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

SOLUTIONSplus, Quito

The SOLUTIONSplus project recived funding from the European Union Horizon 2020 research and innovation Programme under grant agreement no. 875041

Contents

Summary

The National Government of Ecuador and Quito's Municipality have advanced sustainable urban mobility, particularly e-mobility, with key policies and regulations, including the Energy Competitiveness Law (2024) and the National e-mobility strategy (2021). While significant progress has been made, further incentives, regulations, and tools are required for a comprehensive scale-up of e-mobility.

In Quito, the SOLUTIONSplus project has driven e-mobility forward through four areas: low-carbon urban logistics, decarbonizing public transport, Mobility as a Service (MaaS), and gender inclusion. Quito's City Roadmap builds on these results and aligns with the Sustainable Mobility Master Plan (2024) to continue advancing low-carbon, integrated, and inclusive mobility.

Key objectives include:

1. Establishing a Zero Emissions Historic Center with a Light Electric Freight Vehicle (LEFV) system.
2. Enhancing public transport with optimization tools.
3. Promoting intermodality using digital MaaS tools.
4. Closing the gender gap in the transport sector.

Upcoming projects (2023–2029) with a €4 million budget will support the continued development of these initiatives, ensuring their scale-up by 2030.

1. Background – Urban Mobility Context in Quito

Quito, Ecuador's capital, is the second-largest city with a population of 2.7 million. It spans 4217 km², with urbanized areas covering less than 20% of the territory. The city's growth occurred in three phases: radial expansion until the 1950s, north-south expansion until the 1990s, and urban sprawl to the east since then. The city's elevation varies from 500 to 4,780 meters above sea level. The urban area, 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.

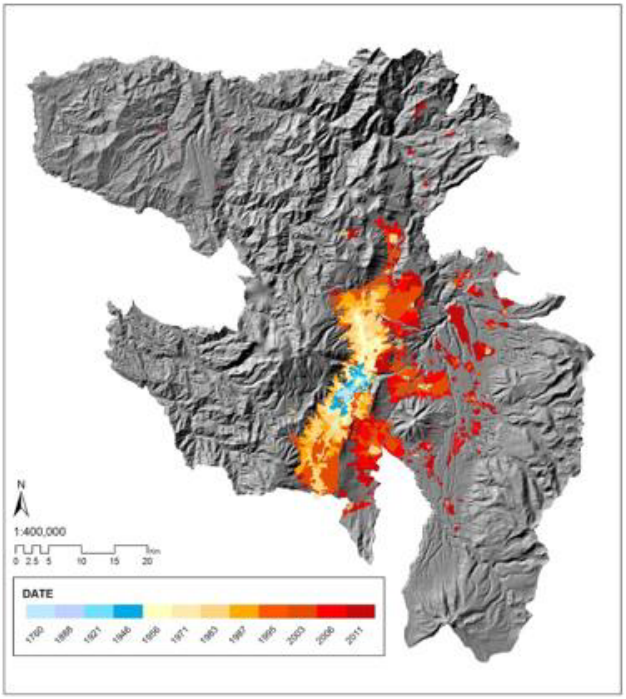


Figure 1. Physical Map of the political-administrative confine of the Metropolitan District of Quito and its urbanized area highlighted.
Source: Territory Habitat and Housing Secretariat (STHV, 2012)

Quito is known for its Historic Centre (HCQ), a UNESCO World Heritage Site since 1978. The HCQ is a significant crossing point for commuters and a commercial and mobility hub.

Environment and GHG Emissions

In 2020, air quality was good for 26% of the year, acceptable for 71%, and concerning for 3%, with significant improvement due to pandemic-related mobility restrictions. Noise levels in Quito's Historic Center exceed WHO guidelines, though they fall within local norms.

Quito's 2015 GHG emissions inventory showed a total of 7.6 million MT CO2e, with the transport sector responsible for 40%. The road subsector is the largest emitter, due to the operation of BRT buses, taxis, and private vehicles.

Urban Transport and Policy Initiatives

Quito handles 3.9 million daily trips, with 70% using sustainable transport. The city's policies align with national goals, such as reducing GHG emissions by 9-21% by 2025 through the 2019 Energy Efficiency Law and 2021 Transport Law reforms.

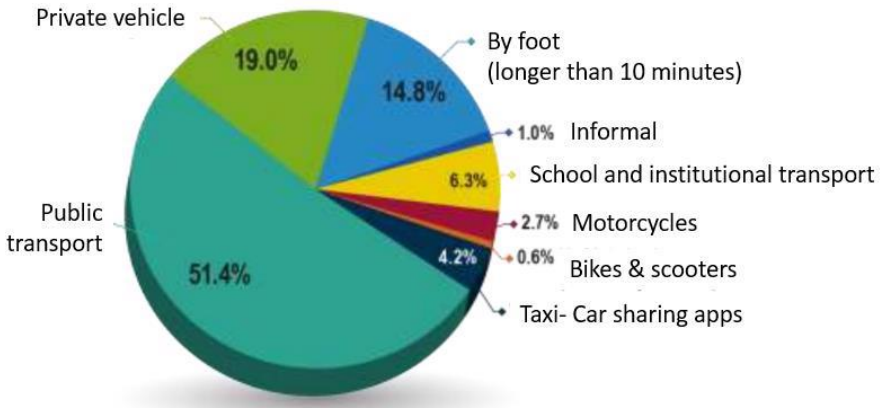


Figure 3. Transport Modal split in DMQ 2022.
Source: Diagnostic Synthesis- Sustainable Urban Mobility Master Plan (DMQ, 2022

The Climate Action Plan (PACQ), introduced in 2020, targets a 30% GHG reduction by 2030 and climate neutrality by 2050. Key actions include zero emissions public transport, an emissions-free Historic Center, efficient public transport, active mobility, and low-carbon freight. The city has enacted ordinances to promote electric mobility and is considering further regulations on decarbonization and light electric vehicles (LEV).

