low-interest rates and extended repayment periods. This approach aims to democratize access to EVs, particularly for individuals and small businesses with limited capital. In this matter, Governments, in partnership with private stakeholders, can introduce incentives and subsidies to lower the upfront costs of electric vehicles (EVs). These incentives may include tax breaks, rebates, or grants, encouraging uptake and stimulating market demand.

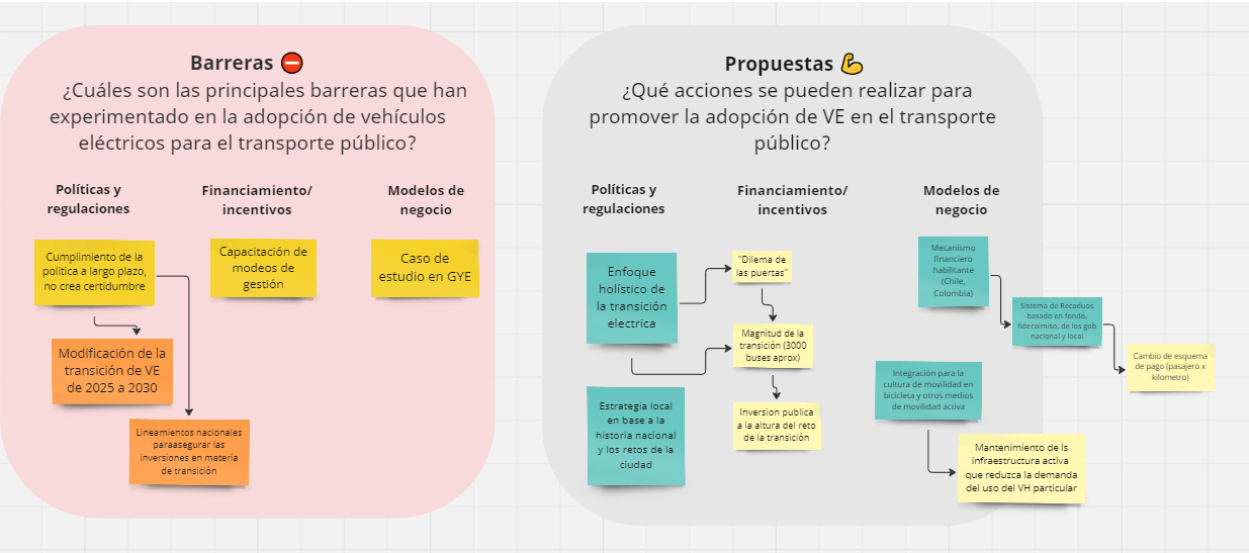


Figure 56. Partial of Miro's Dashboard. City Road Map Workshops. January 2024

Then, supporting infrastructure, such as charging stations and grid enhancements, is vital for the widespread adoption of EVs. Public-private partnerships can facilitate the deployment of charging infrastructure, strategically located in urban centers and along major transportation routes. This infrastructure expansion enhances the convenience and reliability of electric transportation, addressing range anxiety concerns among potential buyers.

Also, targeting commercial fleets, including taxis, delivery vehicles, and public transportation, accelerates the transition to electric mobility at scale. Fleet operators can benefit from bulk purchasing arrangements and tailored financing packages, leveraging economies of scale to lower costs and streamline operations. By electrifying fleets, cities can reduce air pollution, decrease fuel expenditure, and improve overall urban livability.

5.4.2. Focus area 2: Business Models

This choice boasts the most economical approach, achievable through supplier credit or securing low-interest loans from multilateral banks or institutions such as the IFC. Nevertheless, it entails a lengthier processing period for credits, contract signings, tendering processes, and finalizing agreements.

The company bears all associated risks, encompassing technical challenges with vehicles post-warranty, adapting to new technology learning curves, and addressing potential technical capacity gaps within the organization.

"Leasing" operation by the Mobility Department

This option streamlines the acquisition process by bypassing cumbersome credit procedures. However, it still necessitates approval from the Metropolitan Council and the identification of payment sources. Leasing costs, while convenient, come at a premium of 3 to 5 percentage points above loan interest rates for bus procurement.

Additionally, maintenance under this arrangement will incur extra expenses, estimated to be 10% to 15% higher than standard maintenance costs, owing to administrative charges and capital investments in spare parts for vehicle availability assurance. To mitigate potential parts shortages necessitating imports, the leasing company must maintain a stocked inventory. Moreover, it's worth noting that 70% of the VAT payment can be reclaimed, offering a potential cost-saving advantage.

"Leasing" operation by the EPMTPQ

This is the most expensive option. In addition to all leasing costs, the VAT cannot be recovered, resulting in an extra 8.40% cost in the contract (70% of the VAT that could be recovered by the Department/Municipality).

Furthermore, it's necessary to consider that the EPMTPQ can only enter into a leasing contract if the Municipality approves transferring funds to the company because the fare is insufficient to cover service costs.

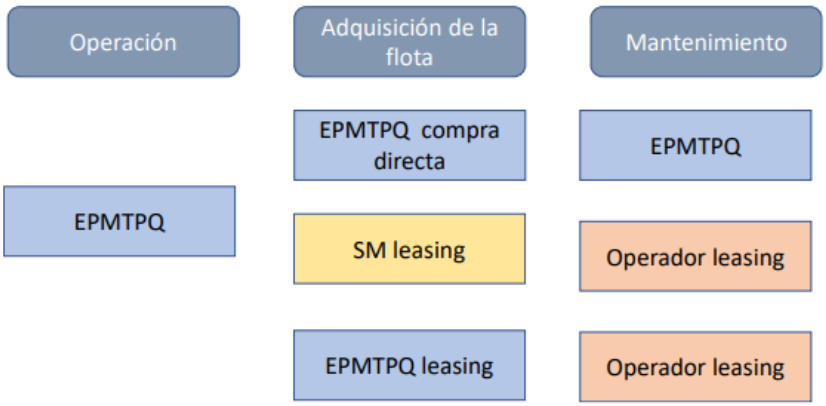


Figura 10. Alternativas de adquisición de flota

Figure 57. Take form the C40 Transition to Electric Buses in the Ecovía Corridor and Extension of the Trolleybus Corridor from El Labrador to Carapungo in Quito, Ecuador (2020)

The advantages and disadvantages of fleet procurement through leasing contracts are as follows:

Table 12. advantages and disadvantages of fleet procurement

Disadvantages	Advantages
I. Higher cost compared to other options. II. Potential conflicts arising from driver performance. **III.** Requires a fund with resources for at least six months' leasing payments (investors may require a fund equivalent to a year). This provides a cushion of time to address payment delinquencies and resolve conflicts in the event of a possible contract breach**.**	I. Ensures better availability of buses. II. Provides better maintenance and eliminates vehicle maintenance costs for the EPTMQ. III. Assumes risks from suppliers for manufacturing defects or bus performance issues. IV. Shares some of the technological risks associated with electric bus technology. V. The contract covers the vehicle's entire lifespan, and the addition of new vehicles entails new leasing contracts.

Modelo	Ventajas	Desventajas
Operación total por la EPMTPQ	a. No se cambia el modelo existente	a. Se mantiene la ineficiencia de las empresas públicas
	b. Facilidad de integración con el metro	b. Se mantiene el subsidio a la empresa
	c. Mantiene la experiencia en la operación y mantenimiento de los trolebuses	
Gestión delegada con concesión parcial operación compartida	a. Inversión por operador privado	a. Operación compartida tiene desempeño de 20 a 30% menor que operación única
	b. Manutención y operación por operador privado	b. Requiere un mecanismo de pago al operador por servicio prestado
		c. El operador tiene responsabilidad limitada en la programación de los servicios
		d. Conflicto de interés entre el privado y la empresa pública
Gestion delegada con concesión parcial del Corredor Ecovía	a. Inversión parcial por operador privado	a. Require transferencia de los buses diésel para el operador privado
	b. Operación del Corredor Ecovia totalmente por operador privado	
	c. Mantenimiento por operador privado	b. Requiere operación compartida de talleres de la EPMTPQ
	d. Mantiene operación independiente del Corredor Central y del Corredor Ecovia	
	e.Capacitación de la EPMTPQ como gestora del contrato	
	f. impacto en el pasivo laboral de la EPMTPQ parcial	c. Requiere contrato con operador privado por servicio prestado y por pasajero transportado
	g. Soluciona en parte el problema financiero del municipio	
Gestión delegada con Concessión total	a. Transfiere todo el sistema para operador privado	a. Pasivo laboral de la EPMTPQ tiene que ser liquidado de un solo golpe
	b. Operación más eficiente	b. Reacción fuerte del sindicato
	c. EPMTPQ se transforma en organismo de gestión	c. Riesgo político alto
	d. Soluciona el problema de dificultad de inversión por la Alcaldía	d. Transferencia de activos de la EPMTPQ al operador privado puede ser complicada

Figure 58. Take form the C40 Transition to Electric Buses in the Ecovía Corridor and Extension of the Trolleybus Corridor from El Labrador to Carapungo in Quito, Ecuador (2020)

From the environmental scope, as a District policy, it is imperative to prioritize the combat against pollution caused by the transport system and safeguard the health of citizens. Additionally, it is crucial to ensure the financial sustainability of the system, promote transparency, enhance efficiency and reliability in the service, and strive for greater gender inclusion. Moreover, it is essential to provide transport services in the most frequented areas of the city, among other key objectives.

The technical scope in the field says, it is crucial to conduct a comprehensive strategic evaluation of the existing Integrated Metropolitan Public Transport System. This evaluation should encompass all its facets, including technical, operational, administrative, financial, and legal aspects. The primary objective of this assessment is to swiftly gauge the current state of the system and identify areas that require improvement or modification. By doing so, we can effectively determine the desired changes and work towards achieving them.

To effectively implement transportation initiatives, it is crucial to form a proficient team and grant them authority at the Mayor's Office level. This team should comprise a dedicated technical staff as well as external experts with extensive knowledge in the field. Their collective expertise will facilitate the successful execution of transportation projects.

Furthermore, it is recommended to designate a single individual responsible for overseeing all modes of transport within the city. This centralized approach will ensure streamlined decision-making and coordination among different transportation sectors.

