

Final Report

C40 Cities Finance Facility

December - 2020



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ABOUT CFF

The C40 Cities Finance Facility (CFF) program is a collaboration between the Climate Leadership Group - C40 Cities for Climate and the German Cooperation Agency (GIZ) GmbH. The CFF supports cities in developing and emerging economies in the development of projects that are ready to access financing in order to reduce emissions and limit the global temperature increase to 1.5°C, strengthening the resistance against the impacts of the climate change. The CFF is funded by the German Federal Ministry for Economic Development and Cooperation (BMZ), the Children's Investment Fund Foundation (CIFF), the United Kingdom Government, and the United States Agency for International Development (USAID).

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1. INTRODUCTION

1.1. THE PROJECT

The C40 Cities Finance Facility (CFF) is supporting the City of Quito in the development of two zero-carbon projects that will be implemented in the city in the coming years:

1. Electrification of the Ecovía BRT corridor, including the installation of strategic charging stations and the acquisition of 193 e-buses.
2. A 10.3-km extension of the Central Trolleybus Corridor, including the construction of two terminals and the acquisition of 69 trolleybuses and 83 e-buses.

LOGIT is a renowned consultancy firm in mobility projects and is developing the feasibility analysis and implementation of E-buses in two Quito BRT corridors. LOGIT has involved a team of consultants in the project who have considerable experience in mobility projects and will work in cooperation with CFF.

This document consolidates the project's phase 5 final report.

1.2. SUMMARY

The project started in early February to end in December, 2020. Due to the coronavirus pandemic, the project had to be developed remotely, with virtual presentations and training using the web.

The preliminary reports were delivered on June 30 and the first draft of the bidding documents in October.

The fact that the city administration has not yet decided on the fare policy and the reorganization of the integrated network has not allowed the study's outputs to be fully conclusive. There is also uncertainty about when the metro will start operation, since a decision has not yet been made on its operator.

However, the study has contributed with elements allowing the administration to simulate new scenarios and use the financial model to verify new results.

The impact of the pandemic on municipal finances and on the public transportation company is such that no commitment can be made yet to fleet replacement expenditures. However, a good part of the vehicles has already exceeded or will soon exceed their lifespan of 25 years, which is actually too generous and not consistent with the buses' economic lifespan. For this reason, the analysis considered a 15-year lifespan for the buses.

In addition to the financial aspect, the impact of a decrease in demand due to the pandemic has also resulted in losses for Quito Metropolitan Public Transportation Company (EPMTPQ). It is uncertain how demand will evolve in 2021 and it is possible this impact will extend into 2022.

In this situation of great uncertainty, strong coordinated action is required from a city administration, but this is not currently the case in Quito. Faced with uncertainty, actions are headed by different agencies, and there is no strong proposal on the route to follow.

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This scattered action has not allowed reaching important decisions that were not easy to take even before the pandemic.

Among important decisions still under discussion are those related to the SITP ordinance and the fare policy. The fare policy is always a difficult decision to make and, because it has a strong political component, technical and financial arguments are often left aside. This difficulty has meant that the fare has not changed in the last seventeen years.

Without these decisions, it is not possible to have a clear scenario in which to size the demand, organize the service system, and make appropriate financial evaluations.

The results presented reflect the scenario discussed at the beginning of the project, which included starting the metro operation and completing the Labrador-Carapungo extension. This analysis has indicated the need for 51 new trolleybuses and 37 electric buses in the initial phase of operations.

The City Administration considers the policy of maximizing passenger demand into the metro system. The consultants have already warned in a timely manner about the risks of such a policy, as it can reduce the quality of the transportation services for the population. A subway is built to serve the city, not the other way around.

Finally, all the reviews show that public transportation in Quito is not sustainable with the current fare, and the idea of transforming current operators into legally organized companies is not feasible. Even introducing a 25- to 35-cent increase into the simulated fare, this would not make it possible to renew the fleet and promote the new mobility arrangement in Quito. It is necessary to conduct a more exhaustive study that includes determining the social and financial impacts in order to make more appropriate decisions.

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2. SCENARIO ANALYSIS, DEMAND ESTIMATION AND REORGANIZATION OF SERVICES

2.1. GENERAL ASPECTS

The public transport system in Quito's Metropolitan District (DMQ) is called the Integrated Public Transport System (SITP). This system is structured by exclusive BRT corridors running north to south, the feeder lines to BRT corridors, running east to west, and conventional lines that have specific routes and provide urban services, as well as services within and between city districts intra and inter and intra parochial routes. Additionally, a metro line was built parallel to the corridors, but is not operating yet.

The Metrobus-Q (Metro-Q) is the trunk feeder system that connects the BRT segregated lanes services (trunk system) and the feeder lines. Metrobus-Q has 3 lines or "corridors": Central or Trolleybus, Oriental (Eastern) or Ecovía, and Occidental (Western). These corridors have several organized routes operated with articulated and bi-articulated buses on more than 71 kms of segregated bus lanes.

The purpose of this project is to study the Trolleybus and Ecovía corridors. The first one was inaugurated in 1995, at which time it had 39 bus stops and two terminals. Later, a south extension was added to reach Quitumbe, and another extension to El Labrador station. Currently, 281 thousand passengers are transported daily, with the following stops, transfer stations and terminals.

Figure 1: Trolleybus Corridor

TERMINALS IN USE	3
UNUSED TERMINAL (LA Y)	1
PROVISIONAL STOPS	8
TRANSFER STATIONS	2
STOPS	44

Source: Quito Passenger Company

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 0.25, reduced USD 0.12, and preferential USD 0.10 fares

Figure 2: User Characteristics

User	Trolleybus	Oriental / Ecovía
Opening	1995	2002
Routes	5	7
Length (km)	22.5	20.9

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User		Trolleybus	Oriental / Ecovía
Stations / Stops		39	38
Transfer Stations		4	2
Distance between stations (m)		400	400
Trunk Fleet	Trolleybus	49	0
	Bi-articulated	55	20
	MB0500	8	32
	Volvo B10M	0	37
	Volvo B12M	0	80
Daily demand (1,000)		281	229

Source: Passenger Transport Company, DMQ, 2017

This project's main objective is to provide technical support for two electro-mobility service projects in Quito:

- Extending the Trolleybus corridor from Labrador to Carapungo, and purchase of new trolleybuses and e-buses
- Ecovía BRT transition from diesel buses to e-buses

Following are the basic aspects this document considers:

- Modeling of public transport services
- Proposal of services in the BRT corridor network for both subprojects - Ecovía and Trolleybus,
- Demand estimates and number / types of buses that will be used as feed services to BRT corridors,
- Calculation of the number of bus.km for the financial model

2.1.1. BASELINE INFORMATION

The baseline information for the analysis of the trunk services and feeder routes of the city's BRT system includes the following databases:

- Transportation model from the study Updating the Demand Model for Quito's Metropolitan District, July 2018.
- Daily records of passenger in the stations of the Trolleybus and Ecovía corridors between 2016 and 2019
- Current operational scheduling of BRT services
- Preliminary draft and final design of the Labrador - Carapungo Corridor, April 2015.

The scenario considers the operation of Metro Line 1 from Quitumbe to Labrador and the future northern extension of the Trolleybus corridor from Labrador to the new Carapungo

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Terminal. The extension has nearly 9 additional kms of exclusive trunk corridor, as illustrated in the following figure.

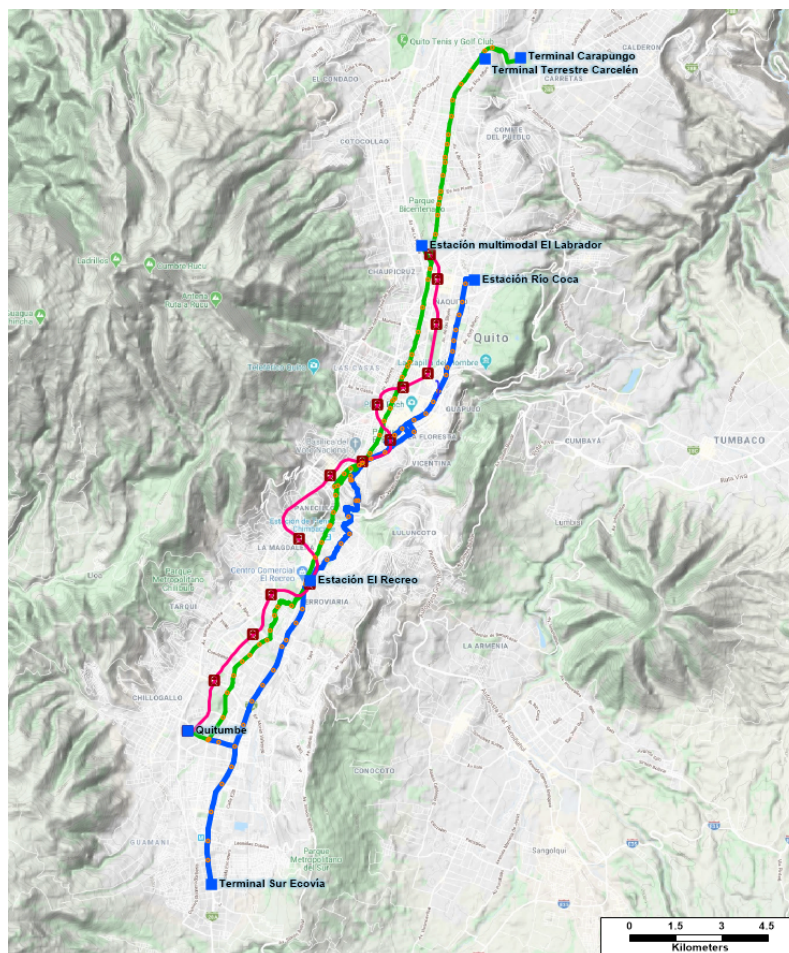


Figure 3: BRT, Trolleybus, Ecovía and Metro Line 1 public transport corridors

Source: Logit

The modeled scenarios consider the following configurations:

- The reference scenario considers the following fares:
 - Metro fare: USD 0.50
 - BRT basic fare: USD 0.35
 - Integration fare with Metro: USD 0.67
- An alternative scenario was developed, without fare integration:
 - Metro fare: USD 0.50
 - BRT basic fare: USD 0.25
 - Without Metro integration fare: USD 0.75
- The scenarios do not consider the reorganization of the conventional routes, only the feeders and trunk services of the Trolleybus and Ecovía corridors.
- No specific feeding system is considered for the Metro.

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- Articulated capacity of 140 passengers.

2.1.2. OPERATIONAL STRATEGY

The starting point is the identification of the demand structure for trips using the transport system in its current state and with the new infrastructure (Metro and BRT's northern extension). Working with the origin/destination matrices, it is possible to identify the zones where public transportation trips are concentrated, and the demand structure.

A great concentration of trips can be observed in the vicinity of the future Carapungo Terminal, in the central region, and especially in the areas around the Ejido and Universities stations, as illustrated in the following figure.