The Sustainable Mobility Master Plan 2022-2042 (PMMS), approved in 2024, aims for a 75% reduction in transport emissions by 2042. It involves a $7.5 billion investment in 9 plans, 33 programs, and 139 projects, focusing on improved travel experiences, a shift in modal split, alternative funding, and reducing road casualties.

The SOLUTIONSplus project, funded by the EU's Horizon 2020, supported Quito's sustainable urban mobility efforts from January 2020 to June 2024. It included:

1. **Multimodal e-Mobility Hub**: Established in Quito's Historic Center, testing e-cargo bikes and planning for e-mini vans and e-quadricycles.
2. **Capacity Building**: Training for municipal staff on e-buses and trolleybuses.
3. **Mobility-as-a-Service (MaaS)**: Developed and tested a MaaS app with local transport operators.
4. **Gender Inclusion**: Addressed gender disparities in the e-mobility sector.

Quito benefited from tailored technical assistance and capacity-building initiatives, including workshops, peer exchanges, and expert consultations. The project also facilitated participation in the Latin American e-Mobility Forum in Bogotá, where Quito's delegation engaged with regional e-mobility leaders.

2. Approach – Methodology

Over the past four years (2020-2024), SOLUTIONSplus in Quito has focused on demonstration activities, impact assessments, capacity building, technical assistance, business models, policy

development, and funding identification. This City Roadmap builds on these efforts and aligns with Quito's Sustainable Mobility Master Plan (PMMS) to advance low-carbon, integrated, and inclusive mobility. The four main action lines are:

1. **Low-carbon Last Mile Logistics**: Introduction of locally produced Light Electric Vehicles (LEV) for urban logistics.
2. **Public Transport Electrification**: Optimization and electrification of public transport.
3. **Mobility as a Service (MaaS)**: Complementing the Integrated Payment System and promoting intermodality with sustainable transport modes.
4. **Gender and (e-)Mobility**: Addressing the inclusion of women in the e-mobility sector.

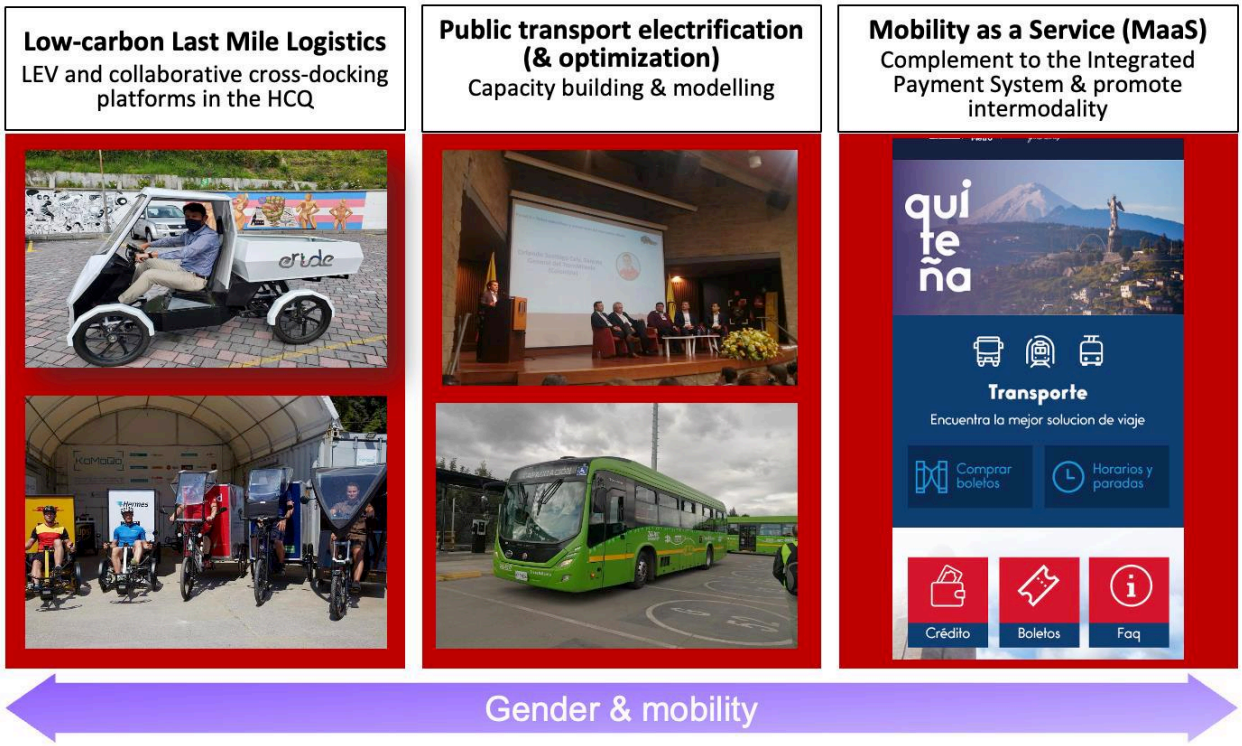


Figure 7. Action lines City Roadmap

The roadmap supports three PMMS objectives: mitigating GHG emissions, promoting low/zero-emissions transport, and creating an integrated, multimodal transport system.