To improve the quality of the city's fleet, it is advisable to phase out vehicles older than 15 years and arrange for their disposal as scrap. Additionally, implementing a ban on the import of used buses will prevent the influx of outdated and potentially unreliable vehicles into the city's transport system. These measures will contribute to enhancing the overall efficiency and safety of the transportation network.

Alternativas para la operación de los servicios de buses y la adquisición de los buses		
Operador	**Adquisición de los buses**	**Modelo de operación**
Operación total por la EPMTPQ	1. Municipio hace la adquisición de buses con baterías	EPMTPQ hace la operación y mantenimiento de los buses
	2. La EPMTPQ hace leasing directo de los buses	a. EPMTPQ hace la operación y mantenimiento de los buses bajo supervisión del la empresa de leasing
		b. EPMTPQ opera y la empresa de leasing hace el mantenimiento
	3. Adquisición compartida	
	La EPMTPQ compra/hace leasing de los buses	•EPMTPQ opera y mantiene los buses
	La empresa de energía compra las baterías	•La empresa de energía mantiene las baterías
EPMTPQ opera el corredor Central Operador privado opera Ecovía	•El municipio compra los trolebuses y e-buses del corredor central	•EPMTPQ opera y mantiene los trolebuses y e-buses del corredor Central
	•La empresa privada compra/lease los e-buses de Ecovía- Extensión Carapungo y asume los buses diésel actuales	•La empresa privada opera y mantiene los e-buses del Corredor Ecovía – Extensión Carapungo
	•Los buses se compran con las baterías o la empresa de energía compra las baterías	•El operador privado mantiene las baterías
	•El proveedor de las baterías también es proveedor de las electrolineras y cargadores para las baterías	•La empresa de energía mantiene las baterías
Operación exclusiva por operador privado	·El operador privado compra/lease los buses y "hereda" los buses diésel actuales	El operador privado opera y mantiene los trolebuses y e-buses del Corredor Central, Corredor Ecovía – Extensión Carapungo
	a. El operador privado compra los buses y las baterías	·El operador privado mantiene las baterías
	b. La empresa de energía compra las baterías	•La empresa de energía mantiene las baterías
	•El proveedor de las baterías también es proveedor de las electrolineras y cargadores para las baterías	•EPMTPQ se transformaría en el organismo de gestión o la Autoridad Única de Transporte
Operación compartida entre privado y la EPMTPQ	Operador privado compra trolebuses y e-buses	•EPMTPQ opera y mantiene los buses diésel
	Operador Privado compra las baterías	Operador privado opera y mantiene los buses electricos (trolebuses y e-buses) y las baterías
	Empresa de energía compra las baterías	Empresa de energía mantiene las baterías

Figure 59. Take form the C40 Transition to Electric Buses in the Ecovía Corridor and Extension of the Trolleybus Corridor from El Labrador to Carapungo in Quito, Ecuador (2020)

The debate surrounding the management models of public transportation in cities like Bogotá and São Paulo reflects the complexities and challenges faced by local authorities in ensuring an efficient, accessible, and sustainable service for their citizens. Criticisms of the subsidy of the service from the municipality in Bogotá, and the questioning of the political cost of the subsidy in São Paulo, raise important questions about the viability and equity of these management approaches.

In the case of Bogotá, the management model involving a direct subsidy of the service from the municipality has been subject to criticism from some experts and officials, including the passenger manager of Quito. The main concern lies in the dependence on the subsidy to maintain affordable fares for users, which can lead to financial imbalances and long-term economic dependency. Additionally, there is the argument that managing public transportation as a public service is incompatible with the participation of private entities, limiting the replicability of the model in other contexts.

On the other hand, in São Paulo, the subsidy of the public transportation service has become a politically sensitive issue due to the high associated cost and the need to review its effectiveness and equitable distribution. The subsidy of approximately 1 billion USD represents a significant burden on public finances and has sparked debates over the prioritization of resources in a context of budgetary constraints and competing demands from other sectors.

Moreover, the lack of updating of the technical fare in 2024 in some cities, including São Paulo, raises concerns about transparency and equity in fare setting. The discrepancy between the actual cost of the service and the fare charged to users can distort the system and disproportionately affect certain segments of the population, especially those with lower economic resources.

In this context, it is crucial for municipal authorities and public transportation experts to address these challenges comprehensively, seeking solutions that ensure operational efficiency, socioeconomic equity, and financial sustainability of the system. This may involve exploring new management models, improving transparency and accountability in fare setting, and implementing policies that promote the efficient use of resources and investment in public transportation infrastructure.

The public transport operator’s transition to an electric fleet represents a significant financial undertaking, necessitating innovative financing and business models. Engaging with international financial institutions and green funds can unlock capital for infrastructure development and fleet procurement. Concurrently, exploring scrapping incentives for conventional buses can provide additional financial levers to support the transition. The development of business models that encompass these elements, facilitated by strategic collaboration with ministries focusing on finance and industry, is important for ensuring the project's long-term sustainability.

5.4.3. Focus area 3: Charging infrastructure and interoperability

About the infraestructure adequacy

The corridors are already operating with stations that are adequate for articulated and biarticulated buses. The terminals also operate with these types of buses and bus depots are designed for articulated buses and are operating with bi-articulated buses. The trolleybuses already have adequate facilities for their technology. However, for both trolleybuses and electric buses, adaptations are necessary for battery recharging equipment.

Stations

When preparing bus specifications, currently operating characteristics such as floor height and number of doors must be complied with. Since the opportunity of batteries is not expected at the stations, no adjustments are necessary. However, new turnstiles may be required to modernize the fare collection system. Once the metro begins operation, demand will drop in the corridors drops and, therefore, less fleet and lower frequency are required. Stations will be less saturated and show a better service level.

E-bus terminals

Terminals do not require adjustments either. However, if decided that opportunity charging is needed in terminals when an operation cycle is carried out, the terminals will have to adapt to the installation and operation of fast recharging systems for electric buses. This charge can take between 6 and 10 minutes. This adaptation can reduce battery costs but will require an extra fleet to handle the increase in cycle time. The logistics of one stop every two cycles can be adopted. That would reduce the impact on cycle time. Vehicle autonomy would drop to less than half. The cost of an opportunity charger is almost the same as a new bus, and the terminal power grid would have to be upgraded. However, this is a decision to be made by the operator after consideration of investment and operating costs.

E-bus depots

Bus depots need adjustments in their parking lots. Fuel filling up areas are no longer necessary, but now an area is needed to charge the buses. Charging stations need to have their own infrastructure with the required protection of chargers and charging operators against weather conditions. The purple area indicates where a roof will be built to protect the front part of the buses and the chargers. The location of bus parking and recharging areas must be specifically designed for each bus depot and depends on the number of buses each will hold.

About the e-buses and infraestructure

To determine the type of electric bus technology and infrastructure of interest to the city of Quito, an analysis was carried out of trolleybuses, battery electric buses and their charging alternatives. This review looked at recent implementations made in Europe, US, Mexico and Latin America. This analysis considered 18-m bus typologies and, primarily, projects in the scaling-up phase, to show how these electromobility solutions have consolidated in the public transport area.

On 18m bus and trolleybus technologies:

Considering cities in Europe, US and Latin America, out of all 52 cities reviewed, 66% involved the implementation of 18-m electric bus fleets. European cities stand as the main cases of escalation. The remaining cases involved articulated trolleybuses (34%). The total fleet of 18-m buses reviewed

involved 1,111 units and 10 OEMs : BYD, Heuliez Bus, Irizar eMobility, MAN, New Flyer, Skoda/Iveco, Solaris, VDL, Volvo and Yutong . The brands of 61% of the 18-m electric buses were VDL, Solaris and Volvo. Similarly, for 18-m trolleybuses, the total fleet reviewed involved 484 units and 8 OEMs: HESS, Iveco, New Flyer, Skoda/SOR, Solaris, Van Hool and Yutong . The brands of 66% of 18-m trolleybuses were Solaris and New Flyer.

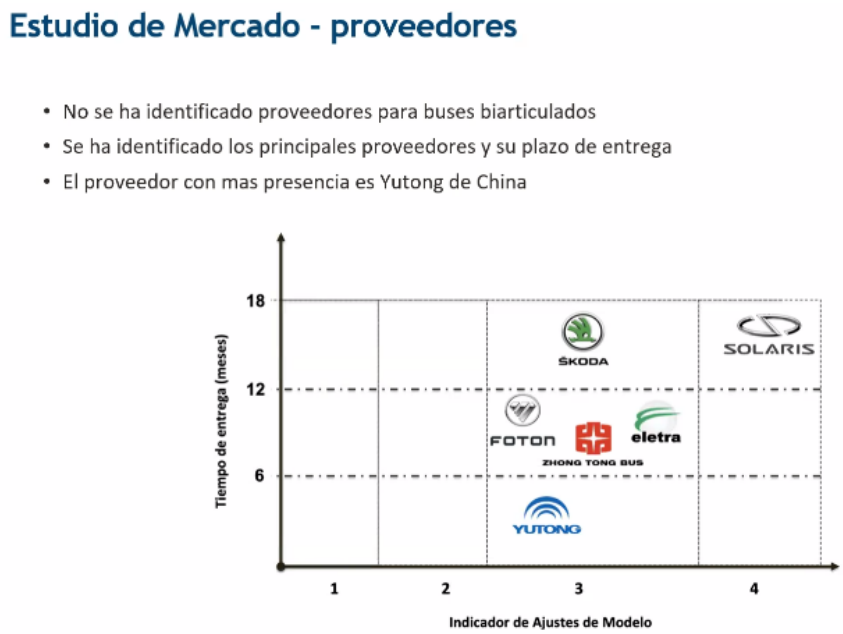


Figure 60. Scheme presented by the consult team of CFF (2020) to the EPMTPQ on March 2024

Knowing about case-studies, some cities in Europe began their scaling-up phase after completing the iconic ZeEUS electric bus pilot program[1] (2013 to 2018). Then, between 2019 and the first quarter of 2020 there were already close to 2,600 battery-powered electric buses[2], and 67% of this fleet was concentrated in The Netherlands, Sweden, France, Spain and Austria. In 2019, The Netherlands and France acquired the highest number of new battery-powered electric buses, respectively 375 and 191 units.