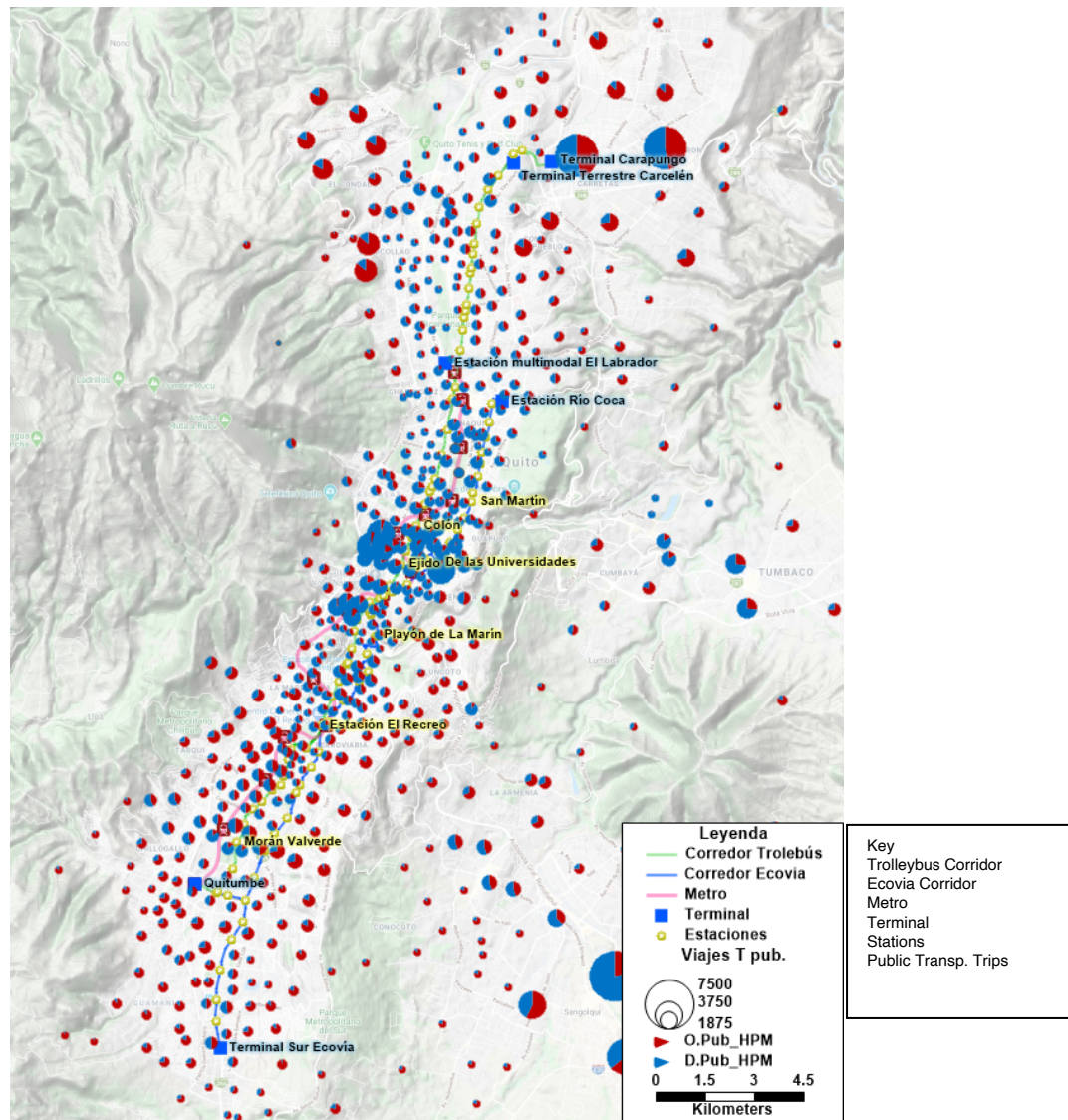


Figure 4: Origin/destination of public transport trips, morning rush hour

Source: Demand model databases, Logit

Although the Metro's areas of influence overlap with those of the Trolleybus corridor, it is possible to propose a modal articulation strategy based on the following principles:

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- The Metro is the backbone of the transport system and mostly provides the mobility function for medium and long-distance trips.
- The Trolleybus corridor provides the accessibility function, since it is mainly used for short and medium-distance trips due to its greater capillarity and station coverage, complementing the Metro coverage.
- The northern extension of the Trolleybus corridor to the Carapungo Terminal offers a great opportunity to establish a feeding scheme for both the Metro and other trunk services in El Labrador multimodal terminal.

The following figures show the areas covered by the Metro and the BRT stations (Trolleybus and Ecovía) and the proposed strategic operational articulation of these modes. The yellow lines show the strategic connections that allow the capillary distribution of short-distance trips, while the red lines show the strategic medium-distance connections of both the Trolleybus and Ecovía corridors.

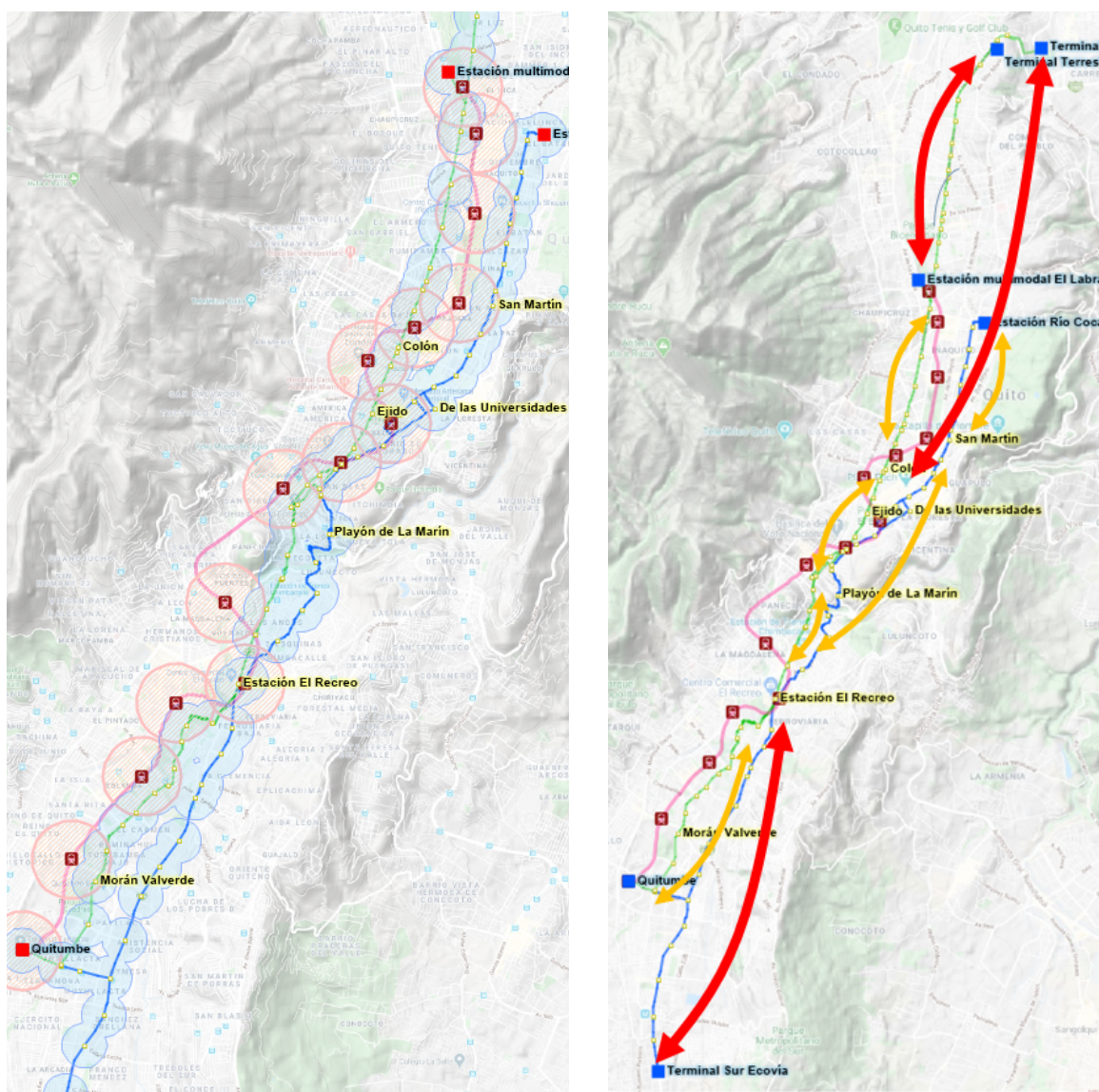


Figure 3 : Areas of influence of Metro and BRT stations and strategic connections of the BRT system

Source: Logit

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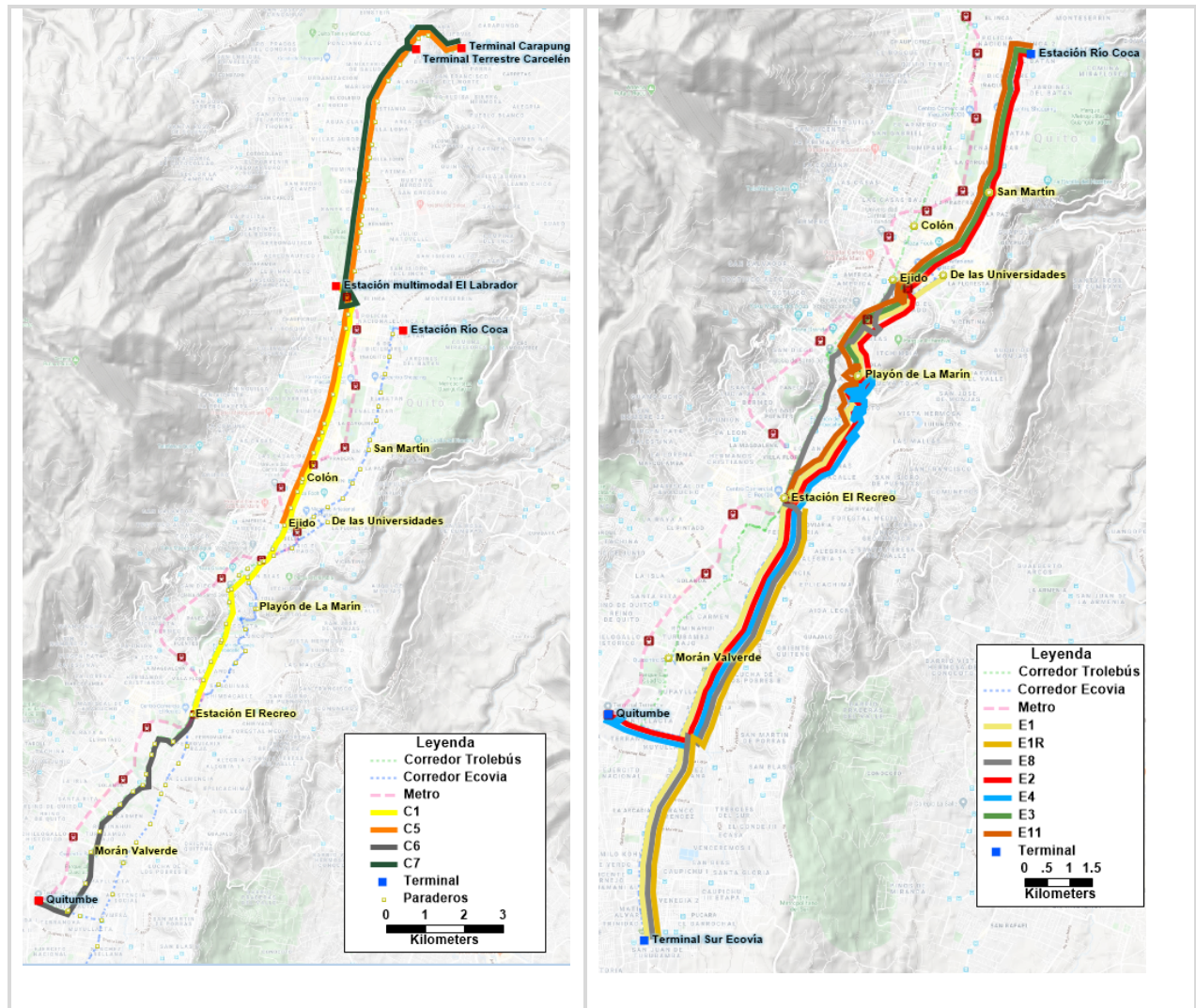
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Based on this operational strategy, various trunk service configurations were assessed and the following service configuration was reached.