Methodology

- **Data Collection:** Assess impact and scale-up potential before and after pilot implementation.
- **Literature Review:** Identify policy gaps and review global and regional trends in sustainable mobility.
- **Observations and Documentation:** Identify challenges from the project's four-year duration in Quito.
- **Expert Interviews:** Consult with local policymakers, transport operators, and vehicle manufacturers to find barriers and solutions.
- **Case Studies:** Analyze successful practices from other Latin American cities.

- **Stakeholder Workshops:** Conducted in January 2024 with over 200 participants from various sectors to ensure broad involvement in the City Roadmap.

Workshop Participation:

- **Public Sector:** 6 participants (8%)
- **Private Sector:** 4 participants (6%)
- **Academia:** 21 participants (28%)
- **Civil Society:** 44 participants (58%)

This participatory process is crucial for effectively transitioning to low-carbon urban mobility in Quito, with workshops organized by SOLUTIONSplus, the Municipality of Quito, and EPN, involving over 200 representatives from various sectors.

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

The Roadmap – Where are we going?

Vision

By 2024, urban mobility must incorporate trends like electric vehicles, shared mobility, digitalization, and innovative business models. This City Roadmap merges these trends with Quito's SOLUTIONSplus experiences and existing policies to propose creative, realistic solutions. It follows the PRIF (2021) mobility pyramid, focusing on passenger and freight transport, micro and light electric vehicles, shared mobility, and gender inclusivity. Quito aims to lead Latin America in low-carbon urban mobility, aligning with the Sustainable Mobility Master Plan (PMMS) to achieve a safe, efficient, integrated, and inclusive transport system while meeting GHG reduction goals.

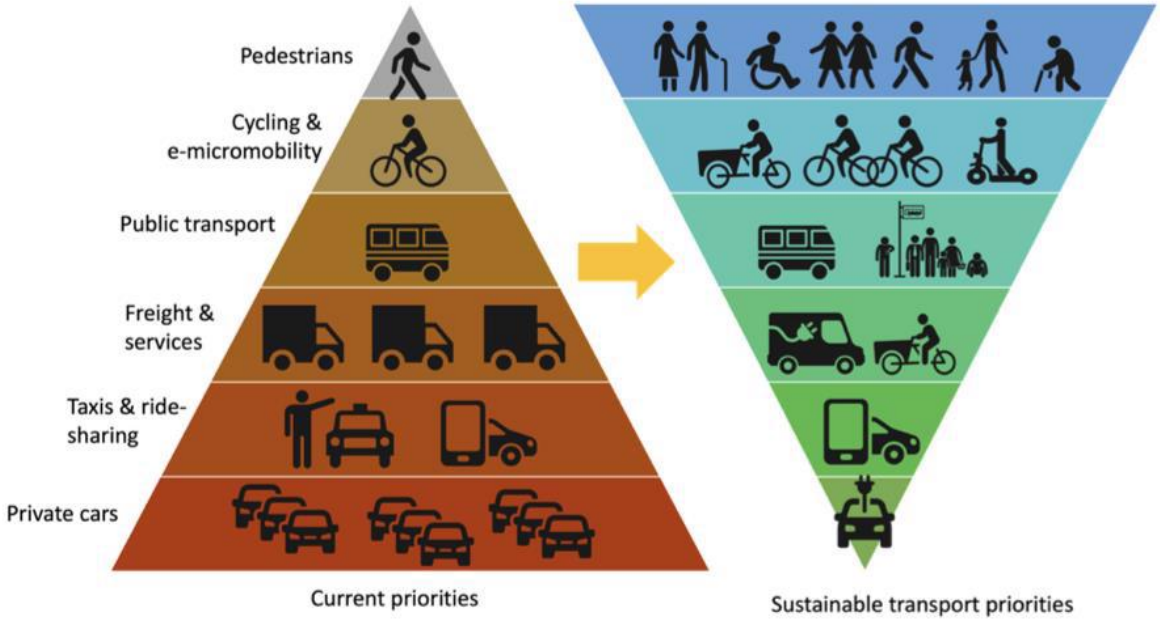


Figure 9. Shift from a car-oriented paradigm to a people-first one. Source: PRIF (2021)

Objectives

1. Implement a LEFV system for urban logistics to achieve a Zero Emissions Historic Center.
2. Improve public transport efficiency and integration with optimization tools and models.
3. Enhance intermodality using digital tools like Mobility as a Service applications.
4. Promote gender inclusivity and economic opportunities for women in the transport sector.

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

Stakeholders

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

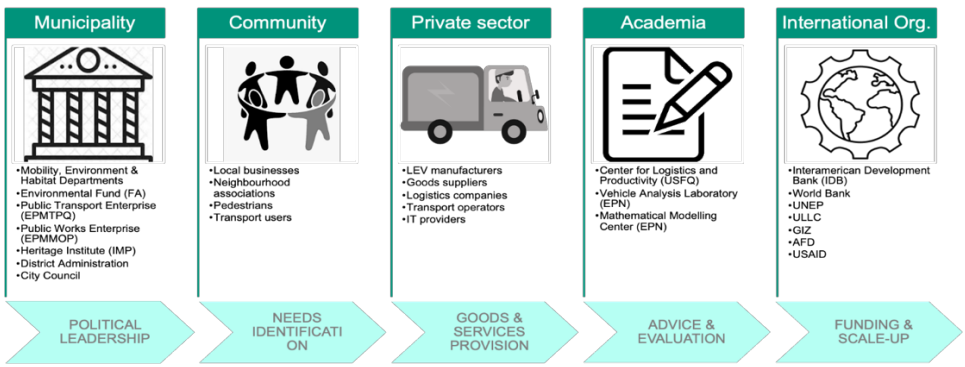


Figure 10. Stakeholder map and roles

Action Line 1: LEV System for Urban Logistics in the Historic Center of Quito (HCQ)

Current Policy Framework and Market Readiness

The Historic Center of Quito (HCQ), covering 3.75 km² and home to around 29,071 residents, is a vibrant area with over 2,000 businesses and significant daily foot traffic. Despite a decrease in residential population, its commercial and tourist appeal remains strong.