Regarding the review specific to 18-m battery electric buses, the most recent cases reviewed – 2018, 2019, 2020, and 2021 (to be implemented) – focused on 14 cities in Romania, Poland, Switzerland, Norway and Germany. Considering a total of 927 units, the main characteristics of the solutions used in these countries are listed below:

- All 18-m electric buses have a low floor.
- Various engine configurations: 200 kW (1 u) to 400 kW (2 u, 200 kW each).
- Passenger capacity: 99 to 151.
- Predominant charging strategy: combination of pantograph and terminal plug chargers.
- Only 4 cities implemented the 2019-2020 solution with night charging (Cologne, Barcelona, Luxembourg, Frankfurt). • Autonomy (A/C operation):
- Pantograph + plug: 40-200 km (145-396 kWh).
- Night charge: 200 - 250 km (525-640 kWh)
- Top 7 OEMs: BYD, Heuliez Bus, Irizar eMobility, MAN, Solaris, VDL, Volvo

Regarding the review specific to 18-m trolleybuses, the most recent cases reviewed – 2018, 2019, 2020, and 2021 (to be implemented) – focused on 12 cities in Italy, France, Switzerland, Austria, Poland, Czech Republic and Romania. Considering a total of 231 18-m units and 46 24-m trolleybuses, the main characteristics of the solutions used in these countries are listed below:

- All trolleybuses have a low floor. • All include "in motion charge" technology to recharge the battery bank on the move, allowing them to operate disconnected from the catenaries.
- Various engine configurations: 240 kW (1 u) to 320 kW (2 u, 160 kW each).
- Passenger capacity: 120 to 155 (18-m case); 180 to 220 (24-m case).
- Autonomy (A/C operation): from 10 to 25 kms; battery bank 26 kWh to 87 kWh.
- Top 5 OEMs: HESS, Iveco, Skoda , Solaris, Van Hoo

In the US, the review of cases recently implemented are mainly concentrated on 2 OEMs with the 18-m typology: BYD and New Flyer for electric buses, and only New Flyer for trolleybuses. In the case of 18-m electric buses, a total of 142 new units were identified in Indianapolis, Albuquerque, New York, Los Angeles, and King County, while in the case of 18-m trolleybuses, recent cases were a total of 157 units, concentrated in San Francisco and Seattle. The main characteristics of the solutions used in these cases are listed below:

- Concentration of 18-m manufacturers: BYD and New Flyer
- Entre fleet is low floor, both for electric bus and trolleybus.
- Passenger capacity: 105 to 123.
- Battery electric buses employ night-charging strategy, 500 kWh battery banks, (stated) 300-km autonomy, and A/C operation.
- Autonomy issues in winter were reported for BYD buses in Albuquerque and Indianapolis.

Finally in Latin America, Santiago de Chile and Mexico City leads the implementation. The case of Mexico City was examined in depth as it had the most recent implementation (2019-2020) of new 12-m and 18-m trolleybus fleets, as well as the operation of the first 18-m high-floor electric bus to be integrated into its BRT system (called Metrobus). Although there are no 18-m electric buses operating in the City of Santiago, it is a relevant case to consider as the city in Latin America with the largest number of buses in operation. As of May of 2020, the electric bus fleet exceeded 750 units, all 12-m and from Chinese OEMs: BYD, Yutong, Foton, KingLong, Zhongtong.

First, this case is of interest to the city of Quito since between 2019 and the first quarter of 2020, Mexico City introduced both 12-m and 18-m state-of-the-art trolleybuses made by the Chinese brand Yutong. Leading this effort was the new head of government, who in 2018 used the results of CFF/C40/GIZ studies to strengthen the trolleybus system within the Electric Transport Service (STE), with a goal to acquire 500 new trolleybuses by 2023. By the end of 2019, 63 new 12-m Yutong trolleybuses were already operating, with 75-km autonomy, a 147- kWh LFP battery bank with a power consumption of 0.8 kWh/km, capacity for 85 passengers, and including an "in motion charge" system. Subsequently, the Governor approved the 51 purchases of another 130 new trolleybuses, of which 80 were 12-meter long and cost around 327,000 USD each, and 50 were 18-meter long, costing approximately 600,000 USD each, all planned to start operating in the second half of 2020. The bidding process for the purchase of the first 63 12-m trolleybuses has relevance to Quito, because of the interest to bid by OEMs such as SunWin, Dina + Skoda, Eletra, New Flyer, and Yutong, company to which the contract was awarded.

Regarding the implementation and commissioning of the trolleybus fleet, the STE team interviewed reported that the brand had offered full and constant assistance and provided a stock of essential parts at the STE terminal. Upon starting the trolleybus operation, it was determined that contact terminals needed to be redesigned as they were showing excessive wear. Fortunately, this did not impact the operation since it was diagnosed early. On the other hand, the very operation of the system with the new trolleybuses required minor adaptations to the catenary, and the old units (40-20 years) could operate in mixed or intercalated form with the new units without disconnecting issues. As for maintenance, it was identified early that a lubricant was not available in Mexico's supply, so it had to be imported from China.

Finally, Mexico City also stands out for the incorporation of 18-m high-floor battery-powered electric buses, exactly as the city of Quito requires for operating its BRT service (Metrobus). In May of 2020, the process was completed to ensure the first bus with these characteristics could start running by the end of 2020. This bus is part of a purchase order of 10 to 30 units, depending on the performance of the head bus in the array. Its main technical characteristics are:

- Passenger capacity of 160 pax.
- Autonomy of 330 km.
- On its 10th year, the battery must still hold at least 75% of the initial nominal capacity.
- High-floor bus.
- Operation without A/C.
- Chinese OEM: Yutong; purchase made by ENGIE power company.

On the second, the oldest fleet in the Santiago Metropolitan Network (Red Metropolitana) already has more than 1 year of continuous operation, and the operating company METBUS reports the following results of interest:

- The electric buses are BYD, 12-m, AC charger, European standard.
- Savings in maintenance of 70% compared to a Euro VI diesel bus.
- 97% availability for operation (almost no issues are reported with these buses).
- Energy cost estimate per kilometer is 0.12 USD/km for the electric bus versus 0.42 USD/km for a diesel bus.

Another point of interest in the city of Santiago is that new bidding processes started in 2020 for upgrading 2,000 units of the RED Metropolitana system. The following are its most relevant aspects:

- The bidding process is divided into two stages: first, the supply of bus fleets, and then the operators who will provide passenger transport services using the buses acquired from the first stage.
- There is an energy efficiency measurement protocol, published as Exempt Resolution No. 2243/2018 by the Ministry of Transport and Telecommunications, giving a higher score to buses that demonstrate better energy performance; it grants a maximum of 100 points for performances from 0 - 4 (MJ/km), which is equivalent to 0 - 1.1 (kWh/km) (López, 2020), a rate that electric buses can achieve.
- High autonomy electric buses must guarantee a 215-km range under the energy efficiency protocol, while electric buses with opportunity charge must guarantee 50 kms.
- The bidding process also specifies battery warranties, whereby the battery cannot lose more than 20% of its autonomy over its useful life, otherwise the supplier must replace the battery bank. • The new bidding processes set forth explicitly the charging infrastructure

requirements, which must comply with the European standard CCS Type 2 and direct current (DC).

- The electrical terminals become assets of the public transport system.

Finally, the city of Santiago conducts pilots only for 18-m electric buses, among them from Chinese OEMs BYD and SunWin. In the case of the BYD bus, the model brought over was not optimized for Santiago's operating conditions, so the energy consumption results – around 2.8 kWh/km – were not satisfactory. As of May 2020, a Zongthong articulated bus was undergoing a certification process.

In the case of other cities in Latin America, the panorama of battery electric buses in other Latin America cities shows that suppliers are mostly Chinese: Yutong, SunWin, BYD, Zhongtong. In some cities, a recent scaling up of fleets considers the 12-m and 9-m typologies, with models operating both with and without A/C. In the case of Bogotá, Colombia, in a bidding process conducted towards the end of 2019, an European supplier (Caetano Bus) was interested, but capital costs resulted 40% higher than the Chinese model, so negotiations were stalled. In Brazil, there is a supplier of electric traction systems called Eletra which, through partnerships with body and chassis suppliers, offers 12-m, 18-m and 24-m battery electric buses and trolleybuses, but their autonomy only nears 100 kms. Another point to highlight in electric fleet implementation is that purchasing processes are being conducted in the same city without considering the interoperability of the charging infrastructure. In Santiago, out of the first 200 electric buses, 100 are AC-charged, and 100 are DC-charged. In Montevideo, out of its 30 electric buses, 20 are charged under the European CCS standard, and 10 under the Chinese GB/T standard.

About charging infraestructure and implementation

Electromobility solutions must be comprehensively sized and consider bus technology, charging strategy (see Figure 61), and any restrictions imposed by the local transport system. In relation to charging strategies and their associated infrastructure, the opportunity charging strategy uses pantograph-type conductive chargers or inductive chargers, both with DC charging. Power output varies from 250 kW to 600 kW in pantographs, and 200 kW to 300 kW in inductive chargers. Time to recharge range from 2 to 15 minutes. The night charging strategy uses socket or plug-type chargers, either DC or AC, with power output varying generally from 30kW to 150 kW. Time to recharge range from 2 to 4 hours. Plug-type chargers and night-time charging strategy are the systems most widely used globally and in Latin America. In the case of Quito, night charging has the advantage of being less expensive: rates are 10-14 cents/kWh for "day" charging, versus 4 cents/kWh for "night" charging. Moreover, the use of pantograph in Latin America is almost nonexistent. In Santiago there is a pilot with a 350-kW pantograph (ENEL-Reborn-Metbus), but the bus does not operate transporting passengers, only at the test level.

Another relevant aspect to decide on is to consider terminal recharging management, which allows optimizing the number of chargers and costs. In Santiago, 1 charger is placed for every 2 e-buses. IEA global projections for 2030 have plug-type chargers with usage rates of 8 buses per charger and output power around 190 kW.