2.2. TRUNK SERVICE PROPOSAL

The recommended service configuration streamlines the offer in each of the main sections of the Trolleybus and Ecovía corridors. The proposal includes 4 structural services for the Trolleybus corridor and 7 services for Ecovía, as illustrated in the following figure.



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Trolleybus corridor			Ecovia corridor		
Line	Round trip distance (km)	Round trip duration (min)	Service	Round trip distance (km)	Round trip duration (min)
C1: Terminal El Labrador - El Recreo	24.4	104	E1: South Terminal - Universities	36.4	135
C6: Terminal Quitumbe - El Recreo	14.9	58	E1R: South Terminal - Recreo	21.3	79
C5: Terminal Carapungo - Ejido	29.0	106	E8: South Terminal - Ejido	32.5	119
C7: Terminal Carapungo - El Labrador	19.5	73	E2: Quitumbe – Río Coca	41.4	146
			E4: Quitumbe - El Playón	23	85
			E3: Río Coca - El Playón	18.4	76
			E11: - El Recreo	26.1	97

Figure 4 : Proposed services for the Trolleybus and Ecovía corridors

Source: Logit

Ecovía's E1R and E8 services only operate during peak hours. Quitumbe Terminal will be served by services E2 and E4. The E2 service operates during peak hours, while E4 during off-peak hours. This same scheme is proposed for Río Coca terminal. E3 services operate during off-peak hours and E11 during morning and afternoon peak hours.

2.3. PASSENGER DEMAND

The main results of the modeling process of the proposed route configuration are detailed below.

2.3.1. SCENARIOS

The following scenarios were reviewed:

Table 1: Scenarios

Configuration	Esc. A	Esc. B	Esc. C
Labrador-Carapungo Extension	Yes	Yes	No
Metro Fare	USD 0.50	USD 0.50	USD 0.50
BRT Base Fare	USD 0.35	USD 0.25	USD 0.35
Fare Integration with Metro	USD 0.67	USD 0.75	USD 0.67

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Configuration	Esc. A	Esc. B	Esc. C
Articulated Bus Capacity (pax)	140	140	140
Capacity: Bi-articulated Bus (pax)	220	220	220

2.3.2. TRIP DISTRIBUTION

The first result corresponds to the distribution of stages or boarding for each mode (BRT, Metro, feeders). In the reference scenario (A), Metro boarding account for 5% of the total, with close to 160,000 trips per day. The Trolleybus and Ecovía corridors, together with their corresponding feeding systems, transport around 20% of daily passengers, as shown in the following table and figure:

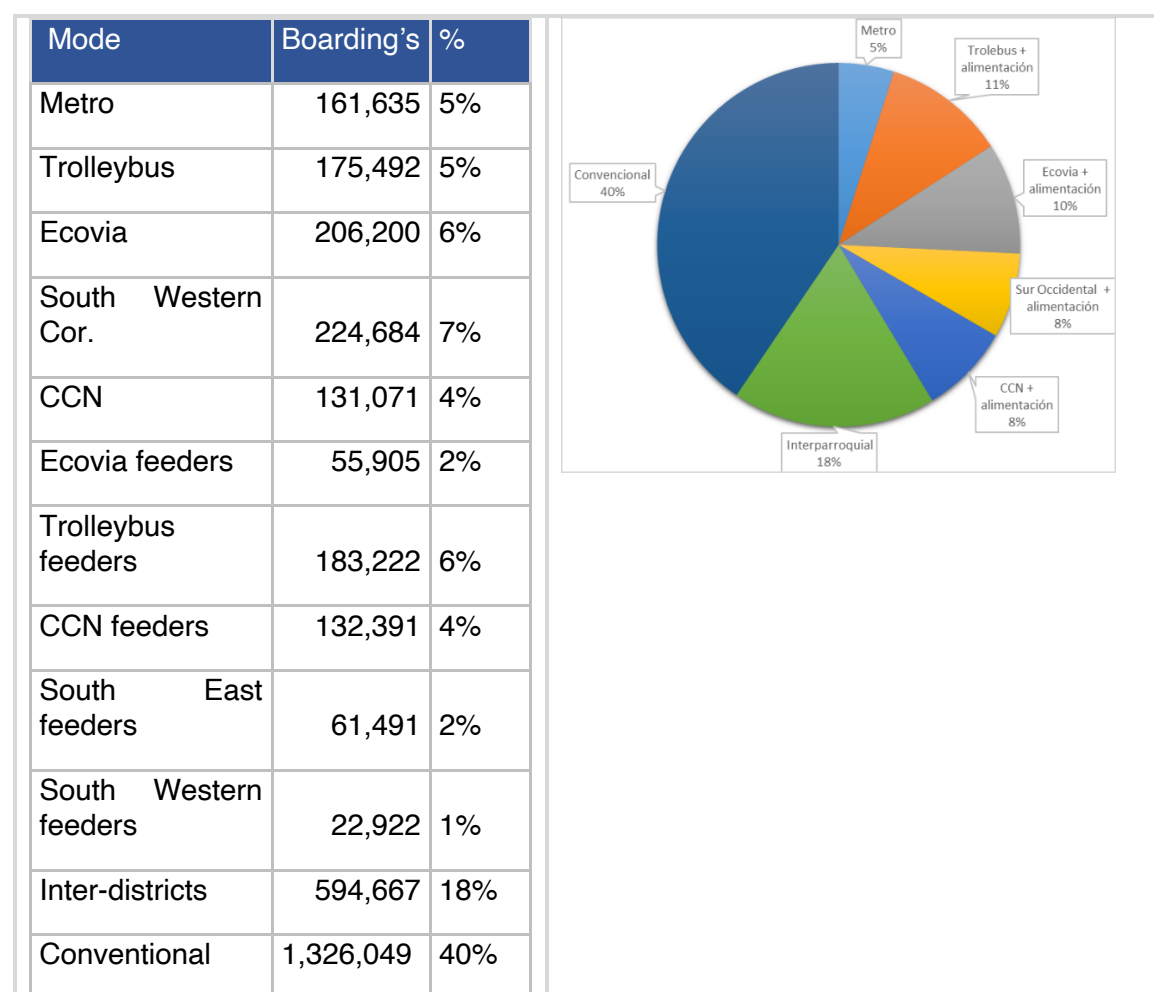


Figure 5: Daily boarding by mode of transport (scenario A) - Base rate USD0.35, Metro 0.50

Note: Boarding's include internal transfer between modes

Source: Logit

Passenger demand as they enter the stations is very fare-sensitive, especially for the metro and trolleybus modes. The fare scheme without integration (Scenario B) stands out as the “pessimistic” scenario for the metro, as demand in this case decreases by more than 30%, compared to the reference scenario (scenario A), as shown in the following table.

Funding partners:

Implementing agencies:

Table 2: Daily passenger demand by mode of transport

Mode	Reference Scenario (A)		Scenario without integration (B)		Scenario without north extension (C)	
	Boarding's	Passengers	Boarding's	Passengers	Boarding's	Passengers
Ecovia	206,200	174,413	231,633	191,777	203,490	172,217
Trolleybus	175,492	156,409	204,854	172,228	150,976	140,068
Metro		161,635		104,731		159,640

Boarding's includes internal transfers

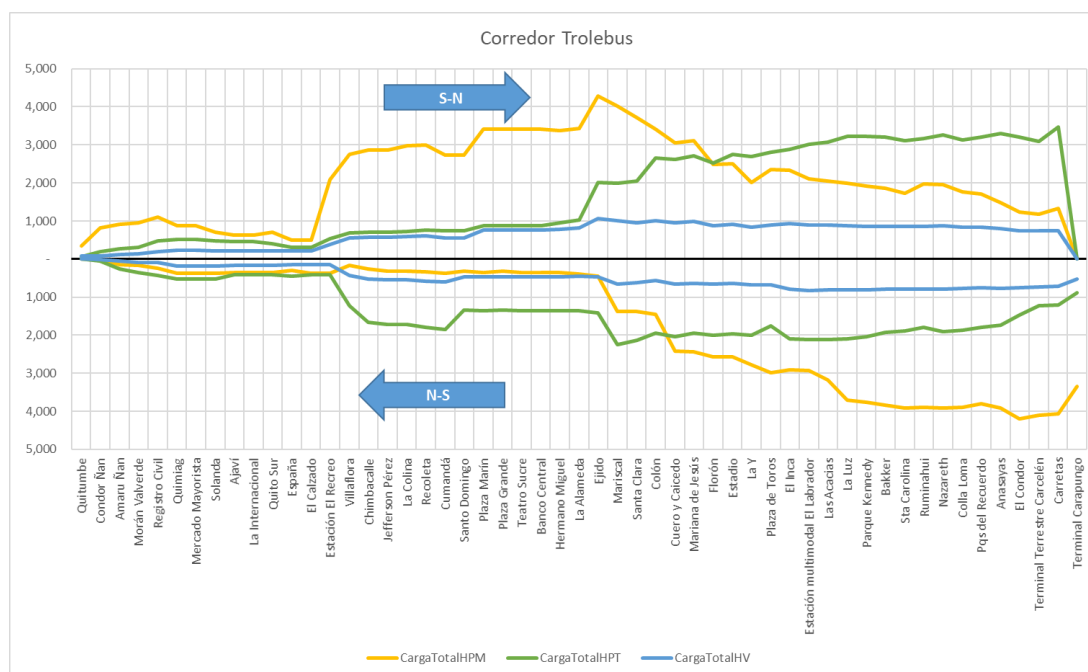
Passengers: entering the stations (paid passengers)

Source: Logit

2.3.3. LOAD PROFILE

In the scenario with integration (Scenario A - base fare 0.35), the expected load profile for the situation including the project shows two sections with loads close to 4,000 pax/h. The first appears around the Ejido station, which is known for a high concentration of activities. The second is located in the northern extension, around the Carcelén Terminal.