Local Policies

- Quito, a C40 Climate Leadership Group member, aims for a Zero-Emission Historic Center by 2030.
- Ordinance No. 0194 (2017) and its 2019 expansion regulate various mobility vehicles.
- The 2018 Integral Plan prioritizes electric transport to reduce pollution.
- Ordinance No. 147 addresses logistics but current schedules and infrastructure issues complicate operations, causing congestion and damage to historic buildings.

SOLUTIONSplus Project Initiatives

- Introduced an LEV system to improve last-mile logistics.
- Proposed new regulations for Light Electric Vehicles (LEVs) and non-motorized mobility.
- Part of the PMMS, with Plan IV focusing on logistics hubs and Plan IX targeting the Zero Emission Zone in the HCQ.

Logistics Dynamics

Surveys conducted by SOLUTIONSplus in 2021 and 2023 show a focus on wholesale, retail, and accommodation sectors. The area's logistics dynamics reveal a strong interest in electric mobility pilots. The study covered 241 businesses in 2021 and 107 in 2023, exploring current practices and potential improvements.

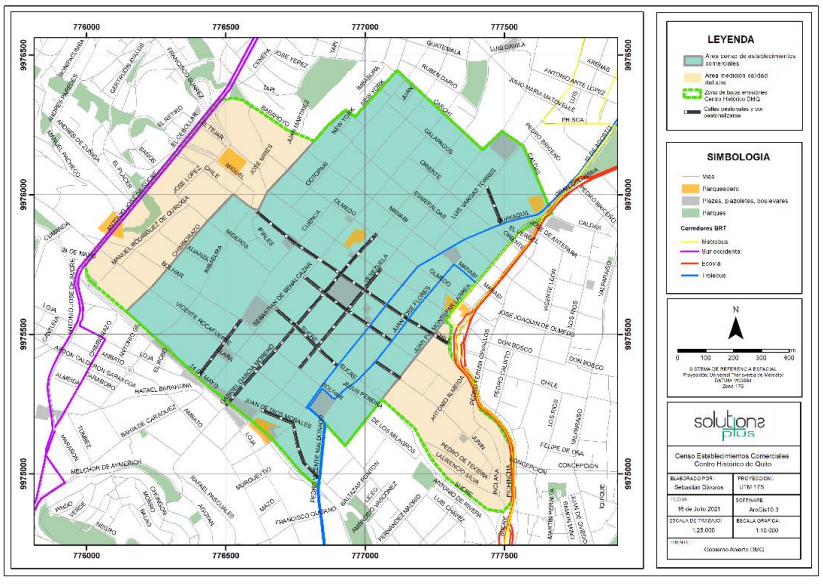


Figure 11. Defined Area

In the HCQ, 43% of businesses get goods from direct suppliers, 25% handle their own provisioning, and 32% use both methods. Most (63%) receive deliveries at least weekly. The most common delivery vehicles are small trucks (30%), followed by light-duty vehicles (20%), vans/pickups (15%), and large trucks (11%). Non-motorized methods, such as bicycles and wheelbarrows, make up 8%.

Delivery parking is primarily on sidewalks (59%), with only 5% using designated bays. Additionally, 62% of businesses lack storage, leading to frequent deliveries. Disruptions are prevalent on Streets Vargas, Cuenca, Sucre, Rocafuerte, Montúfar, and Olmedo, indicating issues with loading regulations and potential for improved logistics coordination.

The Demonstration Actions

The project's key initiative in Quito, the multimodal e-mobility hub in the HCQ, aimed to support the Zero Emissions Historic Center by introducing locally designed Light Electric Vehicles (LEVs) to enhance last-mile logistics and connectivity.

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

Seed funding was provided by SOLUTIONSplus, through UN-Habitat and the Environmental Fund, to local SMEs for LEV development and assembly. Bixicargo received funding for 10 e-cargo bikes, Sidertech for 4 e-quadricycles, and Grupo Miral for 4 e-mini vans, focusing on both logistics and passenger transport. Technical support and components, including Valeo drivetrains, were also provided. Additionally, PEM Motion, IDIADA, ERTICO, and FIER contributed to vehicle design, battery sizing, and business models through the SOLUTIONSplus Start-up Incubator.

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

The Pilot Design

In 2021, the Technical University of Berlin (TUB) proposed an intermodal corridor for the Historic Center as part of the Zero Emission Zone initiative. This design, which includes three markets and key transport stations, was validated by municipal entities and initiated stakeholder discussions. In early 2022, a workshop with over 50 stakeholders, organized by the Center for Productivity and Logistics (CATENA), focused on low-carbon Last Mile Logistics (LML) and introduced regional LML pilots. This led to 20 expressions of interest from various entities to test SOLUTIONSplus Light Electric Vehicles (LEVs).

Based on feedback, five operating schemes were developed, with pilot phases targeting different schemes. Initially, Yaku municipal parking was chosen for cross-docking but was later replaced by the Medranda private lot due to municipal constraints. The Medranda lot facilitated parking and charging for the pilot's e-cargo bikes and e-quadricycles.