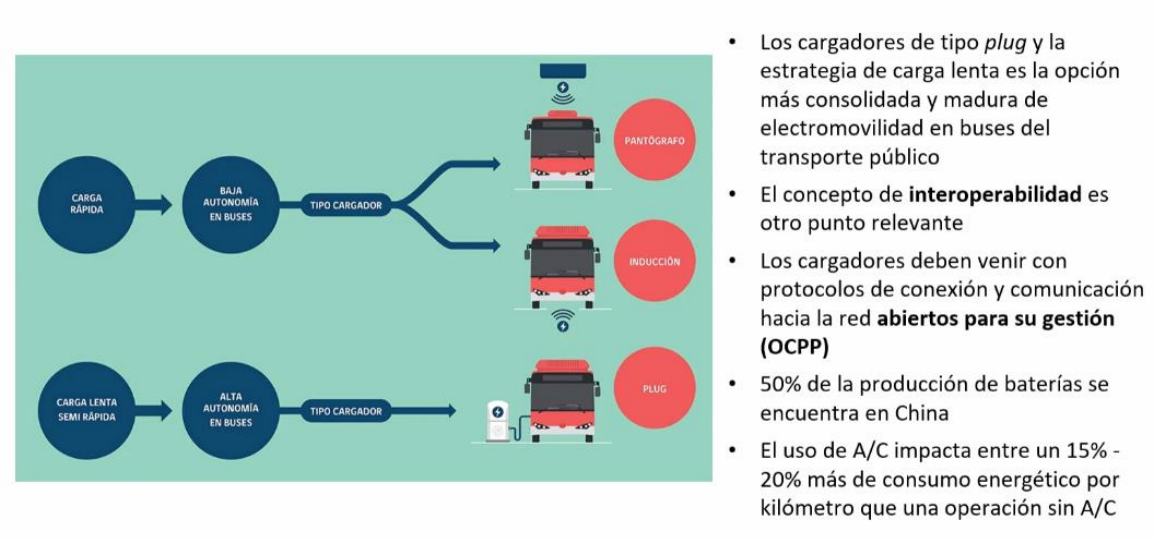


Figure 61. Scheme presented by the consult team of CFF (2020) to the EPMTPQ on March 2024

Plug-type chargers and slow-charging strategy are the most consolidated and mature electromobility options for public transport buses; they are also easy to operate and have low maintenance requirements. However, the main barrier to this solution is to size it correctly and to fully develop the engineering project, including both civil and electrical works.

The concept of interoperability is another relevant point when moving from a pilot phase to a scaling-up phase. It is highly recommended that Latin America fleets that begin to scale up the number of electric buses define a standard of chargers, adopting a system vision, as opposed to a fleet-operator vision. In the city of Santiago, the first 200 electric buses introduced are not interoperable: 100 of them are BYD, 12-m, AC charger, CCS Type 2, while the other 100 are Yutong, 12-m, DC charger, GB/T. This incompatibility was quickly noticed by the RED Metropolitana authority, which now stipulates all electric buses must be DC charged and comply with the CCS Type 2 standard.

The city of Montevideo also presents a similar situation with the 30 buses that arrived in the city in 2020, which chargers are not interoperable: 20 are BYD buses following the European CCS standard, while 10 buses are Yutong under the Chinese GB/T standard. Another consideration regarding the charging infrastructure is that chargers must come with network connection and communication protocols that open for management (OCPP). This is particularly relevant for charge management in large fleets, where there are multiple software offered by various dedicated companies, which can be freely exchanged without the need to change the charger. Chile has specified that chargers shall have open protocols OCPP 1.6 or higher. The flexible management of the charging infrastructure is especially important to ensure proper bus operation, but also to optimize fare costs according to time periods. By managing chargers using charging software, Metbus was able to reduce energy costs from $ 0.3/km to $ 0.12/km.

5.4.4. Focus area 4: Transport optimization models to support low-carbon mobility planning and electrification in Quito

The optimization of bus routes, to complement the newly launched metro system, requires a data-driven approach, utilizing advanced mobility analytics and passenger flow data. Collaborations with academic institutions, such as the Escuela Politécnica Nacional (EPN), can facilitate the development of mathematical models and simulation tools, refining route planning to minimize travel time and maximize service coverage. Incorporating digital tools for real-time mobility management can further enhance operational efficiency, aligning with the **ACCESS** project's objectives on digitalization and optimization of public transport.

By leveraging digital technologies such as route optimization software, real-time tracking systems, and autonomous vehicles, the business model achieves heightened operational efficiency. This enables streamlined delivery processes and reduced costs. Moreover, seamless integration with e-commerce platforms and customer-facing applications enhances transparency, convenience, and the overall user experience.

Furthermore, a new business model emphasizes continuous research and development (R&D) investment and partnerships with tech startups to remain at the forefront of innovation. This proactive approach ensures that the company stays competitive and can quickly adapt to emerging technologies and changing market dynamics. Overall, the integration of digital solutions and a commitment to innovation are key components of the business model's success in optimizing last-mile delivery operations.

The success of the business model hinges on its ability to adapt to the changing needs and desires of customers. It recognizes that personalized delivery options, flexible scheduling, and eco-friendly packaging are highly valued by environmentally conscious consumers. By prioritizing responsiveness, reliability, and sustainability, the business model aims to stand out in the competitive marketplace. This customer-centric approach not only enhances customer satisfaction but also reinforces the brand's commitment to social and environmental responsibility, ultimately contributing to long-term success and loyalty.

By embracing electrification, active mobility, and ecosystem development, the proposed business model for last-mile delivery represents a sustainable and future-proof approach to urban mobility. Through collaboration, innovation, and customer-centricity, businesses can drive positive social, environmental, and economic outcomes while delivering goods efficiently and responsibly in urban environments.

Good and Replicable Practices: Express Logistic Project with a pilot logistic project and data analysis in the city of Buenos Aires – Argentina.

Action line 3: Mobility as a Service (MaaS)

6. Action line 3: Mobility as a Service (MaaS)

6.1. Current Policy Framework and Market Readiness for deployment of e- mobility

In an increasingly urbanized world, where more than half of the global population already lives in cities (2/3 by 2050), digital technologies will have a pivotal role in advancing sustainable urban development and formulating effective policies and measures for climate change mitigation. In parallel, the emergence of new mobility concepts and the widespread use of smartphones worldwide has brought along the emergence of a significant number of mobility applications aimed at improving the efficiency of urban mobility services both for freight and passenger transport. Local and international mobility (and micromobility) apps such as Uber (Eats), Ola, Gojek, SafeBoda, Glovo, PedidosYA, tembici, Moveo, etc. already operate in Africa, Asia and Latin America, showing the great penetration and potential that app-based mobility services already have in the Global South. The integration of such services under the Mobility as a Service (MaaS) concept could contribute to modal shift and reduced energy consumption (Hensher et al., 2021; Sochor et al., 2018).

MaaS is a new transport and mobility concept that integrates existing and new mobility services (NMS) into a single digital platform, providing customized mobility options and offering personalized trip planning and digital payment possibilities (Jittrapirom et al., 2017). MaaS has the potential to improve the travelling experience, reduce travelers' costs, efficiently manage travel demand, and improve environmental and social outcomes. MaaS has been gaining popularity in Europe / the Global North and has been implemented in several cities with positive results related to sustainable and low-carbon mobility (Durand et al., 2018; Hensher et al., 2021; Sochor et al., 2018). However, in developing countries, in contexts of fragmented and often informal public transport systems, lack of data, cash economies, low digitalization levels, the implementation of such a concept comes with a lot of challenges (Hasselwander & Bigotte, 2022). Figure 62 presents the functionalities of Jelbi, the MaaS app owned by the municipal PTO, the BVG.

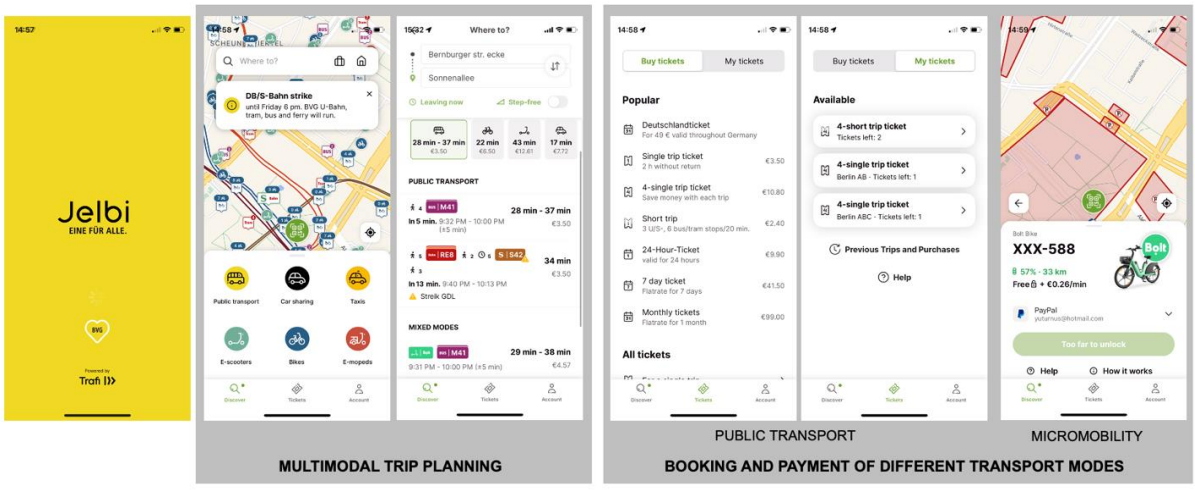


Figure 62. Jelbi app

By the shift towards eco-friendly modes of transportation, MaaS has the potential to mitigate the environmental impact of urban mobility. By minimizing reliance on fossil fuels and reducing greenhouse gas emissions, MaaS contributes to the creation of more sustainable and environmentally friendly transportation systems.

In conclusion, the scope of Mobility as a Service encompasses a comprehensive approach to transforming urban mobility. By integrating various modes of transportation, leveraging digital technologies, streamlining payment processes, personalizing travel experiences, fostering collaboration, and prioritizing sustainability, MaaS has the potential to revolutionize the way people move within cities. As cities continue to grow and evolve, MaaS offers a promising solution to the complex challenges of urban transportation, paving the way for more accessible, efficient, and sustainable mobility systems.