In the northern extension of the corridor, peak-hour loads may exceed 4,000 pax/h, which indicates this section has a high demand potential that is comparable, if not greater than that of the central corridor.

**Figure 6: Hourly loading profile - Trolleybus Corridor (Scenario A)**

Source: Logit

Funding partners:



Implementing agencies:



Records at the Ecovía corridor indicate a maximum load at the Playón de la Marín station of close to 8 thousand passengers in the morning peak hour and south-north direction (see figure below).

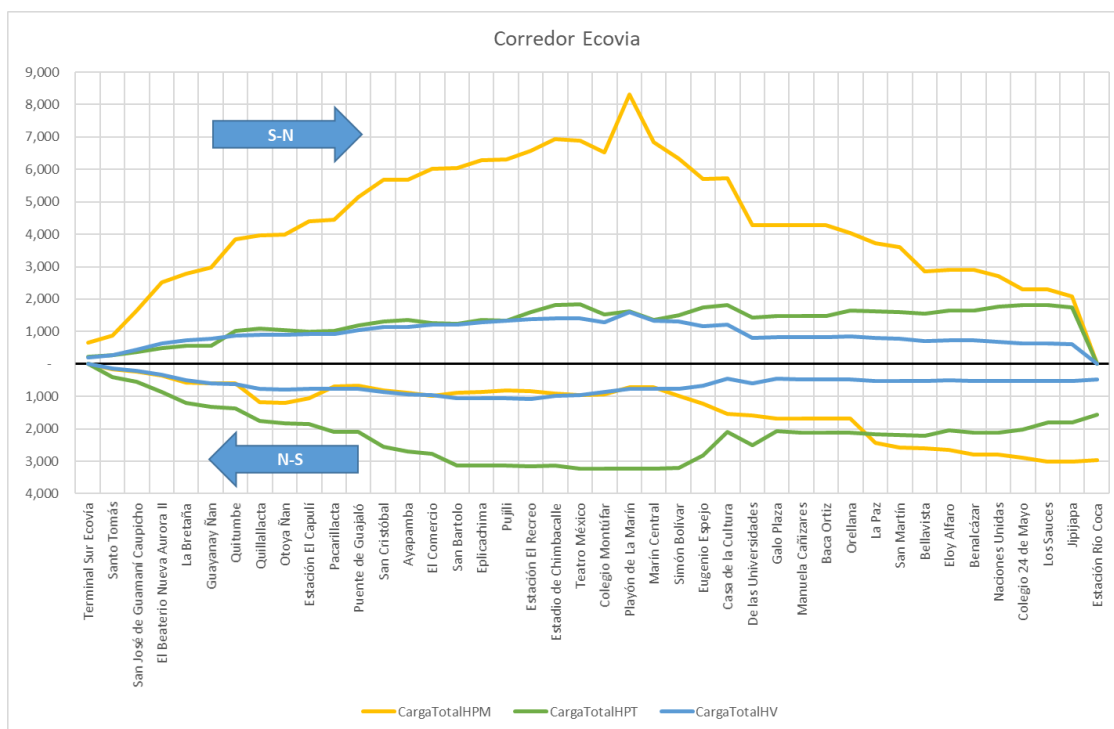


Figure 7 : Hourly load profile - Ecovia Corridor (Scenario A)

Source: Logit

2.3.4. OPERATIONAL INDICATORS

The following tables show the operational fleet (including a 10% reserve) and the passenger-kilometer indicator (ratio of kilometers traveled over operational fleet).

Table 3: Operational indicators considering current demand

Vehicle Scenario A	Fleet			IPK		
	Fleet Subtotal	Trolleybus	Ecovia	Fleet Subtotal	Trolleybus	Ecovia
Trolleybus	69	69	0	7.5	7.5	0.0
Articulated	150	20	130	8.7	8.1	9.2
Bi-articulated	80	40	40	7.7	8.1	7.6
Total	299	129	170	8.0	7.8	8.2

With North Extension. Metro fee USD 0.50; BRT base fare USD 0.35; Integration fare with Metro, USD 0.67, Capacity: 140 for articulated buses

Funding partners:



Implementing agencies:



Vehicle Scenario B	Fleet			IPK		
	Fleet Subtotal	Trolleybus	Ecovia	Fleet Subtotal	Trolleybus	Ecovia
Trolleybus	70	70	0	9.6	9.6	
Articulated	187	24	163	8.7	8.1	9.2
Bi-articulated	80	40	40	7.7	8.1	7.6
Total	337	134	203	8.5	8.9	8.2

With North Extension. Metro fee USD 0.50; BRT base fare, USD 0.25; without Metro Integration (USD 0.75), Capacity: 140 for articulated buses

Vehicle Scenario C	Fleet			IPK		
	Fleet Subtotal	Trolleybus	Ecovia	Fleet Subtotal	Trolleybus	Ecovia
Trolleybus	69	69	0	8.0	8.0	0.0
Articulated	124	0	124	7.9	6.0	9.3
Bi-articulated	80	41	39	7.2	6.0	7.4
Total	273	110	163	7.6	7.1	8.1

Without North Extension. Metro fee USD 0.50; BRT base fare, USD 0.35; Integration fee with Metro, USD 0.67, Capacity: 140 for articulated buses

Source: Logit

2.3.5. OPERATIONAL SCHEDULING

The hourly profile of the proposed services to offer follows the hourly distribution of the demand observed in visual occupancy surveys conducted for the Preliminary Project for the Labrador - Carapungo Corridor (2015). This profile is compatible with the BRT system's current hourly scheduling.

The table below includes the proposed operational schedule for a working day in the reference scenario (A). A capacity of 140 and 220 was used for articulated and bi-articulated buses, respectively.

Funding partners:


**CHILDREN'S
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Implementing agencies:



Table 4: Working Day Operational Schedule - Scenario A

Service	Fleet Type	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
C1: Terminal El Labrador - El Recreo	Trolleybus	22	29	29	24	21	19	19	21	19	18	22	24	27	27	19	15	12	9	5
C6: Terminal Quitumbe - El Recreo	Trolleybus	9	12	12	10	9	8	8	9	8	8	9	10	11	11	8	6	5	4	2
C5: Terminal Carapungo - Ejido	Bi-articulated	15	20	20	16	14	13	13	14	13	12	15	16	18	18	13	10	8	6	3
C7: Terminal Carapungo - El Labrador	Articulate	10	13	13	11	10	9	9	10	9	8	10	11	12	12	9	7	6	4	2
E1: South Terminal - Universities	Articulated	16	21	21	17	15	14	14	15	14	13	16	17	19	19	14	11	9	7	4
E1R: South Terminal - Recreo	Articulated	9	11	11	9															
E8: South Terminal - Ejido	Articulated	9	11	11	9							9	9	10	10					
E2: Terminal Quitumbe - Río Coca	Bi-articulated	11	14	14	12							11	12	13	13					
E4: Terminal Quitumbe - El Playón	Articulated					7	7	7	7	7	6	8	8	9	9	7	5	4	3	2

Funding partners:


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für Internationale
Zusammenarbeit (GIZ) GmbH


Implementing agencies:

Service	Fleet Type	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
E3: Terminal Río Coca-El Playón	Articulated					16	16	16	17	16	16	16								
E11: Terminal Río Coca - El Recreo	Articulated	14	18	18	15							14	15	17	17					

Reference Scenario (A1): With extension Labrador - Carapungo; Metro fee USD 0.50; BRT base fare, USD 0.35; Metro Integration fee, USD 0.67; Articulated capacity: 140; Bi-articulated capacity: 220.

Source: Logit

Funding partners:



**CHILDREN'S
INVESTMENT FUND
FOUNDATION**

 **UK Government**



giz Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH



Implementing agencies:

2.4. FEEDER ROUTES

To avoid competition with the services of the northern extension of the Trolleybus corridor and to benefit from the presence of the new Carapungo terminal, a reorganization of the corridor's feeding services is proposed.

The following table includes the main operational characteristics of the feeder routes: cycle time, demand, type of vehicle and required fleet.

Funding partners:



Implementing agencies:



Corridor	Line	Terminal / Initial Station	Round trip distance (km)	Round trip duration (min)	Daily Boarding's	Fleet
Ecovia and Sur Oriental	CP-56: Capulí - Caupicho	Capulí	11.0	49	2570	5
Ecovia and Sur Oriental	CP-57: Capulí - La Cocha	Capulí	10.8	48	3260	5
Ecovia and Sur Oriental	MG-16: La Magdalena – Forestal Station	La Magdalena Station	10.7	48	7990	8
Ecovia and Sur Oriental	GI-58: T. Guamaní - La Joya	T. Guamaní	8.9	41	2640	3
Ecovia and Sur Oriental	GI-63: T. Guamaní - San Juan de Turubamba	T. Guamaní	7.2	34	190	3
Ecovia and Sur Oriental	GI-65: T. Guamaní - Venecia	T. Guamaní	4.1	22	30	2
Ecovia and Sur Oriental	GI-66: T. Guamaní - Héroes de Paquisha	T. Guamaní	8.5	39	1610	3
Ecovia and Sur Oriental	GI-67: T. Guamaní - San José de Cutuglagua	T. Guamaní	10.1	46	3170	4
Ecovia and Sur Oriental	IN-70: T. Guamaní - T. Quitumbe	T. Guamaní	12.8	56	11390	19
Ecovia and Sur Oriental	QT-99: T. Quitumbe - Quitus Colonial	T. Quitumbe	11.5	51	2070	4
Ecovia and Sur Oriental	QT-55: T. Quitumbe - Ciudadela El Ejército	T. Quitumbe	8.3	38	2500	3
Ecovia and Sur Oriental	RE-11: T. Recreo - Solanda	T. Recreo	11.0	49	2870	4
Ecovia and Sur Oriental	RE-12: T. Recreo - Chillogallo	T. Recreo	16.9	72	2350	5
Ecovia and Sur Oriental	RE-13: T. Recreo - Oriente Quiteño	T. Recreo	14.5	63	6370	9
Ecovia and Sur Oriental	RE-14: T. Recreo - Lucha de los Pobres	T. Recreo	17.9	77	12560	17
Ecovia and Sur Oriental	RE-15: T. Recreo - Ferroviaria	T. Recreo	8.3	38	2440	4
Ecovia and Sur Oriental	RE-26: T. Recreo - Argelia	T. Recreo	14.8	64	11000	12
Ecovia and Sur Oriental	RC-17: T. Río Coca - Monteserrín	T. Río Coca	5.6	27	450	2
Ecovia and Sur Oriental	RC-18: T. Río Coca - La Luz	T. Río Coca	8.7	40	910	3
Ecovia and Sur Oriental	RC-19: T. Río Coca - Agua Clara	T. Río Coca	15.9	68	8170	11
Ecovia and Sur Oriental	RC-20: T. Río Coca - Comité del Pueblo - La Bot	T. Río Coca	19.8	84	4140	12
Ecovia and Sur Oriental	RC-22: T. Río Coca - San Juan de Cumbayá	T. Río Coca	33.9	141	410	10
Ecovia and Sur Oriental	RC-23: T. Río Coca - Zámiza	T. Río Coca	12.2	54	2080	4
Ecovia and Sur Oriental	RC-24: T. Río Coca - Nayón	T. Río Coca	22.2	94	12520	24
Ecovia and Sur Oriental	RC-25: T. Río Coca - 6 de Julio	T. Río Coca	12.3	54	2370	4