SCHEME 1

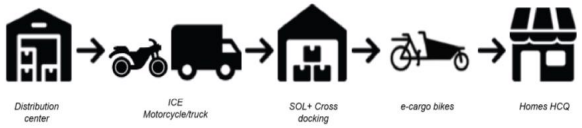
Operators: Bike messengers and Central Market stevedores
Use case: Food distribution from local markets and shops to restaurants and hotel

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

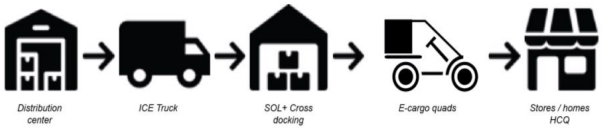


Figure 19. Five operating schemes

SOLUTIONSplus enhanced local knowledge through training, including the 2021 Regional Training on low-carbon urban logistics and the Latin American Electric Mobility Forum in Bogotá (2024), along with other international events.

Pilot Implementation and Monitoring

The pilot unfolded in two phases: Phase one tested 10 e-cargo bikes, and Phase two will test 4 e-mini vans and 4 e-quadricycles.

Monitoring included:

- **Daily Data Collection:** Mobile air quality sensors on e-cargo bikes tracked air quality, routes, distance, and operational details.
- **User Surveys:** Post-pilot surveys gathered feedback from logistics operators, drivers, and end-users.
- **IDB Collaboration:** Included pedestrian surveys and data analysis to assess LEV perceptions and pilot scalability.

Phase one, from November 7, 2022, to January 6, 2023, involved 7 users across 4 operating schemes. Results showed efficiency gains and economic benefits, with informal market workers and recycling associations increasing income by 81% and 25% while reducing working hours by 43% and 56%. Courier companies also saw improvements, increasing deliveries from 8 to 35 per day, indicating strong potential for scaling up and reducing ICE vehicle use.

Scale-Up Potential

A 2021 survey of 240 businesses found an average of 1.7 vehicle deliveries per week, with small trucks making up 30.2% of deliveries (see Table 5). Fully implementing zero-emission logistics could replace 397 internal combustion engine (ICE) vehicles daily, cutting about 600 tons of CO2 emissions annually.

Barriers and Opportunities

Barriers:

- **End User:** Limited awareness of electromobility benefits.
- **Economic:** High LEFV costs and infrastructure needs.
- **Operational:** Few demonstrative experiences.
- **Environmental:** Challenges like steep terrain and weather.

Opportunities:

- **Economic:** Promote business models and funding for LEFV.
- **Operational:** Implement Monitoring, Reporting, and Verification (MRV) systems.
- **End User:** Raise awareness and offer test drives.

Scale-Up Potential:

- **Willingness to Pay:** High interest in LEFV services in the HCQ.
- **Cost Analysis:** Assess operational costs for effective planning.
- **Incentives:** Offering incentives could boost LEFV adoption.

Next Steps:

- **Evaluation:** Analyze pilot results to guide scaling up in Quito.
- **Public Sector Role:** Balance economic costs with freight transport impacts.

Supply Side Trends

Urban transport changes in Quito's central area will impact sustainable mobility and LEFV adoption. Key areas of focus include:

- **Regulatory:** Restrictions on time, volume, weight, and emissions.
- **Market-Based:** Congestion charges and subsidies.
- **Land Use Planning:** Zoning activities.
- **Infrastructure:** On-street loading bays.
- **New Technologies:** Advances in vehicle tech and ICT.
- **Management:** Freight forums and consolidation centers.

Implementation Plan

To achieve a Zero Emissions Historic Center, a LEV system is proposed, focusing on:

- **Orgware:** Building a stakeholder network coordinated by a neutral entity.
- **Software:** Optimizing LEFV system design.
- **Hardware:** Designing LEFVs and infrastructure, addressing capacity, range, and charging needs.

These elements must evolve together with a tailored policy framework to ensure successful implementation.

Focus Area 1: Orgware

Introducing Light Electric Freight Vehicles (LEFVs) in Quito's Historic Center requires collaboration among stakeholders due to the complexity of urban freight logistics. Key motivators include environmental benefits, increased accessibility, economic savings, public support, and positive branding, though conflicts among residents, transport operators, and tourists pose challenges.

Opportunities and Challenges:

- **Opportunities:** Growing private sector interest, successful small-scale trials, and potential for expansion.
- **Challenges:** Regulatory limitations, resistance to operational changes, and issues with insurance and financing.

A cooperative business model is essential, supported by clear governance structures and efficient information-sharing. This involves designing a legal framework, creating a cooperative network, and implementing ongoing monitoring. Success depends on stakeholders' willingness to share risks, costs, and profits, addressing both cultural and financial barriers. A phased approach, starting with key partners and expanding gradually, is recommended.

Network Configuration and Fleet Composition:

- **Network Configuration:**
  - Direct trips work well in high-density areas.
  - City centers may need transshipment or consolidation nodes to optimize deliveries.
- **Fleet Composition:**
  - Options include a dedicated fleet of e-cargo bikes or a mixed fleet with various LEFVs.
  - Choices depend on market analysis and system efficiency.
- **Node Types:**
  - **Urban Consolidation Centers (UCC):** Not ideal for cycle logistics due to distance.
  - **Micro Consolidation Centers (MCC):** Closer to delivery areas, enabling multiple operators to consolidate shipments.
  - **Transshipment Points (TP):** Locations for transferring goods from larger vehicles to LEFVs, requiring precise timing. Can be stationary, semi-stationary, or mobile.

Multimodal Schemes Overview:

1. **Direct Transport System:**
   - Freight moves directly from origin to destination.
   - Example: Local businesses handling deliveries themselves.
2. **Single-Level Multimodal System:**
   - Involves one transfer between origin and destination.
   - Freight goes from a distribution center (DC) to a node (UCC, MCC, or TP) and then to LEFVs for last-mile delivery.
3. **Two-Level Multimodal System:**
   - Involves two transfers: from DC to UCC, then to MCC or TP for last-mile delivery.
   - Neutral management of intermediate nodes is essential to avoid conflicts.