In Quito, one of the 3 action lines of the PMMS is the recovery and upgrade of the public transport system. In the short run, this action line seeks the integration of the PT system by the introduction of the Integrated Payment System (SIR), the User Information System (SIU) and the Data Exploitation System (SAE) following the launch of the first subway line in 2023. In the long run, the objective is Mobility as a Service (MaaS), which in the PMMS is "conceived as an essential element of smart cities and a tool to improve the quality of life of PT users and of all citizens. This is a user-centric approach that aims to change the way in which people travel, having as its main objective the reduction of the use of private vehicles as long as the sustainable transport options are integrated, fast and user-friendly through mobile applications, creating a better and more efficient user experience. The focus is on making transport more accessible, inclusive and sustainable" (MDMQ, 2024, p. 60). Moreover, the PMMS includes the development of a MaaS app for the city as one of the projects to be implemented in the medium term under the Program Efficient Public Transport System, Subprogram Smart Mobility.

The context of modernization in which Quito is at the moment due to the launch of the first subway line and the urgent need to integrate this new and modern mass transportation system with the existing BRT lines and the conventional buses, is a unique opportunity to introduce and consolidate the MaaS approach. Is in this context that in the past years the Municipality of Quito and its PTOs (EPMTPQ and Metro de Quito) have been working in the design of a properly integrated transport system and are currently in the process of procurement of the SIR, SIU and SAE. Figure 63 presents the governance structure of the integrated public transport system Quito is pushing forward. As it can be seen, it contemplates the use of different means of payment including digital ones.

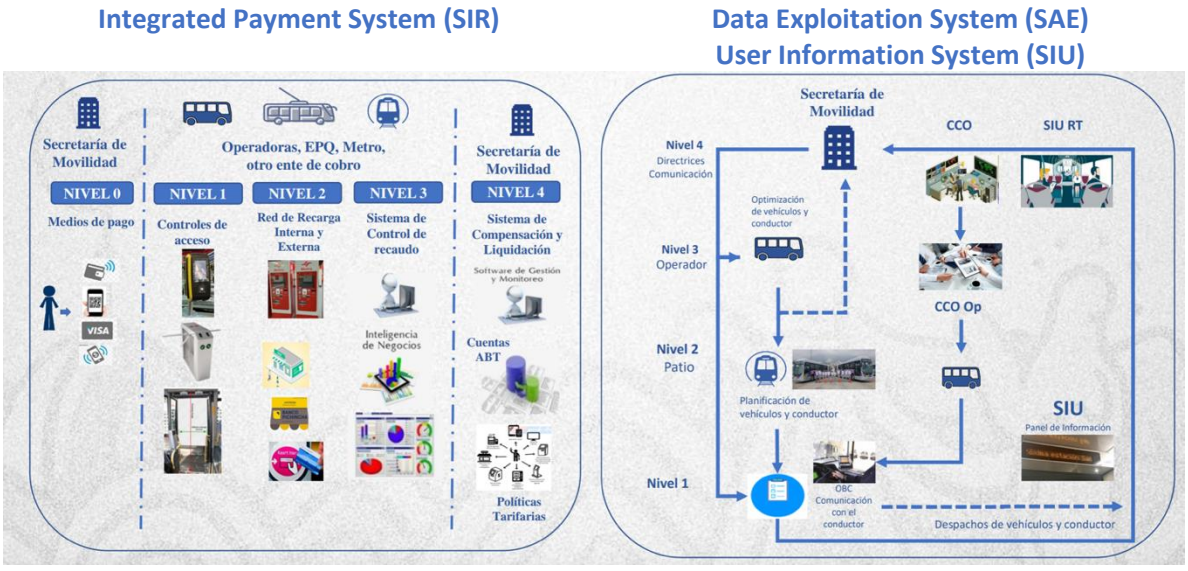


Figure 63. Governance Structure of Quito's SITP. Source: Mobility Secretariat (2024)

This process has led to the creation of a new regulation framework that will enable the actual integration of al the different subsystems of Quito's public transport. Figure 64 presents the list of relevant regulations issued in the past 5 years to enable this transition.

Figure 64. Regulatory framework for the SITP. Source: Mobility Secretariat (2024)

6.2. The Demonstration actions

One of the components that SOLUTIONSplus offered to its demonstration cities was the development and use at no cost of a Mobility as a Service (Mobility as a Service) white label application tailored to the needs of each city for the duration of the project (January 2020 - June 2024). This offer was presented in April 2020 to the Mobility Secretariat of the MDMQ. After analyzing the legal and technical feasibility and verifying that the application could be integrated as a means of payment to Level 0 of the Integrated Payment System (SIR) and that, therefore, its piloting would be very useful for the Metropolitan Public Company of Passenger Transportation (EPMTPQ) and the Metropolitan Public Company Metro de Quito (EPMMQ), The offer was accepted and a work schedule was agreed upon for the company PluService, a member of the SOLUTIONSplus consortium, to develop the application according to the needs and the current regulatory framework of Quito.

Since then, weekly meetings were held between the regional SOLUTIONSplus team, PluService, the Secretariat of Mobility, the EPMTPQ and Metro de Quito, in order to adapt the application to the needs of the Integrated Transport and Collection System of Quito.

After two years of joint work between the SOLUTIONSplus team and the MDMQ, the application was ready to be piloted with the EPMTPQ. The solution developed for Quito includes the following components:

- *La Quiteña* mobile application
    - Multimodal trip planner
    - Timetables, stops and transport lines
    - E-wallet for ticket purchase
- *Assistant* web application for user registration and e-wallet top-ups at the ticket office
- *My Check* application for verification and validation of tickets at the time of use

In this context, several meetings were held with the EPMTPQ about the application and the possibility of collaborating with the SOLUTIONSplus team in carrying out a controlled pilot exercise with a group of university students during the last quarter of 2022 in order to evaluate its performance and the acceptance of its users. To formalize the collaboration, on August 10, 2022 SOLUTIONSplus sent a letter of invitation to the EPMTPQ to collaborate in the execution of the pilot. On September 26, 2022, the EPMTPQ accepted to participate in the execution of the pilot. In October 2022, the National Polytechnic School (EPN) was approached to identify students interested in being part of the pilot of the Mobility as a Service (MaaS) application. On November 17, 2022, a training and participation agreement was signed with 47 EPN students interested in being part of the pilot. From November 21, 2022 to December 16, 2022, the first phase of the mobile wallet pilot was carried out.

6.2.1. Characteristics of the pilot

- Target group: university students from the EPN
- Number of participants: 45 university students
- BRT Station in which the pilot took place: De las Universidades (Av. 12 de octuber y Veintimilla)
- Duration: 4 weeks (21 November – 16 December)
- Each participant received coupons for an amount of USD 7,00 worth 20 PT trips

6.2.2. Results

To analyze the results of the first pilot phase of the MaaS application, the following sources of information were used: 1. User reports generated by the App, 2. User Perception Survey and 3. Daily incident reports.

According to the figures reported by the application, 45 accounts were generated, 37 of which were active (purchased and activated tickets). During the 4 weeks of piloting, 216 tickets were purchased for a total value of US$ 75.60. The daily evolution of ticket issuance had is peak on November 24, with a total of 28, an average of 11 tickets were issued daily for an average value of USD 3.78 per day. Each student issued an average of 7 tickets and a maximum of 20 tickets.
Of the 216 tickets issued, 164 were validated (75% of the tickets) for a value of USD 57.40. The validation was done by presenting the QR code using the My Check application. An average of 6 tickets per user and a maximum of 17 tickets were activated.

Regarding the rating of the app's functionalities, 44% of the respondents rated as good their experience downloading the app, 68% rated as bad their experience registering the account in the app, 44% rated as bad the trip planner, 48% rated as bad their experience recharging the mobile wallet at the ticket office, 64% rated as bad and very bad their experience buying tickets on the App, while 64% of students surveyed rated as bad and very bad their experience with the validation of tickets at the stop. Regarding the travel experience using the App, 7 students stated that using the App made them feel safe because they did not have to use cash.

When asked if they would like to participate in the second phase, 18 (72%) said yes and 4 said maybe. In response to the question, if the application were available with all the issues resolved, how often would you use it, 22 people (88%) responded that between 3 times a week and every day. Additionally, 80% of students said they agreed and totally agreed that the application should

include other public transportation options such as metro, trolleybus, conventional buses, etc. Also, 60% of the students would like the application to include other alternative means of transportation (scooters, BiciQ, etc.) and other means of payment.

6.3. Main barriers and opportunities for scale-up

Despite its progress, the consolidation and functioning of the integrated public transport system still faces a series of challenges. As a matter of fact, even though the subway started its commercial operation in December 2023, at the moment there is still no integration to the other subsystems.

In order to analyze the feasibility of implementing MaaS in the SOLUTIONSplus demonstration cities, an evaluation framework with a total of 20 variables identified as enabling factors for MaaS implementation was created based on the existing literature on the topic. These were classified using the TOE (technology, Organization and Environment) framework. The elements considered under Technology refer to the level of digitalization in the selected cities. In terms of Organization ena-blers, policies, plans and the governance structure related to digitalization of transport and intelligent transport systems were analyzed. Under Environment, the enabling factors are related to the integration level of the public transport system and other transport services (Muñoz B. et al., 2024).

The results of the analysis using the TOE framework are summarized in Figures 65. As it can be seen, only very few factors are fully met in Quito. Nevertheless, in most factors Quito complies partially, which means there is already some level of advancement. The main barriers identified are the governance structure and business / operating models of the public-private collaboration that with be needed for the functioning of a MaaS approach. The other aspect, where an important barrier is identified is the user acceptance.