Funding partners:

Implementing agencies:



Corridor	Line	Terminal / Initial Station	Round trip distance (km)	Round trip duration (min)	Daily Boarding's	Fleet
Ecovia and Sur Oriental	RC-28: T. Río Coca - Simón Bolívar - Carapungo	T. Río Coca	24.0	101	20400	24
Ecovia and Sur Oriental	RC-29: T. Río Coca - Llano Chico	T. Río Coca	17.7	76	3040	6
Trolleybus	PI-51: Atucucho - Comité del Pueblo	Atucucho	25.1	106	22040	34
Trolleybus	MV-08: Morán Valverde - Martha Bucaram	Morán Valverde	12.5	55	1230	4
Trolleybus	MV-45: Morán Valverde - San Francisco de Huarca	Morán Valverde	10.6	47	5060	11
Trolleybus	NO-03: T. Norte - Rumiñahui	T. Norte	13.6	60	2890	4
Trolleybus	NO-04: T. Norte - Kennedy - Edeen	T. Norte	5.4	27	650	2
Trolleybus	NO-05: T. Norte - Comité del Pueblo	T. Norte	13.0	57	12430	11
Trolleybus	NO-06: T. Norte - Laureles	T. Norte	6.4	30	990	3
Trolleybus	NO-10: T. Norte - Cotocollao	T. Norte	14.7	64	2640	5
Trolleybus	AL01: Terminal Carapungo - San Juan de Calderón	Terminal Carapungo	16.0	69	3170	6
Trolleybus	AL02: Terminal Carapungo - Alborada De La Paz	Terminal Carapungo	21.3	90	14250	17
Trolleybus	AL03: Terminal Carapungo - Divino Niño - Pradera	Terminal Carapungo	25.7	109	14070	17
Trolleybus	AL04: Terminal Carapungo - Bicentenario - Ecuador	Terminal Carapungo	14.7	64	8870	13
Trolleybus	AL05: Terminal Carapungo - UCE	Terminal Carapungo	7.2	34	650	3
Trolleybus	AL06: Terminal Carapungo - Luz y Vida	Terminal Carapungo	17.2	74	2470	7
Trolleybus	AL07: Terminal Carapungo - La Tola - San José	Terminal Carapungo	17.6	75	10870	14
Trolleybus	AL08: Terminal Carapungo - Collas	Terminal Carapungo	14.9	65	10420	9
Trolleybus	AL09: Terminal Carapungo - Cisne - Zabala	Terminal Carapungo	17.1	75	11590	10
Trolleybus	AL10: Terminal Carcelén - Carcelén Bajo	Terminal Carcelén	10.0	45	9320	8
Trolleybus	AL11: Terminal Carapungo - Llano Grande	Terminal Carapungo	18.0	78	7830	11
Trolleybus	AL12: Terminal Carapungo - La Cruz - Zabala	Terminal Carapungo	24.0	101	4300	7
Trolleybus	INT01: Terminal Carapungo - Terminal Ofelia	Terminal Carapungo	14.3	62	1420	5
Trolleybus	INT02: Terminal Carapungo - Río Coca	Terminal Carapungo	20.4	87	14630	26

Source: Logit

Funding partners:



Implementing agencies:



3. TECHNICAL FEASIBILITY

The section on the project's 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 is even more critical as there has been no fare increase over the last 13 years, while inflation has accumulated to 56% over the same period.

It is understandable that decisions to adjust fares are difficult, but the results depend on these decisions.

In the absence of decision, the study has made the recommendations that consultants believe are the most appropriate. Technical feasibility is also part of these limitations.

3.1. THE CITY OF QUITO

The city of Quito is the political-administrative capital of Ecuador. Currently, the Metropolitan District of Quito (DMQ) is estimated to be the largest canton in the country, with more than 2.7 million inhabitants in 2020. In 2010, Ecuador's Population and Housing Census reported 2.3 million inhabitants in DMQ, of which 72.3% live in urban districts (City of Quito) and the remaining 27.7% live in rural areas of the canton.

3.1.1. TOPOGRAPHIC AND WEATHER CONDITIONS

Quito is located on a plateau at 2,850 meters above sea level, surrounded by the mountains of the Western Cordillera of the Andes, in a region called Sierra de Ecuador. The city has a predominantly longitudinal topography, extending 5 to 8 km from east to west, and 20 km north to south. The topography favors public transportation based on trunk and feeder lines, such as the ones currently operating in the city.

The rugged topography includes streets with slopes of up to 20%, requiring more powerful public transport vehicles.

Due to its altitude and proximity to the equator line, Quito's climate is classified as Cfb, i.e. mountainous but humid, with mild temperatures and little variation year round. There are only two seasons: dry season, with higher temperatures, from June to September, and rainy season for the rest of the year. However, Quito's rainfall is high even during dry season,.

A mild climate is helpful for electromobility purposes, since batteries usually do not work as well in very cold or hot temperatures. Also, balmy weather dispenses with air conditioning or heating, systems that can considerably drain batteries.

3.1.2. THE TRANSPORTATION SYSTEM

The DMQ public transport system is structured as exclusive BRT corridors from north to south, feeder lines to the BRT corridors, running east to west, and finally conventional lines with specific routes that include urban services, as well as inter-district and intra-district services.

Funding partners:

Implementing agencies:



Additionally, construction is nearly finished on the first Metro line which runs parallel to the BRT corridors.

Metrobus-Q (Metro-Q) is the feeder-trunk system that connects the exclusive BRT lines (trunk system) and the feeder lines. Metrobus-Q is made up of 3 “corridors”: Trolleybus, Oriental (also known as Ecovía), and Occidental. These corridors have several organized routes operated with articulated and bi-articulated vehicles on more than 71 kms of segregated roads.

3.1.3. DEMAND CHARACTERISTICS

Passenger demand is highly sensitive to the fare scheme. 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. The study considered three horizon years for fleet change: 2022, 2027 and 2033. The type of bus considered is the 18-m articulated bus, with a capacity of 140 passengers. The resulting demand for these three horizons are shown in Table 5 **Error! Reference source not found.**

Table 5: Demand Results

Demand (pax/day)	Trolebus	Ecovia	Total
2020 (demand before the pandemic)	192,767	183,371	376,138
2022 (with metro operación)	150,692	188,249	338,942
2027 (with the extension Labrador-Carapungo)	174,539	190,532	365,071
2033 with only electric buses	174,539	190,532	365,071

3.2. THE PURPOSE OF ELECTROMOBILITY PROJECTS

3.2.1. THE CENTRAL CORRIDOR

The Trolleybus Corridor was inaugurated in 1995, initially with 39 stops, and later extended south as far as the Quitumbe Station. It currently has 3 terminals, 8 temporary stops, 2 transfer stations and 44 stops in operation. On average, it transports 281,000 passengers a day. The corridor has an extension of 22.5 km between the Quitumbe terminals to the south and El Labrador, to the north.

The implementation of the trolleybus corridor in 1995 already reflected Quito's concern with pollution, but the initiative did not prosper in the other corridors due to the investment the system required.

The system adopted all features of high-quality BRT systems, including middle stations that require buses operate with doors on both sides.

Funding partners:



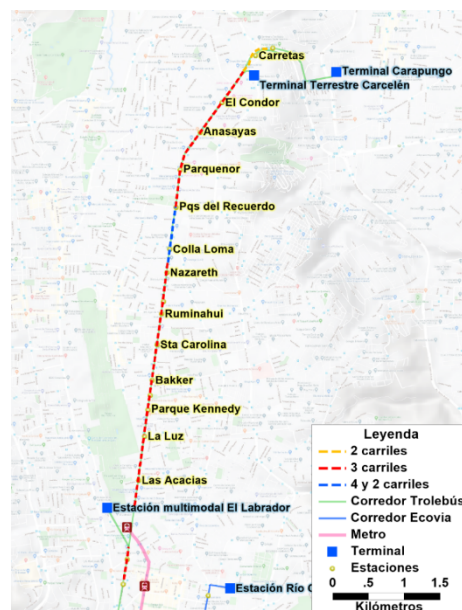
Implementing agencies:



Table 6: Trolleybus Corridor

Corredor Trolebus		
Inauguración		1995
Circuitos		5
Longitud (km)		22,5
Estaciones/Paraderos		39
Estaciones de Transferencia		4
Distancia entre estaciones (m)		400
Flota Troncal	Trolebús	49
	Biarticulados	55
	MB0500	8
Demanda diaria (mil)		281

Source: Passenger Transport Company, DMQ, 2017



3.2.2. THE LABRADOR-CARAPUNGO EXTENSION

The northern extension to the Carapungo terminal has a length of 8.7 km, and 13 stations are planned for it (including the Carapungo Terminal). This new section of the corridor will not have catenary coverage. The figure below shows the layout and location of Northern Extension stations.