Business Models

The City Roadmap utilizes a General Business Model (GBM) for a cooperative Light Electric Freight Vehicle (LEFV) network, based on Osterwalder's canvas:

- **Customer Segments:** Target audiences.
- **Value Propositions:** Solutions for customer needs.
- **Channels:** Delivery methods.
- **Customer Relationships:** Engagement strategies.
- **Revenue Streams:** Income sources.
- **Key Resources:** Necessary assets.
- **Key Activities:** Core operations.

- **Key Partnerships:** External support.
- **Cost Structure:** Financial framework.

GBM Overview:

- **Partners:** Municipality, LEFV providers, freight operators, suppliers, repair services.
- **Key Activities:** Pickup and delivery.
- **Value Proposition:** Reliable and timely service.
- **Customer Relationships:** Cooperative and client-focused.
- **Customer Segments:** B2B and B2C.
- **Channels:** Internet, subcontractors, local shops.
- **Cost Structure:** Wages, maintenance, rent.
- **Revenue Streams:** Service fees, advertising.

Governance: A balanced structure combining contracts and relational mechanisms. The network coordinator manages operations and resolves issues, with a focus on reducing costs and fostering trust. Long-term relational contracts are preferred, with formal contracts used as needed.

Data Framework: Automated platforms for service planning, with backups like EDI and email. Investments in IT infrastructure and data security are essential.

Contractual Framework: A mix of contractual and relational governance ensures trust and cooperation, evolving from formal contracts to more relational approaches over time.

Focus Area 2: Software

To reduce truck usage and CO2 emissions, the software focus optimizes micro hub locations and LEFV routes.

Key Issues Addressed:

- Optimal micro hub placement.
- LEFV routes and delivery times.
- Comparison of new solutions with current costs, time, and emissions.

Tasks:

1. Identify optimal micro hub locations.
2. Determine best LEFV routes.
3. Assess impacts on costs, time, and emissions.

LEFV Optimization:

- **Micro-hub Location:** Modeled as a p-median problem.
- **LEFV Routing:** Optimized using capacitated vehicle routing with time windows.

Software Solution:

- **Application:** Web tool for LEFV routing, integrating with existing platforms.
- **Cargo Bike Optimizer:** Developed by ZLC, using OpenStreetMap, OpenStreet Routing Machine, and VROOM for route optimization. Includes:

- **OSM:** Geographic data.
- **OSRM:** Map service.
- **VROOM:** Route optimization.
- **Docker:** Application containers.
- **PHP Interface:** User interface.
- **phpMyAdmin:** Database management.

Constraints and Inputs: Fixed depots, varied LEFV fleets, capacities, time windows, street restrictions. Supports real-time updates via Google Maps API.

Focus Area 3: Hardware

The hardware stage involves designing LEFVs (Light Electric Freight Vehicles) and sizing micro hubs, closely linked to the software stage which addresses demand, spatial distribution, and hub locations.

Opportunities and Challenges:

- **Opportunities:**
  - Existing 125 km of bike lanes, with 25 km added during COVID-19.
  - Potential use of underutilized municipal parking in the Historic Center.
- **Challenges:**
  - Disputes over LEV access to bike lanes.
  - Lack of insurance for e-cargo bikes/tricycles.
  - High import taxes and strict ARCSA regulations affecting LEV use for food and medicine.

LEFV Design:

- **Specifications:** Electric propulsion, speeds up to 45 km/h, various designs with load boxes, trailers, and customizable features.
- **Considerations:** Must meet market needs, infrastructure compatibility, local regulations, and have higher payload capacity and customizable options. Prefer larger battery capacities with home charging capability.

Local Developments:

- **Manufacturing:** Funded manufacturers produced e-cargo bikes and e-mini vans, adapting five models to user needs.
- **Public Feedback:** Prototypes, tested in August 2022, received positive ratings for autonomy, charging ease, and performance, though improvements in driving ease, stability, comfort, and safety are needed. Overall, 73% satisfaction with continued use for 1.5 years.

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

Micro Hub Location/Size (Hardware Perspective)

LEFV Services:

- **Point-to-Point (P2P):** Transport between locations.
- **First/Last Mile:** Delivery from distribution centers to customers.

Micro Hub Location:

- **Placement:** Near city center or outskirts to minimize vehicle range issues.
- **Types:** Dedicated, shared, or mobile hubs. Containerization (e.g., Cubicycle) can enhance efficiency and safety.
- **Costs:** Depends on real estate and staffing. High costs can be reduced by using existing spaces or municipal support.

Sizing:

- **Demand:** Hub size should match delivery demand. Underutilized municipal parking buildings in Quito, such as Yaku, La Ronda, and San Blas, could serve as micro-hubs, providing storage, charging, and transshipment without adding congestion.

Case Study: Grupo Nutresa, Colombia

- **Operations:** 26 distribution centers with a mixed fleet, including electric and e-cargo bicycles.
- **Microhubs:** Established in Bogotá, reducing working time by 3 hours and CO2 emissions by 1.2 tons annually. A new microhub at Bogotá's Southern Bus Terminal supports 3 logistics operators.

Results:

- **Working Time:** Reduced from 180 to 30 minutes.
- **Distance Traveled:** Daily travel decreased by 24 km, saving 10,078 km annually.