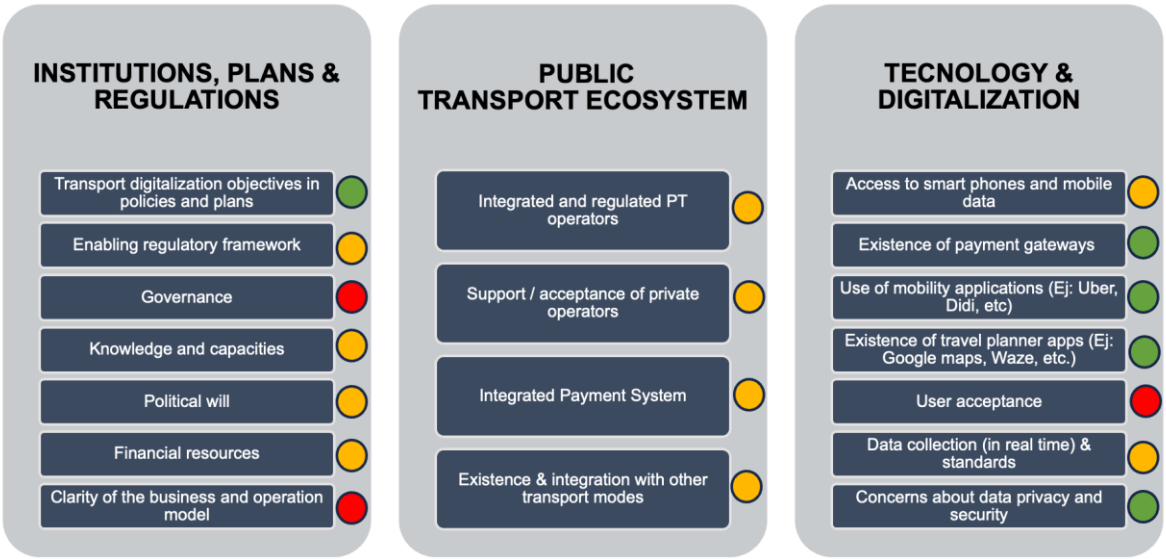


Figure 65. Analysis of the enabling factors for MaaS implementation in Quito. Source: Muñoz B. et al. (2024)

6.4. Implementation plan - How do we get there?

As it was mentioned before, the MaaS approach and the corresponding mobile application to profit from its benefits is already included and budgeted in the PMMS. Moreover, in the context of the ACCESS project, one of the proposed pilots is Multi-modal integration building on a gender-inclusive MaaS concept and the Integrated Payment System (SIR) being implemented in Quito. Thus, the topic and resources are available. However, in order to implement successfully the MaaS concept significant barriers related to the regulations and governance structure still will have to be overcome. Moreover, complementary urban planning measures such as mobility stations could enhance the impact for intermodality of the MaaS concept.

6.4.1. Focus area 1: Regulatory & collaboration framework

Furthermore, the development of MaaS has the potential to transform urban transportation by offering a more efficient and sustainable alternative to private car use. However, its implementation requires careful consideration of regulatory solutions to address challenges and ensure safe, equitable, and efficient transportation options. Here are some key regulatory solutions for MaaS development:

1. Data Sharing and Privacy Regulations: Establishing protocols for sharing transportation data among different service providers and public agencies is crucial for a cohesive MaaS ecosystem, and regulations must be in place to ensure the protection of users' personal data, such as travel habits and payment information.
2. Interoperability Standards: Adopting technical standards for various aspects of MaaS (e.g., payment systems, ticketing, and APIs) to ensure interoperability and seamless integration among different service providers. The MaaS solutions must be compatible with existing transportation systems and services, requiring regulatory oversight to maintain consistency.
3. Safety and Security Regulations: Ensuring that all vehicles and drivers within the MaaS ecosystem meet established safety standards is essential for passenger protection. Also, establishing regulations to safeguard MaaS platforms and users from cybersecurity threats and data breaches.
4. Equitable Access and Inclusivity: Regulatory measures can be implemented to ensure fair and transparent pricing, as well as to provide subsidies or discounted services for underserved communities. Regulations may mandate that MaaS services provide options for people with disabilities and other special needs, ensuring equitable access for all users.
5. Environmental and Sustainability Goals: Encouraging or mandating the use of low-emission vehicles within MaaS platforms to support environmental sustainability. The regulations can incentivize the use of shared and sustainable transportation options (e.g., public transit and biking) over single-occupancy vehicles.
6. Consumer Protection: Ensuring that users have clear, accessible information about service terms and conditions, including fees, cancellation policies, and dispute resolution. Establishing standardized procedures for addressing user complaints and disputes with MaaS service providers.
7. Governance and Oversight: Encouraging collaboration between public agencies and private MaaS providers to ensure the alignment of services with public interests and policy

goals. Allowing MaaS providers to experiment with new services and business models in a controlled environment to facilitate innovation while maintaining regulatory oversight.

These regulatory solutions aim to balance the need for innovation and flexibility within the MaaS ecosystem with the need to protect users, ensure fair competition, and meet broader policy goals related to sustainability and equity. By creating a comprehensive regulatory framework for MaaS, cities and governments can help drive the development of efficient, sustainable, and user-friendly mobility solutions.

In this sense, the implementation requires cooperation between government agencies, transportation operators, technology providers, and urban planners. By forging strategic partnerships and fostering an ecosystem of innovation, MaaS initiatives can leverage collective expertise and resources to deliver more integrated and sustainable transportation solutions. Moreover, policy and regulatory frameworks must be developed to support the growth of MaaS, promoting open data standards, interoperability, and incentives for sustainable transportation alternatives.

6.4.2. Focus area 2: Mobility stations to enhance intermodality

Mobility Stations are being implemented in many cities around the world with 3 main objectives:

1. to order the use of public space by LEVs,
2. provide charging infrastructure for their efficient use, and
3. to promote intermodality between public transport and micromobility services.

Figure 66 shows the mobility points and stations installed by Jelbi, Berlin's MaaS app provider in order to enhance multimodality in the city. These are multimodal hubs being deployed throughout the city to promote the use of public transport, by connecting it efficiently to LEV services. The services included in these stations are: public transport, e-cargo-bike sharing, e-moped sharing, EV sharing and charging and taxis.

Figure 66. Jelbi Mobility points and stations from [Jelbi]

In this context, using the advantage of a new and modern PT system, such as the subway and the existence of an important amount if cycling infrastructure in the city, the installation of mobility stations in Quito could improve multimodality and the ridership of the PT.

Action line 4: Gender and e-mobility

7. Action line 4: Gender and e-mobility

7.1. Current Policy Framework and Market Readiness for deployment of e- mobility

In Ecuador, most people use public transport to get from their home to work, educational establishment, etc. Women have a higher rate of use of public transport (47.6% use public transport, compared to 43% of men) and they also commute in a higher proportion on foot (32.9% of women compared to 28.6% of men). Moreover, among men, the possession of a vehicle is more frequent (72% of men compared to 28% of women) and they are the ones who use the private vehicle the most individually or jointly. In Quito, according to the 2011 mobility survey, women make more trips by public transport (64.4%) than men (58.8%). On the other hand, they are also the ones who travel more on foot (16.2%) compared to men (15.1%). Regarding trip purposes, according to the Quito mobility survey 2022, the main reasons for travelling among women are care-related activities, such shopping or as escorting others (33.3%), followed by going to work (30,9%), whereas the main motive for men is work-related (47.8%).

Freedom of movement for women does not only depend on the design of the supply of means of transport. Although Ecuadorian women travel mainly by foot or on public transport, one of the reasons that may discourage women from walking long distances or not using public transport is the insecurity they perceive in these places (robberies, thefts, and different forms of harassment and violence). This is a fundamental factor for their personal development and autonomy, as well as for the equal use of services and enjoyment of leisure.

According to the National Institute of Statistics and Census, public transport is the place where the Ecuadorian population feels most insecure, closely followed by the streets. According to the study "Ella Se Mueve Segura", 61% of women feel unsafe in the public transport in Quito (and 59% of men). Among the different crimes that occur regularly on the street or in public transport nationwide, the most important are those related to acts of harassment and sexual violence, occurring almost exclusively to women and girls. As reported in a survey conducted by UN Women in Quito in 2012, 75% of women had been verbally assaulted in public spaces, and 70% had suffered physical assaults and harassment. The National Survey of Family Relations and Gender Violence against women of the INEC (2011) reveals that 6 out of 10 women suffer gender violence.

Regarding to the labor market and the transportation, according to the National Employment, Unemployment and Underemployment Survey, in Ecuador by October 2023 only 9% of the economically active population employed in the transport and storage sector were women. This shows how job roles are often prescribed based on gender.

The gender data also indicates that women in Ecuador are afforded many political rights and equalities, and while they do compare statistically to men in a few categories, women are still not included in mobility processes and designs as much as men are. Women should be encouraged to work in the mobility field, especially in leadership positions, and gender mainstreaming should remain a serious concern for Ecuador.

At national level, the government of Ecuador has continuously emphasized the importance and connection between gender and climate change, mainly by including gender considerations in their Nationally Determined Contribution (NDC). Documents available have extensively analyzed and evaluated previous efforts and possible future pathways for Ecuador in the topic of Gender and Climate Change (see e.g. the Third National Communication, the Concept Note on the Gender Action

Plan and Climate Change for Nationally Determined Contributions, or the "Design, Validation and Systematization of the Methodology for the Construction and Implementation of the NDCs of Ecuador Including the Gender Approach"). The Ministry of Environment, Water and Ecologic Transition (MAATE) has advocated for the mainstreaming of gender in their projects, as well as incentivizing gender analyses and proposing a gender action plan in line with the enhanced Lima Work Programme on gender.

During 2024 MAATE has issued the Gender and Climate Change Action Plan which aims to improve the systematic integration of gender considerations into climate policies and actions, with an incremental incorporation of other gender identities; promote the generation of tools to identify the differentiated impacts of climate change and gender-related gaps; and, promote gender and climate change analysis in accordance with the guidelines issued by the specialized bodies in the field.

Specifically, in the transportation field at the local level, the municipality of Quito, through the Patronato Municipal San José Unit, has developed the comprehensive Bájale al Acoso Strategy, whose general objective is to prevent and address cases of sexual violence that arise in the Quito Integrated Transport System through technological tools. Additionally, the municipality of Quito, on its 2012 ordinance provides concepts, budget, protocols and specific arrangements inside the Municipality to eradicate violence towards women in the city. In this context, the city has implemented campaigns such as "Free-Harassment Streets" (2012), "Tell me"[2] (2014), "Stop harassment" (2017), all of which were financed by the Municipality of Quito.