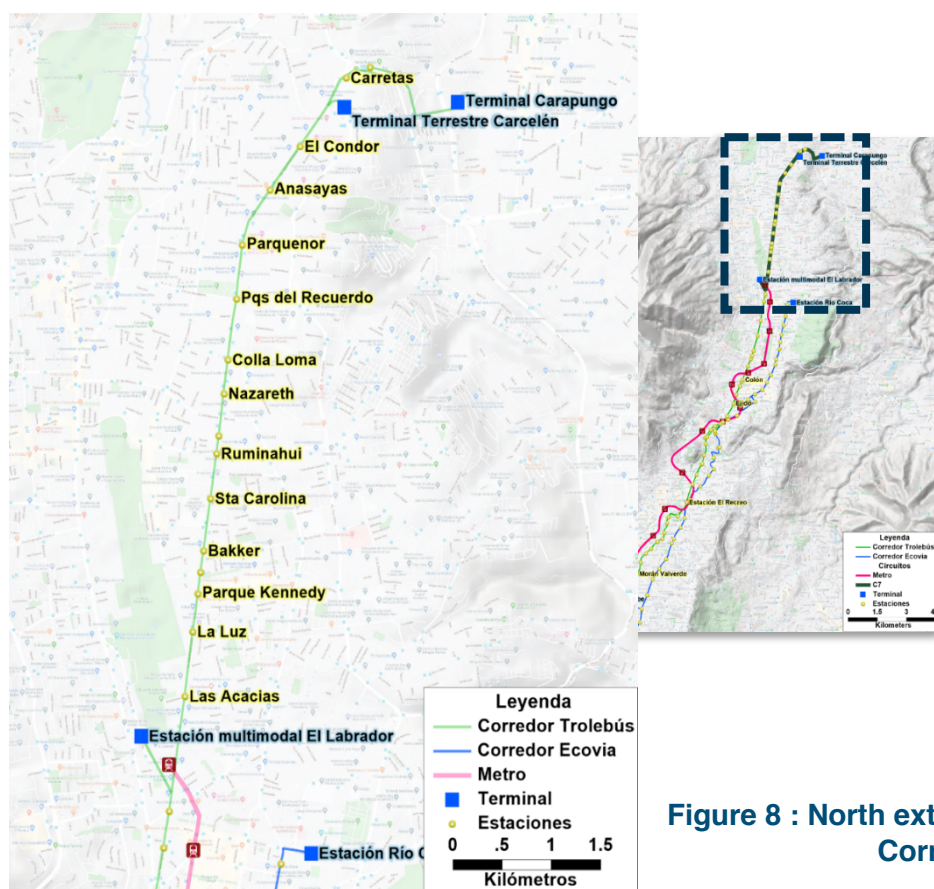


Figure 8 : North extension - Trolleybus Corridor

Funding partners:



Implementing agencies:



The Northern Extension has one exclusive lane per direction for the circulation of the trunk services of the Trolleybus corridor. For mixed traffic, the number of lanes is 2 and 3 per direction, depending on the section, as shown in the following figure.

The stations will be offset and will have a passing lane. They are all single-module stations.

Figure 9: Number of lanes available for general traffic per section

Source: Logit

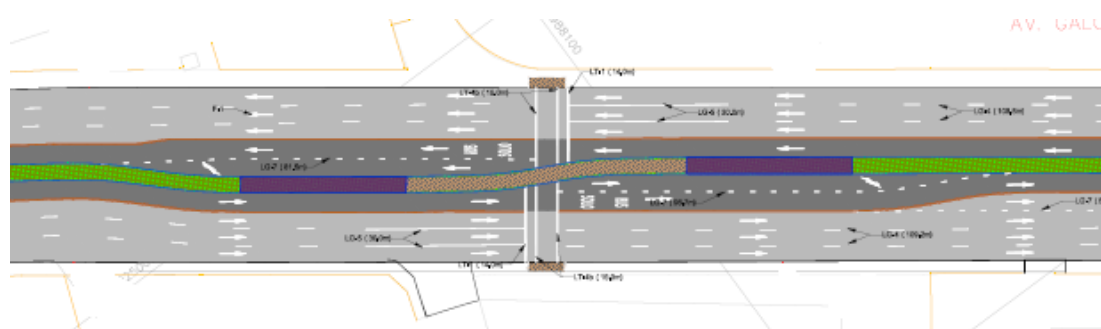


Figure 10: Location of the stations in the section between Calle De Los Eucaliptos and Av. Eloy Alfaro

Source: Logit

3.2.3. THE ECOVÍA CORRIDOR

Ecovía, which was inaugurated in 2002, has 38 stops, 2 transfer stations, and transports an average of 229,000 passengers a day.

Table 7: Ecovia Corridor

Oriental Corridor / Ecovía	
Inauguration	2002
Routes	7
Length (km)	20.9
Stations/Stops	38
Transfer Stations	2

Funding partners:

Implementing agencies:

Oriental Corridor / Ecovía		
Distance bet. stations (m)		400
Trunk Fleet	Bi-articulated	20
	MB0500	32
	Volvo B10M	37
	Volvo B12M	80
Daily Demand (1,000)		229

Source: Passenger Transport Company, DMQ, 2017

3.3. SCENARIOS INCLUDING METRO'S OPERATION

The scenarios that include the Metro's operation vary depending on the fare policy and the restructuring of the bus network. Several scenarios were evaluated, but no decision has yet been made on which scenario to recommend.

3.3.1. THE SUBWAY DILEMMA

Feasibility studies are usually distorted to make the investment viable and bankable. In general, the investment is underestimated, while benefits are overestimated.

Some modeling assumptions are: reorganization of the network so people are practically forced to use the metro; fare increase; and handling speeds and capacity restrictions within the model. Since models are almost never questioned, and the bank's interest is for the project to be viable, all analysis is directed toward financing construction.

To make the metro faster, stations have been spaced at an average distance of 1,400 m. If the model does not consider the distance increase in accessing the metro and dividing the city into smaller size zones, the estimated demand for the metro becomes inflated. Invalid assumptions do not appear in modeling, but they do in real life.

The problem is that, if demand and fares are not defined, there is more uncertainty regarding revenues. If revenues are low, larger subsidies become necessary which may seriously compromise the city's budgetary situation.

Strong action to increase demand in the Metro by decreasing supply in parallel BRT corridors may lead to an increase of illegal transport due to the lack of capacity of the system. The difficulties introduced for people to make their trips, such as an excessive number of transfers, can lead users to look for other alternatives.

The issue is even more complicated now that international lenders put pressure for the private operation of the metro they financed. This means additional payment for private service, without the risk of demand or fare increases.

This requires a system reorganization study and a decision on fare policies based on modeling that makes valid assumptions, where the results are shown in a financial model for the entire system, including private operators. This study must include a risk assessment of each alternative solution.

Funding partners:

Implementing agencies:

The problem is complex and probably cannot be solved without a joint effort by the Mayor's Office, the Mobility Commission, and the Metropolitan Council. This also requires support of a highly qualified external consultant.

3.3.2. FINANCIAL IMPACT OF THE PANDEMIC

The financial impact of the pandemic on municipal accounts and the operating companies was very intense.

On the administration side, revenues fell significantly, but commitments were maintained. As for the operators, people distancing requirements reduced vehicle occupancy, but operating costs did not decline accordingly.

For private operators, this cost is almost totally absorbed by the drivers, who own the buses. State-owned or controlled companies, which already had large deficits before, the situation became worse and created a scenario of more uncertainty as to how this financial gap could be closed. This uncertainty is then transferred to the company's suppliers and impacts the city's and the country's economies.

This also requires a medium-term solution, including a well-defined strategy for how to get out of the situation once the pandemic is over. So far, none of these decisions have been made by the city administration.

3.3.3. SCENARIO ADOPTED BY THE ELECTROMOBILITY STUDY

The scenario that includes the project considers the operation of Metro Line 1 between the Quitumbe Terminal and Labrador and the northern extension of the Trolleybus corridor to the new Carapungo Terminal, which includes about 9 additional kms of exclusive trunk corridor, as shown in the following figure.

Funding partners:



Implementing agencies:

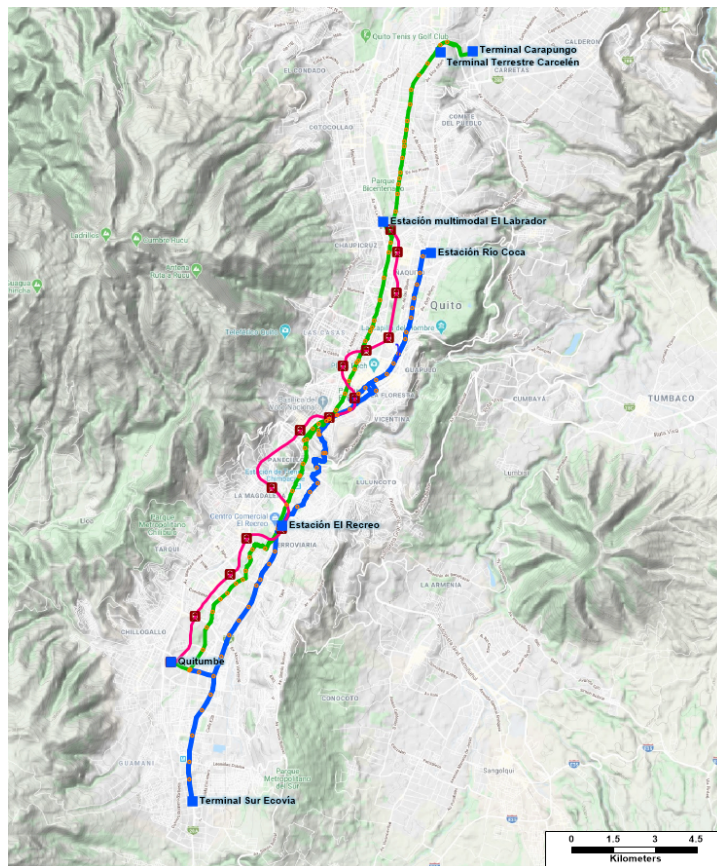


Figure 11 : Transportation corridors of the scenario that includes the project

Source: Logit

The modeled scenarios include the following configurations:

- The reference scenario considers a tariff scheme with the following values:
 - Metro fare USD 0.50
 - BRT base fare, USD 0.35
 - Integration fare with Metro, USD 0.67
- Scenario with fare increase, but without fare integration:
 - Metro fare USD 0.50
 - BRT base fare, USD 0.25
 - Integrated Trip BRT/ Metro, USD 0.75
- The scenarios do not consider the reorganization of the conventional routes, only the feeders and trunk services at the Trolleybus and Ecovía corridors.
- It does not consider a specific feeder system for the metro.
-

Reorganizing the Trolleybus Corridor routes and the Labrador-Carapungo Extension

This corridor has three structural sections with different levels of demand:

Funding partners:

Implementing agencies:

- Terminal Quitumbe - El Recreo
- El Recreo - Terminal El Labrador
- Terminal El Labrador - Terminal Carapungo

The proposal includes four trunk services:

Table 8: Proposal of structural services for the Trolleybus corridor

Line	Round trip distance (km)	Round trip duration (min)
C1: Terminal El Labrador - El Recreo	24.4	104
C6: Terminal Quitumbe - El Recreo	14.9	58
C5: Terminal Carapungo - Ejido	29.0	106
C7: Terminal Carapungo - El Labrador	19.5	73

Source: Logit

The following figure shows the layout of these routes.