Adequate Road Infrastructure:

- **Integration:** LEVs may require reorganization of road space, including new parking and charging areas. Concepts like multimodal hubs are emerging to accommodate LEVs alongside public transport.
- **Examples:** NACTO's guide suggests adapting lanes for micromobility vehicles, and Madrid's ordinance includes multimodal lanes with speed limits prioritizing non-cars. A 2021 proposal from the Technical University of Berlin illustrates LEV integration in Quito's Historic Center.

Focus Area 4: Policy Framework

Government plays a crucial role in shaping LEV (Light Electric Vehicle) policies. Challenges include integrating LEVs into crowded urban areas and addressing safety and congestion concerns. Municipalities can:

- **Regulate:** Implement restrictions, like environmental zones or access to pedestrian areas (e.g., Utrecht).
- **Coordinate:** Connect supply and demand for charging and logistics facilities (e.g., Amsterdam).
- **Stimulate:** Offer financial incentives for LEV purchases (e.g., The Hague, Maastricht).
- **Experiment:** Use LEVs in municipal activities.
- **Facilitate:** Support innovation with bicycle streets or affordable logistics spaces.

Current Barriers in Quito:

- Lack of unified micromobility definitions.
- Outdated norms and pending ordinances.

Recommendations:

- **National:** Recognize LEVs as a transport mode, streamline import processes, and include leasing options.
- **Local:** Designate the HCQ as a Zero Emissions Zone, expand micromobility regulations, and formalize the use of under-utilized spaces as micro-hubs.

Case Study: Argentina

- **Regulations:** Decree 32/2018 integrated LEVs into Argentina's transport system. Buenos Aires supported LEVs through the Urban Logistics Unit and amended Law N° 2.148 to authorize cross-docking and micro-hubs.
- **Results:** Buenos Aires saw a 25%–30% reduction in CO_2 emissions per 100 liters transported with LEVs.

Case Study Box 3: ZUMAs in Bogotá

In October 2023, Bogotá launched its first Better Air Urban Zone (ZUMA) in Bosa–Apogeo to enhance air quality by reducing emissions, increasing vegetation, and improving transport.

ZUMA Plan:

- Promote active mobility and public transport.
- Prioritize zero- and low-emission vehicles.
- Consolidate goods distribution.

The BiciCarga project in Bosa–Apogeo aims to replace 20% of cargo transport by ICE vehicles with e-cargo bikes, reducing 60 kg of PM 2.5 and 95 tons of CO2 annually. Additionally, Bogotá's first Consolidation Center was established following positive results from Nutresa's microhub.

Public Transport Electrification and Optimization in Quito

Current Status: Quito's transport system includes the Metrobus-Q subsystem and conventional routes. The city's BRT system, with 5 lines spanning 136 km, serves 1 million trips daily. The Trolebús, Quito's sole electric BRT line from 1995, is affected by frequent diesel use and aging vehicles, with 87 out of 324 buses over 21 years old. Additionally, 2,380 diesel buses operate privately, making 1.6 million trips daily.

Challenges include overcrowding, congestion, poor service organization, and increased private vehicle use. To address these, Quito integrated a new 23 km subway line in December 2023 and plans further electrification, supported by global initiatives and green funds, to cut CO2 emissions and enhance mobility. As a C40 member, Quito aims to replace diesel buses with electric ones, aided by the C40 Cities Finance Facility.

Ongoing Projects:

1. **Subway Line:** A 22.6 km subway line with 18 trains and 15 stops, expected to start full operations in late 2023.
2. **EPMTP Projects:** Includes infrastructure upgrades (48% complete), communication campaigns (77%), zero-emission units (82%), intelligent transport systems (10%), and completed parking space adaptations.
3. **Labrador-Carapungo Corridor:** A new eco-friendly BRT corridor with 14 stops and 2 transfer stations.
4. **Demand Scenarios:** Projections for future transport demand and growth.
5. **Mathematical Modeling:** Research on fleet optimization, transitioning to electric buses, and the Low Carbon Mobility Management App (LCMM) to optimize schedules and reduce emissions.

Barriers and Opportunities:

Challenges:

1. **Operator Coordination:** Effective collaboration among bus operators is needed.
2. **Regulations:** Lack of retrofitting regulations; preference is shifting to new electric buses.
3. **BYD Bus Rentals:** Regulatory issues with renting BYD buses.
4. **Infrastructure Gaps:** High investment required for charging infrastructure and bus transitions.
5. **Feeder Routes:** Need for detailed electrification plans.
6. **Training:** Staff training on e-mobility and smart charging systems required.
7. **Energy Management:** Efficient energy management strategies needed.

Opportunities:

1. **Regulatory and Financial Framework:** Stable tariffs and long-term subsidies for financial stability and public-private collaboration.
2. **Incentives:** Electronic fare payments and rewards can enhance user participation and service.
3. **Monitoring:** Regular service evaluations and stakeholder involvement can improve quality.
4. **EV Financing:** Flexible financing, incentives, and public-private partnerships can support EV adoption and charging infrastructure.

Focus Area 2: Business Models

Options for Financing:

- **Supplier Credit/Low-Interest Loans:** Offers cost savings but involves longer processing times and company bears all risks.
- **Leasing by Mobility Department:** Simplifies acquisition with higher costs (3-5% above loan rates) and maintenance expenses (10-15% higher). 70% VAT reclaimable.
- **Leasing by EPMTPQ:** Most expensive due to non-recoverable VAT (adds 8.4% to cost). Requires municipal funding due to insufficient fare revenue.

Leasing Pros and Cons:

- **Advantages:** Better bus availability, improved maintenance, risk coverage for defects, and shared technological risks.
- **Disadvantages:** Higher costs, potential performance conflicts, and substantial funding required.