Safe transport free of sexual harassment against women and girls, establishes the creation of a Protocol of Action in Cases of Sexual Violence in the Metropolitan Passenger Transport System of Quito, which allows to clearly establish the procedure to respond effectively to victims of sexual violence in public transport.

In addition, 44 Trolleybus stops of the Integrated Transport System of Quito have been remodeled considering urban planning principles for safety, such as the fact of seeing and being seen, principles of equal access to public transport service, information and attention.

In the same line, the gender perspective has been incorporated in the construction of the first line of Quito's subway to have an integrated transportation system that is safe and free of gender-based violence. Currently, Quito´s subway incorporated female drivers and uses protocols for reporting violence on public transport.

Regarding to electric vehicles and charging infrastructure Electric vehicles still represent a tiny fraction of the vehicle market in Ecuador[3], as the country is only taking its first steps towards the transition to a cleaner, more sustainable model of mobility that is based on EVs. Sector information is not systematically compiled and published, and information about the development of electric mobility is still scarce in Ecuador. However, the Ecuadorian Association of Automobile Enterprises (AEADE) registered in their annual reports the sales of battery electric vehicles: 109 (2016), 123 (2017), 130 (2018), 103 (2019) and 106 (2020)[4], which is less than 0.11% of the sales for each of these years. In addition to this, since 2015, an average of 1,807 hybrid vehicles have been sold. This means that 0.43%

[3] El Comercio. *El uso de automotores eléctricos es mínimo en Quito* (2021). Available here.

[4] AEADE. *Anuario 2020* (2021)

of the total fleet presented in Table 1above is either hybrid or electric; and only 0.02% of the fleet is entirely electric.

Most of the electric vehicles introduced in 2019 were automobiles (57%) and SUVs (23%), from the brands Dayang, Kia and BYD. Nevertheless, it is important to mention that in 2019 the first fleet of 20 electric buses was introduced in the city of Guayaquil; a similar trend was observed in 2020, when the first five light duty EVs were sold[5].

Concerning charging infrastructure, as of 2022 there are 59 public charging connectors distributed throughout the cities of Quito, Guayaquil, Cuenca, Loja, and the Galapagos Islands, with a relatively even number of level 1 and level 2 chargers and only six fast (>50kW) chargers[6]. This infrastructure is typically located in the retail shops of KIA and BYD, shopping malls and vehicle high transit areas[7]. The number of charging stations is extremely low in comparison to the 1,085 filling stations for conventional vehicles[8], and no charging infrastructure exists outside the main cities. This has been identified as a critical challenge for massive adoption of EVs, as this limits EVs to urban usage within the few cities with charging stations. It is also important to consider that Ecuador has an unregular topography, which means that in cities such as Quito, located in the highlands, there are important hills which probably will consume more energy from the battery, and this issue has not yet been thoroughly assessed and understood. The battery autonomy under local conditions still needs to be studied and determined to give users (and authorities) proper information to reduce range anxiety.

In recent years, several pilots involving electric mobility have taken place in Ecuador. Unfortunately, these have not always been successful, which has resulted in increased perception of risks from the relevant stakeholders. Unfortunately, many of these pilot projects often provide scant information about their outcomes and the integration of a gender perspective into their actions. In other cases, efforts to promote gender mainstreaming are still in their early stages, which presents a significant opportunity for further development of this issue in future related projects.

7.2. The Demonstration actions

7.2.1. Participation of women in the piloting phase of SOLUTIONSplus project in Quito

In the 2 months of the pilot, two women participated from a total of ten drivers, the e-cargo bikes travelled a total of 1,071 km carried 16 tons of cargo, made 229 deliveries, collected recyclables from 134 points and achieved an estimated reduction in emissions of 491.74 kg (about twice the weight of a large motorcycle) CO2e. The significant efficiency gains experienced by most of the participants reveal a high scale-up and replication potential.

Among the main findings from this pilot include the following elements:

- It was identified that the participating women required prior training over a considerable period to adequately handle light electric vehicles such as cargo bikes or electric

[5] AEADE. *Anuario 2020* (2021)
[6] VARUS, *La red nacional de electrolineras en Ecuador* (2022). Available here.
[7] Hinicio. *Estrategia Nacional de Movilidad Eléctrica de Ecuador*. Interamerican Development Bank (2021)
[8] El Telégrafo. *Dos urbes concentran las gasolineras más rentables* (2021). Available here.

quadricycles. This training, in addition to strengthening their technical knowledge, provides safety in handling participants.

- In the case of vehicles such as minivans, it was identified that women, in addition to having sufficient knowledge to operate these types of vehicles, also needed to possess the corresponding driver's license, so that they could enter the labor market in the Courier and messaging sector, for example.
- In parallel with the need for training in technical aspects of driving electric vehicles, it was also identified as necessary to strengthen skills in soft skills and raise awareness on gender and human rights issues, so that women have greater agency in the environments in which they operate.

Additionally, the SOLUTIONSplus project also promoted coordinated actions with the Quito Metropolitan Passenger Transport Company (EPMTPQ) to transition to electric passenger transport vehicles. In the framework of these collaborative actions, the following was identified:

- Globally, less than 20% of those working in the transport sector are women.
- Only 7.8% of women drive heavy transport in Ecuador.
- 30% of the staff out of a total of 1,665 employees are women at EPMTPQ.
- At the senior hierarchical level of EPMTPQ (executive level), women occupy 41% compared to 59% occupied by men.
- Women's participation in technical transport and operations areas accounts for 34% of a total of 1,189 positions.
- There is greater participation of women (63%) compared to men in the collection area.
- Only 2% of drivers are women, out of a total of 509 drivers.

Considering that the EPMTPQ is procuring 50 new fully electric trolleybuses, among actions implemented in SOLUTIONSplus project seeks to increase the number of female drivers by, which means to include at least 10-12 new female drivers for the new electric units.

In this context, considering the issue of the employment gender gap for the transportation sector in the country. SOLUTIONSplus actions aimed to increase the representation of women in the e-bus driving workforce, potentially addressing gender disparities in the transportation sector.

7.2.2. Financial support for driving courses and professional license costs

It is important to consider that by 2021, 29.5% of women live in poverty situation in Ecuador, and 41.7% of women from rural areas are poor (INEC, 2021). With this context, the activities proposed in this pilot focuses in removing a financial barrier for women interested in pursuing careers as e-bus drivers and courier drivers by covering Professional License Costs and the Tuition of Professional Driving Course in Ecuador.

Looking into successful programs in Latin America to increase the number of women drivers of e-buses, shows that economic incentives help women to stay in this type of programs. For example, in Jalisco-Mexico, the State’s renewal transportation policy, known as Mi Transporte [My Transportation] funded the Mujeres Conductoras Program which in addition to covering the costs of driving courses and professional license, also provides a monthly stipend, equivalent to one minimum monthly salary which is paid in week 4 and week 8 the course to assure the completion.

As part of this effort of closing gender gaps, UEMI has facilitated a call for scholarships to participate in a professional driving course, focusing on enabling women to obtain a Type C and Type E professional license. This license qualifies 5 women to drive passenger vehicles and 12 women to drive vehicles used in the courier sector. The goal for these trained women is to transition to electric busses as soon as they start driving. For this activity, UEMI will sign an MoU with the Empresa Pública Metropolitana de Transporte de Pasajeros Quito (EPMTPQ), which manages the largest public transportation system in Ecuador.

One of the significant barriers for women interested in pursuing careers as e-bus drivers is the financial cost associated with obtaining a professional license in Ecuador. To mitigate this, UEMI (under the SOLUTIONSplus project) has provided financial support to cover the costs for 5 women of the EcoVial course, which is necessary to obtain a Type C license and 12 women to obtain type E licenses. While UEMI has covered the course expenses, participants will be responsible for the license examination fee to foster commitment.

7.2.3. Capacity Building

The project successfully developed the necessary skills and training processes for women. It significantly increased their participation in sustainable mobility sectors and ensured that they possess the essential skills and knowledge to operate electric vehicles safely and efficiently. This included the SOLUTIONSplus workshop: Empowering Women through Sustainable Mobility, designed for women leaders from waste picker associations Buena Esperanza de Pichincha and ASOREUN, and bicycle courier associations in Quito. In cooperation with Fundación Red Sostenible[9], this workshop provided hands-on training in operating and maintaining electric cargo bikes, leadership development, and sustainable practices. Participants engaged in a combination of theoretical and practical sessions across six workshops, covering topics such as customer service, applied psychology, communication, teamwork, and strategies to prevent gender-based violence. The program also emphasized environmentally friendly practices and personal safety, fostering improved working conditions. Upon completion, participants received ongoing support to disseminate their knowledge within their organizations, ultimately contributing to a more sustainable Quito.

7.3. Main barriers and opportunities for scale-up

In 2025 it is expected to evaluate the main barriers that women have faced in pursuing a career in the transport sector. Specific activities include an initial assessment of the 17 women currently (June 2024 – March 2025) take part in the driver licenses (Type C and Type E) training in Quito and are planned to obtain their licenses by March 2025. The assessment will be conducted to identify specific barriers to job opportunities. One significant barrier has already been identified is the internal HR regulation requiring drivers to have *three years* of experience at EPMTPQ. This will be analyzed in depth to understand its impact and explore potential changes.

To address these barriers and support women's employment in the e-mobility sector, the following steps will be taken:

[9] This is a grassroot organization which has worked with women and for women, especially for capacity-building processes in the use bicycles and cycling skills in cities and urban contexts.

Short-Term Employment: EPMTPQ and UEMI will work to place the women as drivers on feeder routes in the short term.

Regulatory Changes: Suggestions for changing the internal regulations will be proposed to allow women to be hired more quickly, bypassing the three-year experience requirement. This will involve analyzing successful examples from the region (Bogotá and Santiago) to understand if they faced similar challenges and how they dealt with them.

Long-Term Action Plan: We will explore different strategies and will be validated. One potential approach could be integrating graduates as drivers for the four electric vans rented for the E-MOVILIZA pilot project in 2025. Additionally, we are considering forming strategic alliances with companies like Grupo Entregas, which have shown a willingness to offer internships to the graduated women. The Ecuadorian Association of Courier Companies is also addressing this topic and has expressed interest in collaborating with us.