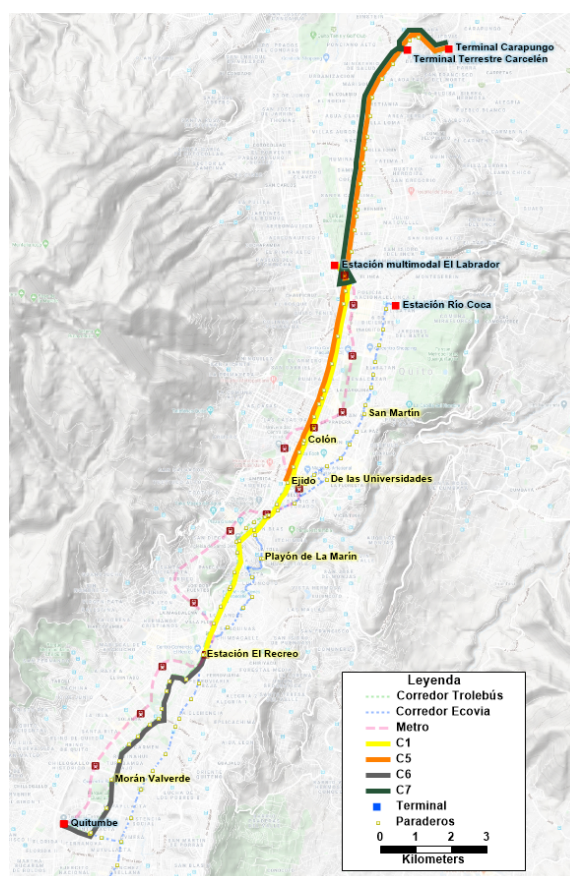


Figure 8 : Proposed services at the Trolleybus corridor

Source: Logit

Funding partners:



Implementing agencies:



Reorganizing the Ecovía Corridor routes

The proposal includes seven services:

Table 9: Proposal of structural services for the Ecovia corridor

Service	Round trip distance (km)	Round trip duration (min)
E1: South Terminal - Universities	36.4	135
E1R: South Terminal - Recreo	21.3	79
E8: South Terminal - Ejido	32.5	119
E2: Quitumbe-Rio Coca	41.4	146
E4: Quitumbe- El Playón	23.0	85
E3: Rio Coca-El Playón	18.4	76
E11: Rio Coca - El Recreo	26.1	97

Source: Logit

Three services, E1, E1R and E8 use South Terminal. E1R and E8 services only operate during peak hours.

Quitumbe Terminal will have services E2 and E4. The E2 service operates during peak hours, while E4 during off-peak hours.

This same scheme is proposed for the Río Coca terminal. The E3 service operates during off-peak hours and E11 during morning and afternoon peak hours.

The following figure shows the layout of the services.

Funding partners:



Implementing agencies:



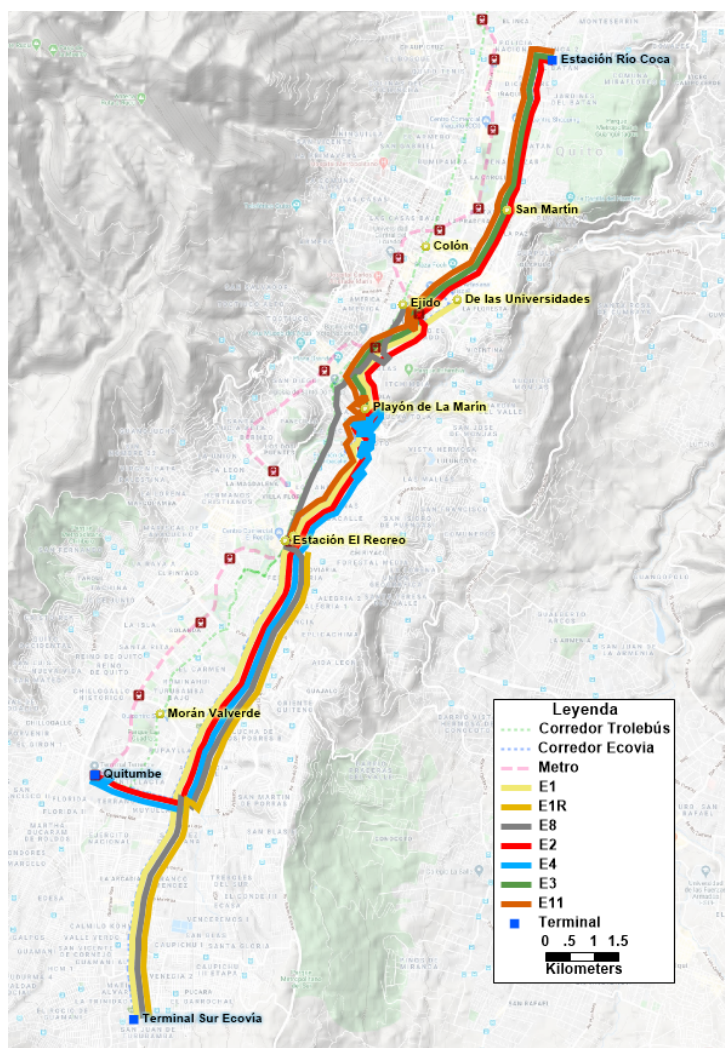


Figure 9: Proposed services - Ecovia corridor

Source: Logit

3.3.4. ESTIMATED DEMAND

Passenger demand when entering the stations is highly sensitive to the fare scheme, especially for the metro and trolleybus modes. The fare level without integration (Scenario B) stands out as the “pessimistic” scenario for the metro. It results in a decrease in demand greater than 30%, compared to the reference scenario (scenario A), as shown in the following table.

Table 10: Daily passenger demand by transport mode

Corridor	Reference Scenario (A)		Scenario w/out integr. (B)		Scenario w/out north extension (C)	
	Boarding's	Passengers	Boarding's	Passengers	Boarding's	Passengers

Funding partners:



Implementing agencies:



Ecovía	206,200	174,413	231,633	191,777	203,490	172,217
Trolleybus	175,492	156,409	204,854	172,228	150,976	140,068
Metro		161,635		104,731		159,640

Boarding's: Include internal transfers

Passengers: entering the stations (paid passengers)

Source: Logit

3.4. UMV INTEGRATION WITHIN THE CORRIDORS UNDER STUDY

We understand urban mobility vehicles (UMV) as light individual vehicles, including electric vehicles, which are used mainly over short distances. These vehicles are part of a micromobility system and, as technological tools, they contribute to more sustainable mobility. The following are considered UMTs: segways, scooters, unicycles, hoverboards and bicycles (electric or not) as illustrated in the following image:



Segway



Electric Scooter



Electric unicycle



Hoverboard



Electric Bike

Bicycle

Funding partners:



Implementing agencies:



Figure 10:. Types of UMV
Table 11: Features UMVs

VMU	Wheels	Electric?	Portable	Shared system?	Well with grades?	Price (USD)
Bicycle	2	No	No	Yes	Physical effort required	\$100 to \$200
e-bicycle	2	Yes	No	Yes	Yes	\$1000 to \$1500
Scooter	2	Yes	No	Yes	Up to 20°	\$350 to \$700
Segway	2	Yes	No	No	Up to 30°	\$2000 to \$7000
Monocycle	1	Yes	Yes	No	Up to 15°	\$1200 to \$2000
Hoverboard	2	Yes	Yes	No	Up to 18°	\$350 to \$700

3.4.1. THE QUITO EXPERIENCE

Hop Scooter

Currently, there are only two types of UMVs available for sharing in Quito: By Hop scooters and BiciQuito bicycles.

Scooters

Scooters are operated by Hop scooter in a restricted banking area, and has no integration or specific connection with the public transport system. The Trolleybus and Ecovía corridors run along the perimeter of their circulation area, but there is no integration between the systems. To use the scooters, you need to download an app that pay two separate fees, one for unlocking the scooter and other per minute of use. The recommendation in the app is to use the 75 scooters on bike lanes, when possible.

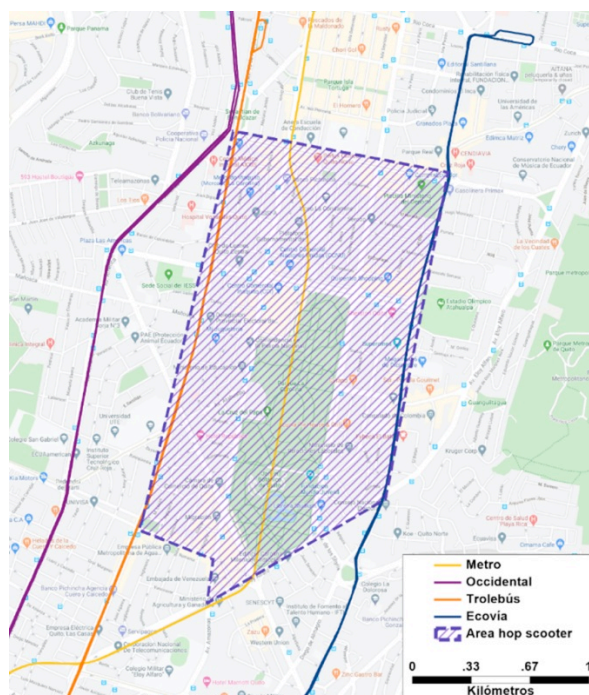


Figure 11: Hopscooter Area of Operation

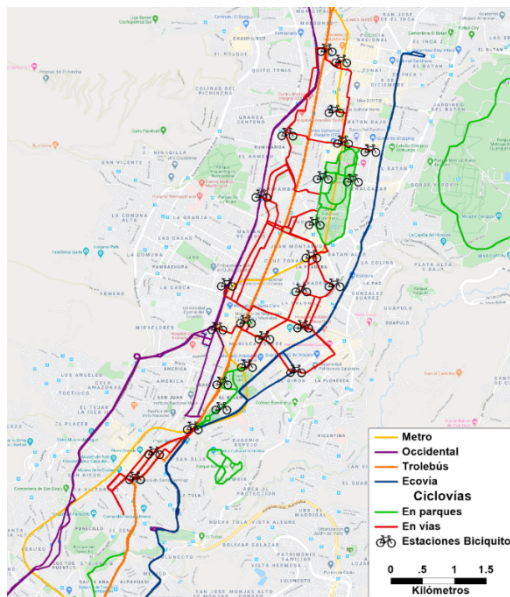
Funding partners:



Implementing agencies:



BiciQuito



BiciQuito exists since 2012 as a free bicycle sharing system. Currently, it has 25 stations and 658 bikes, with more than 100 electric bikes. BiciQuito is operated by AMT and operates Monday to Friday from 7am to 7pm, and Saturday, Sunday and holidays from 8am to 5pm. There is a 45-minute use limit, and a restricted circulation area.

Figure 12 includes a map of the BiciQuito stations, together with routes of possible connection with public transport. 12 of the 25 BiciQuito stations are less than 200 m away from a BRT stop, the most distant station is just over 640 m from a BRT stop.

Figure 12: Location of BiciQuito parking lots

3.4.2. RECOMMENDATIONS

In general, to encourage widespread use of shared UMVs, ITDP makes the following recommendations for the use of electric bicycles and scooters, which could be adopted for all UMVs:

- Consider electric bicycles, scooters and other UMVs as non-motorized vehicles
- Set speed limits for low- and medium-speed vehicles
- Specify the infrastructure where electric vehicles can be used
- Develop safe and inclusive road infrastructure
- Reinforce the safe use of bicycle lanes
- Increase access and exposure to UMVs
- Promote modal change, making the car less convenient
- Design and implement parking and charging spaces
- Offer public roads for safe riding
- Integrate UMVs into plans and strategies for the city
- Collect data for analysis and application

Further, we recommend enacting or updating parking legislation for shared UMVs without stations (dockless). The above listed measures bring security to the population and can attract more shared-UMV companies.