Environmental and Financial Considerations: Prioritize reducing pollution and ensuring financial sustainability. Evaluate the Integrated Metropolitan Public Transport System for improvements, phase out older vehicles, and ban used bus imports to enhance fleet quality.

International Models:

- **Bogotá and São Paulo:** Face challenges with subsidy dependency and high costs, impacting financial viability and equity.

Financing and Business Models: Explore innovative financing, international institution engagement, and incentives for scrapping conventional buses to transition to electric fleets.

18m Bus and Trolleybus Technologies:

- **Overview:** 66% of 18m electric buses are in Europe; 34% are articulated trolleybuses.
- **European Cases:** 2,600 battery electric buses introduced by early 2020; recent models include low-floor designs with ranges from 40-250 km.
- **Trolleybuses:** Implemented in 12 cities with ranges of 10-25 km.
- **US Cases:** 142 electric buses from BYD and New Flyer; trolleybuses primarily from New Flyer.
- **Latin America:** Mexico City and Santiago have significant electric bus fleets and ongoing procurement.

Charging Infrastructure and Implementation:

- **Opportunity Charging:** Fast recharging (2-15 minutes) with pantographs or inductive chargers.
- **Night Charging:** More cost-effective, using plug-type chargers with longer recharging times (2-4 hours). Rarely used pantographs in Latin America.
- **Terminal Charging:** Santiago installs 1 charger per 2 e-buses; IEA recommends 8 buses per 190 kW charger by 2030.
- **Charging Strategy Considerations:** Plug-type chargers are low-maintenance but require precise engineering. Interoperability issues with different charging standards need addressing.

Network and Communication: Chargers should support open communication protocols (OCPP) for efficient management and integration. For example, Metbus reduced energy costs by using advanced management systems.

Focus Area: Transport Optimization for Quito

Optimization and Digital Integration:

- **Route Optimization:** Use data and analytics, in partnership with Escuela Politécnica Nacional, to enhance route planning and coverage.
- **Digital Tools:** Implement route optimization software, real-time tracking, and autonomous vehicles to boost efficiency and integrate with e-commerce.

Business Model Innovations:

- **R&D and Partnerships:** Invest in research and collaborate with tech startups to adopt new technologies.
- **Customer-Centric Approach:** Offer personalized delivery, flexible scheduling, and eco-friendly packaging to meet consumer needs and build loyalty.

Sustainable Urban Mobility:

- Embrace electrification and active mobility to ensure a future-proof, socially, environmentally, and economically positive business model.

Good Practices:

- **Buenos Aires Express Logistic Project:** Demonstrates successful data analysis and logistics optimization.

Action Line 3: Mobility as a Service (MaaS)

Current Policy Framework and Market Readiness:

- With urban populations rising, MaaS integrates various mobility services into one digital platform, enhancing trip planning and payment. While successful in Europe and the Global North, developing countries face challenges with fragmented systems and low digitalization.

Quito's MaaS Integration:

- **Implementation:** Quito's new subway line and existing BRT systems offer an opportunity to integrate MaaS with the Integrated Payment System (SIR), User Information System (SIU), and Data Exploitation System (SAE).
- **Pilot:** The SOLUTIONSplus project provided a MaaS app tailored to Quito, showing mixed results but general interest.

Main Barriers and Opportunities:

- **Challenges:** Incomplete integration and regulatory hurdles identified through the TOE model.
- **Opportunities:** Overcoming these barriers and enhancing intermodality through urban planning.

Focus Area 1: Regulatory & Collaboration Framework

- **Key Aspects:** Address data sharing, interoperability, safety, equitable access, environmental goals, consumer protection, and governance through comprehensive frameworks and strategic partnerships.

Focus Area 2: Mobility Stations

- **Goals:** Optimize public space for LEVs, provide charging infrastructure, and promote intermodality. Quito could benefit from integrating new subway and cycling infrastructure with mobility stations.

Gender and E-Mobility in Ecuador

Current Policy and Market Readiness:

- Women rely more on public transport and walking compared to men, with safety concerns significantly affecting their mobility. EV adoption is low with sparse infrastructure.

Demonstration Actions:

- **SOLUTIONSplus Project:** Piloted e-cargo bikes with female drivers, reducing CO2 emissions and highlighting training needs.
- **Financial Support:** UEMI will cover driving course costs for women. Successful models like Jalisco's Mujeres Conductoras Program provide financial incentives.
- **Capacity Building:** Workshops on EVs, leadership, and gender-based violence to boost women's involvement in sustainable mobility.

Barriers and Opportunities:

- **Challenges:** Regulatory and financial barriers for women in transport careers.
- **Implementation Plan:** The Gender Action Plan under E-Moviliza aims to enhance women's roles in electric mobility, ensure economic inclusion, and design gender-responsive infrastructure.

Key Measures:

- Ensure women's participation in decision-making.
- Provide training and job opportunities in e-mobility.
- Design infrastructure to meet women's needs.

Conclusion and Next Steps

In 2024, urban mobility evolves with electric vehicles, shared mobility, digitalization, and new business models. The City Roadmap builds on Quito's SOLUTIONSplus activities and existing policies to offer innovative solutions.

The Roadmap includes four action lines: integrating micro and light electric vehicles, enhancing shared mobility services, and promoting gender inclusivity. It will guide projects like E-MOVILIZA, ACCESS, E-mobility as a Driver for Change, and EBRT, with a total budget of about 4 million Euros. These efforts aim to expand SOLUTIONSplus initiatives and set benchmarks for future international projects in Quito and Ecuador.

Success hinges on the commitment of municipal and national authorities, along with collaboration from the private sector, civil society, and academia. Continued enforcement and institutionalization of SOLUTIONSplus progress are crucial for achieving these goals.

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