Among the opportunities for scaling-up, it is important to mention that at national level the governance of an inclusive and sustainable transport system requires new thinking and new skill sets and this in turn requires new messages from the top. The presence of women at the decision-making level will also contribute to this change. There is an urgent need to collect not only quantitative but also qualitative data with finer granularity to better understand gender issues and women's roles and concerns in the transport sector. But it is also indispensable to develop appropriate capacities in analyzing data and transform outcomes into concrete mainstreaming measures.

More women employed in transportation fields present opportunities for dialogue on issues women experience in the sector, and thereby can help facilitate development and adoption of solutions that are both inclusive and socially sustainable, including relevant innovative business models for the benefit also of the financially weakest users.

The introduction of EV technologies can be seen as transformative, serving as an opportunity to implement changes, so that EVs improve the mobility conditions of women (implementing vehicles in mobility services used by women), increase their participation in new coordination and decision-making processes, and facilitate a more balanced access to transportation jobs (targeting driving, maintenance and fleet management training on women during project activities). By involving women effectively in project design and implementation, and ensuring that interventions are gender sensitive, the project may support the introduction of increased economic opportunities for women in the transport and electricity sectors and support a just-transition of the workforce from employment in existing high-emission sectors to low-emission ones.

7.4. Implementation plan - How do we get there?

All the actions described in previous sections will be consolidated and implemented through the Gender Action Plan proposed by the project called E-Moviliza: "Supporting the transition to low-carbon electric mobility in Ecuador (2023-2026)". On November 29, 2023, notification was given of the start of activities under the Cooperation Agreement for this project between the United Nations Environment Program (UNEP) as the project implementing agency and the Urban Electric Mobility Initiative (UEMI) on behalf of the Ministry of Water and Ecological Transition (MAATE) as executing agency. The project is financed by the Global Environment Facility (GEF).

The main objective of the project is to accelerate the introduction of low-carbon electric mobility and reduce fossil fuel consumption, greenhouse gas emissions and air pollution in Ecuador's transportation sector.

The project is designed around four key components, including:

- Component 1: Institutionalization of low-carbon electric mobility
- Component 2: E-mobility pilots for short-term barrier removal
- Component 3: Scaling and Replication
- Component 4: Promoting long-term environmental sustainability

On the other hand, the GEF Policy on Gender Equality requires that any planned gender-responsive measures to address differences and identify impacts, risks, and opportunities are provided through a gender action plan or equivalent. The gender action plan is a bridge between gender analysis and implementation, and it is a tool to help translate and make visible findings of the gender analysis in program/project implementation and evaluation[10].

An action plan is highly context specific, however. There are some action domains that can be considered an integral part of a Gender Action Plan, such as those actions that:

- provide equal access to and control over resources and information, such as gender- and age-appropriate training and communication material;
- give equal voice and representation in decision making, such as quotas for women in community resource management groups;
- reduce women's workload, such as introducing labor-saving technologies and tools; and
- engage at policy level, such as review of the existing sectorial policies to identify entry points for women's empowerment.

In this sense, the Gender Action Plan of E-Moviliza mainstreams the gender approach in each one of its components through specific gender related objectives, measures and indicators, which will be described as follows.

7.4.1. Focus Area 1: Institutionalization- Improving women's participation and decision making

Component 1 aims to support the government in demonstrating enhanced coordination, consultation, and increased capacity on promoting low-carbon electric mobility in Ecuador. A national electric mobility coordination body will be established to facilitate coordination on the multitude of efforts being undertaken to promote low-carbon electric mobility across Ecuador. A multi-stakeholder consultation and engagement strategy will ensure the social and economic viability of the scale-up of low-carbon electric mobility. Furthermore, activities will be undertaken to build the capacity of local stakeholders on electric mobility, particularly those involved in urban logistics.

In this sense, it is important to promote women's participation in coordination spaces and multi-stakeholders' consultation strategy. It is expected that representation of women increases for topics related to transport, mobility, and the transition to EVs. The inclusion of activities and measures of

[10] GEF (2017). Guidelines on Gender Equality. Policy: SD/GN/02

gender equality becomes a common factor within the electro-mobility agenda of the different national ministries. The results and advances in the area will be shared within the coordination body.

Proposed measures

- Ensure participation of women in the national electro-mobility coordination body, national body
- Ensure participation of women attending engagement activities organized through the output 1.2 (A multi-stakeholder consultation, communication, and engagement strategy is made available to support the government in scaling up electric mobility through a just transition).
- Ensure participation of women in the training provided.
- Collect gender-disaggregated data

7.4.2. Focus Area 2: Economic inclusion of women

Component 2 aims to provide evidence to local stakeholders (mainly, private decision-makers and public policymakers) of the technical, financial, and environmental viability of low-carbon electric mobility. The outputs in this component will mainly address non-financial barriers referred to in section 1 (namely, the lack of confidence and awareness of local actors as to the viability of low-carbon electric mobility for local conditions) by allowing last-mile logistics and service companies to pilot electric vehicles in Quito as part of their operations. A data management system will be developed to compile information generated by the tested vehicles and chargers to be accessed by all relevant stakeholders, which in turn will provide a valuable input to quantify and calibrate policy decisions that are focused on strictly financial barriers.

As it was mentioned before, women are strongly underrepresented in the sector of transportation and e-mobility, representing only 9% in the transport and storage branch. Thus, it is fundamental to promote better capacities and new labor opportunities in just conditions. It is expected that women who finalized successfully their driving course and obtained their professional license executed as part of SOLUTIONSplus activities, could incorporate and participate in these pilots. However, the inclusion should happen in the whole e-mobility value chain, incorporating women not only as drivers, but also as maintenance staff, technicians, mobility planners and engineers, among others.

Moreover, with regards to Component 3, which focuses on the scaling-up low-carbon electric mobility in the medium- to long-term, it is necessary to design business models identifying opportunities for the integration of women in the labor force and the reduction of work and salary gaps. As a result, solutions that integrate the gender dimension in terms of subsidies, loans, and credits should be promoted.

Finally, the integration of a gender perspective in public transport design and operation addresses a fundamental aspect of social sustainability. Initiatives focusing on the recruitment and training of female bus/eBRT drivers, alongside the deployment of e-trolley buses, exemplify a proactive approach to fostering inclusivity. Collaborative projects with **UNEP**, focusing on gender and e-mobility, can provide a comprehensive framework for assessing the social impact of these initiatives, ensuring that the e-BRT system meets the diverse needs of Quito's population.

Proposed measures

- Inclusion of women as drivers of the electric vehicles introduced in the logistics and passenger transport operations

- Inclusion of women as technicians in the pilot, e.g. as maintenance staff
- Identify regulatory and economic barriers for women and address them (e.g.: years of experience needed to drive a BRT bus or the price of the professional driving license)
- Close the gap by attracting more female STEM students, e.g.: engineers, to join the transportation sector by collaborating with the academia, public and private companies in the field that could offer internship possibilities.
- Promote the creation of credit lines for women to become entrepreneurs in the e-mobility sector
- Creation of mechanisms to incentivize the participation of women in leasing, renting and subscription of EVs
- A just transition strategy for adopting standards and a policy framework which regulates fuel quality is drafted and submitted for adoption by INEN. The strategy includes an assessment of the impact of the increase in fuel quality/price by decile of income and disaggregated by gender.

7.4.3. Focus Area 3: Gender-responsive vehicle and infrastructure design

Component 2 involves the design of the vehicles tested, the cross-docking platform provided and the charging infrastructure installed. Component 3, on the other hand, includes the development of charging infrastructure regulations, along with a strategy to deploy inter-city charging stations. Thus, including a gender-responsive perspective to the design of the vehicles and the infrastructure is key to enable women to join the e-mobility workforce, as well as users to be able to use the technology to conduct their daily activities.

Proposed measures

- Design workshops and focus groups with women to understand their specific needs and requirements
- Design vehicles that take into account the physical characteristics and needs of women
- Design logistics spaces and charging infrastructure that takes into account women's needs
- Plan operations in a gender-responsive way, e.g.: by having flexible schedules compatible with care duties.

8. Conclusion and next steps – what do we need?

In 2024, urban mobility cannot be understood without considering the new mobility trends, of which electric vehicles are just one. Shared mobility, digitalization, new operating and business models are here to stay. In addition, the emergence of new mobility concepts and the widespread use of smartphones worldwide have led to the emergence of a significant number of mobility applications and services aimed at improving the efficiency of urban mobility, both for freight and passenger transport. Therefore, this City Roadmap embraces all these new mobility concepts and trends, linking them to the experience of the demonstration activities carried out in Quito in the context of SOLUTIONSplus and to the available policy framework, in order to propose contextualized, realistic solutions that require thinking outside the box in order to be implemented. In this context, this City Roadmap propose 4 action lines to work towards a mobility system that integrates micro and light electric vehicles for people and goods, and one that takes into account shared mobility services and is gender-inclusive from the conception.

This City Roadmap will guide the design and implementation of the follow-up projects **E-MOVILIZA** (GEF7 – 2023–2026): Support the shift towards low-carbon electric mobility in Ecuador, **ACCESS** (2024–2029): Accelerating Access to Low-carbon Urban Mobility Solutions through Digitalization, **E-mobility as a Driver for Change** (2023–2026): Towards a Gender Transformative and Just Transition to Electric Mobility, and **EBRT** (2023–2026): European Bus Rapid Transit of 2030. These projects will be executed in Quito, Ecuador directly by SOLUTIONSplus consortium members until 2029 with a total budget of approximately 4 million Euros (for the country) and will, therefore, ensure the scale-up of the SOLUTIONSplus action lines to a mainstream phase from 2030 onward. However, the goal is more ambitious, it aims to become a baseline for the work being conducted by other international organizations in Ecuador, and specifically in Quito.

Moreover, the political will of the municipal (and national) authorities to push forward the policies and regulations necessary for the scale-up of the demonstration activities carried out by the SOLUTIONSplus projects and thus the uptake of an efficient, integrated and inclusive low-carbon mobility will be crucial. Finally, this City Roadmap will not be able to be implemented without a collaborative approach whichintegrates the views and the needs of the private sector, the civil society and the support of the academia. SOLUTIONSplus advanced in this collaborative process already, but it requires enforcement and institutionalization.

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