3.5. INFRASTRUCTURE ADEQUACY

The corridors are already operating with stations that are adequate for articulated and bi-articulated 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.

Funding partners:



Implementing agencies:



3.5.1. STATIONS

When preparing bus specifications, currently operating characteristics such as floor height and number of doors must be complied with.

Since opportunity charging 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.

3.5.2. 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 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.

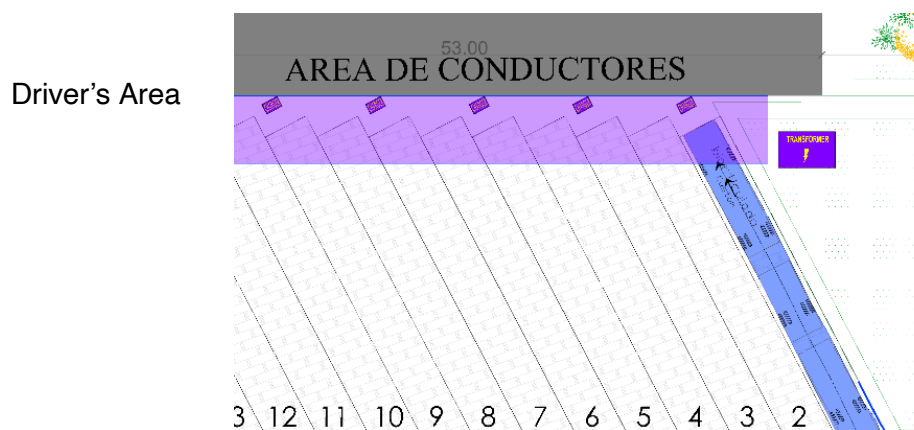
However, this is a decision to be made by the operator after consideration of investment and operating costs.

3.5.3. 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 has to be specifically designed for each bus depot and depends on the number of buses each will hold.



Funding partners:



Implementing agencies:



Figure 13: Bus Depot Design

We recommend designing not for a temporary situation, but take into consideration the electromobility plan and how the depot will have to adapt to each of the project phases.

3.6. TECHNICAL FEASIBILITY

There are no technical infrastructure hurdles or special requirements preventing the implementation of the project.

The Labrador-Carapungo extension has already been designed, but its construction is not expected before 2026.

The resources allocated to operate the metro and pay the loan may affect Quito's budget and future investments, causing more uncertainty about the future.

Considering that it is only a change in vehicle technology, the technical requirements are limited to the problem of recharging the batteries, in addition to tests to certify that the buses can handle the geometrical layout of the roads.

As a conclusion, the project meets all technical feasibility requirements.

Funding partners:



Implementing agencies:

4. E-BUS TECHNOLOGY AND INFRASTRUCTURE

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** (from 2017 to the first quarter of 2020) 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.

In methodological terms, each analysis and diagnostic was based on reviewing the background information and conducting in-depth interviews (see Figure 17).

BACKGROUND REVIEW RECENT CASES TECHNOLOGIES OF INTEREST	IN-DEPTH INTERVIEWS FOCUS THE REVIEW ON LATIN AMERICA AND QUITO	DEVELOP DIAGNOSTIC E-BUS TECHNOLOGY, CHARGERS, BATTERIES	REACH EUROPE, US, LATIN AMERICA
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Figure 14: General methodology for the technology review.

Source: Logit

The study considered reviews of 52 cases of international cities, 22 in-depth interviews, and technical background reviews. The idea was to cover three components of interest to this activity: i) vehicle technologies and their operation, ii) electrical infrastructure used and related requirements, and iii) mechanisms observed for managing batteries in their second life.

4.1. 18-M 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 out as the main cases of escalation (see Figure 18) . 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.

Funding partners:



Implementing agencies:





Figure 15: Cases reviewed: 18-m battery-powered electric buses (BEB) and 18-m trolleybuses. Source: Logit

4.1.1. CASES IN EUROPE

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) .

Funding partners:

Implementing agencies:

- 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 Hool.

4.1.2. US CASE

The review of cases recently implemented in the US 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
- Entire 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.

4.1.3. LATIN AMERICA

The outlook in Latin America for 18-m typology is rather on a pilot scale. 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).

Mexico City, Mexico

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 a “in motion charge” system. Subsequently, the Governor approved the

Funding partners:

Implementing agencies:



purchase 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 particular 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.

Quito, Ecuador

Quito is one of the few cities in Latin America that operates a high-floor electric articulated bus (in addition to Medellín). Its operator is Corredor Central Norte (CCN). This bus was adapted to comply with city requirements; it carries 160 passengers and covers 250-270 kms daily, finishing the work day with 23% of SOC. Actual power consumption varies from 1.41 kWh/km to 1.83 kWh/km; it recharges in 2.5 hours with an AC charger. A technical study reports that operation tests conducted under real-life conditions showed a variable cost per kilometer (operation + maintenance) of 0.543 USD/km for the electric bus vs 0.885 USD/km for the diesel bus.

Santiago, Chile

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.

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:

Funding partners:

Implementing agencies:



- 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. 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.

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 or 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, though 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

Funding partners:

Implementing agencies:

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.

4.1.4. DIAGNOSTICS OF 18-M BUS AND TROLLEYBUS TECHNOLOGY

In geographical terms, there is an obvious trend regarding manufacturers' origins and how and where they are better positioned. Notice that only Chinese brands have had a presence in Europe, the US, and Latin America. On the other hand, manufacturers of European origin are only seen in cities of that continent, and the same holds for the US. As a result, this may be an indication of the types of offers can be expected for the new fleets that the city of Quito seeks to acquire. It is highly likely that the offers will be predominantly from Chinese brands, for both buses and trolleybuses, given that the main European and US manufacturers are serving large purchase orders from their own markets.

Regarding the technical characteristics of the cases reviewed for electric buses, the standard for European models is predominantly based on pantograph charging (between 350 kW and 500 kW per charger) which also combine plug-type charger in terminals (between 30 kW and 150 kW). There were only four (4) cases in which the new fleets considered high autonomy buses and plug-type chargers (Cologne, Frankfurt, Barcelona and Luxembourg). Buses using opportunity charging have battery capacities between 145 kWh and 396 kWh, while those with high autonomy have it between 525 kWh and 640 kWh, the latter being the case for the electric articulated MAN bus just rolled out. Regarding passenger holding capacity, this varies according to region and city, from 99 passengers in Europe to 160 passengers for cities in Latin America.

In the case of trolleybuses, models offered in the cases reviewed are equipped with backup batteries that vary between 26 kWh and 87 kWh in capacity. The 18-m versions carry between 120 and 155 passengers, while the 24-m version can reach 220 passengers. (The latter considers the European standard.)

4.2. CHARGING INFRASTRUCTURE AND IMPLEMENTATION CONSIDERATIONS

Electromobility solutions must be comprehensively sized and consider bus technology, charging strategy (see Figure 19), 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 non existent**. 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.

Funding partners:



Implementing agencies:



Another relevant aspect to decide on the infrastructure is to consider **terminal recharging management**, which allows optimizing 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.

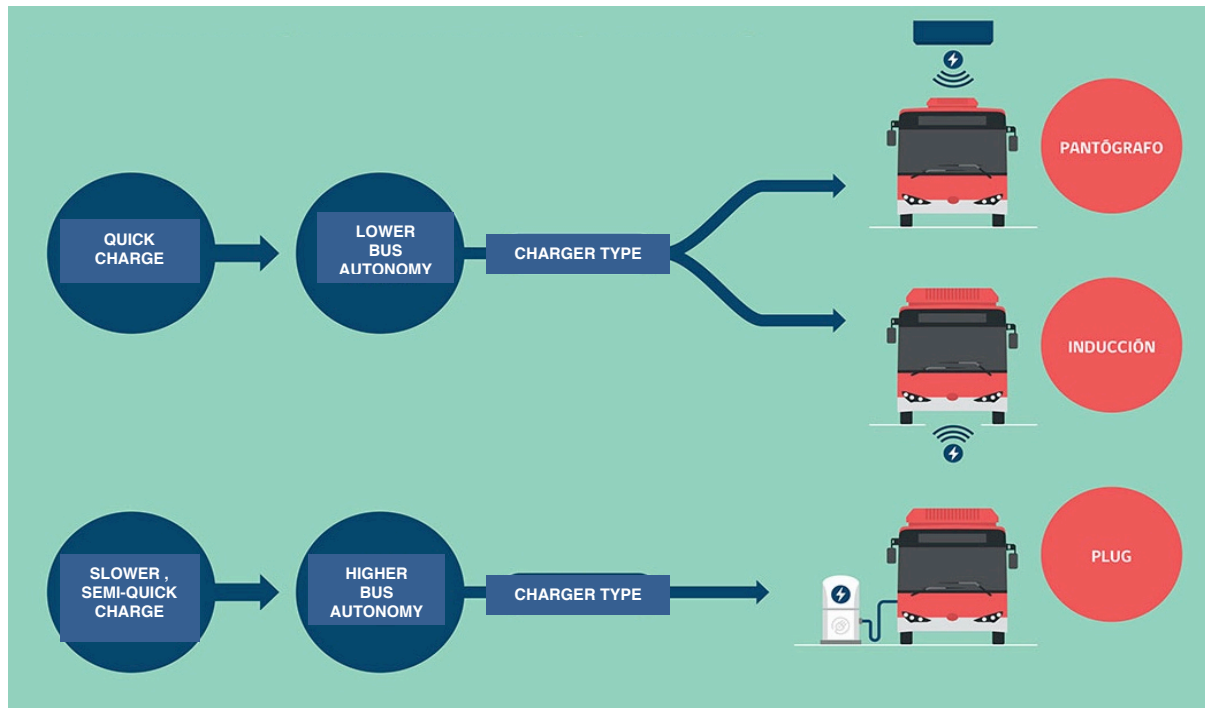


Figure 16: Charging schemes and associated charger technologies. Source: (EM Platform, 2020)

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 (OCPM)**^[5]. 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

Funding partners:

Implementing agencies:

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.

Figure 20 presents a general scheme that includes activities to consider, at a minimum, when evaluating different charging solutions; it is based on a overnight charging strategy with plug-type chargers. The first step is to identify any restrictions imposed by the operation, especially when, how, and for how many hours buses need to be charged. It is also important to know the electric characteristics of access to energy, the power output of the geographical points proposed as electric terminals, and electricity use tariffs. Subsequently, iterations must be carried out to optimize the technical-economic solution, with due consideration of operational and electrical terminal location restrictions, to finally adjust the solution that incorporates recharge management.

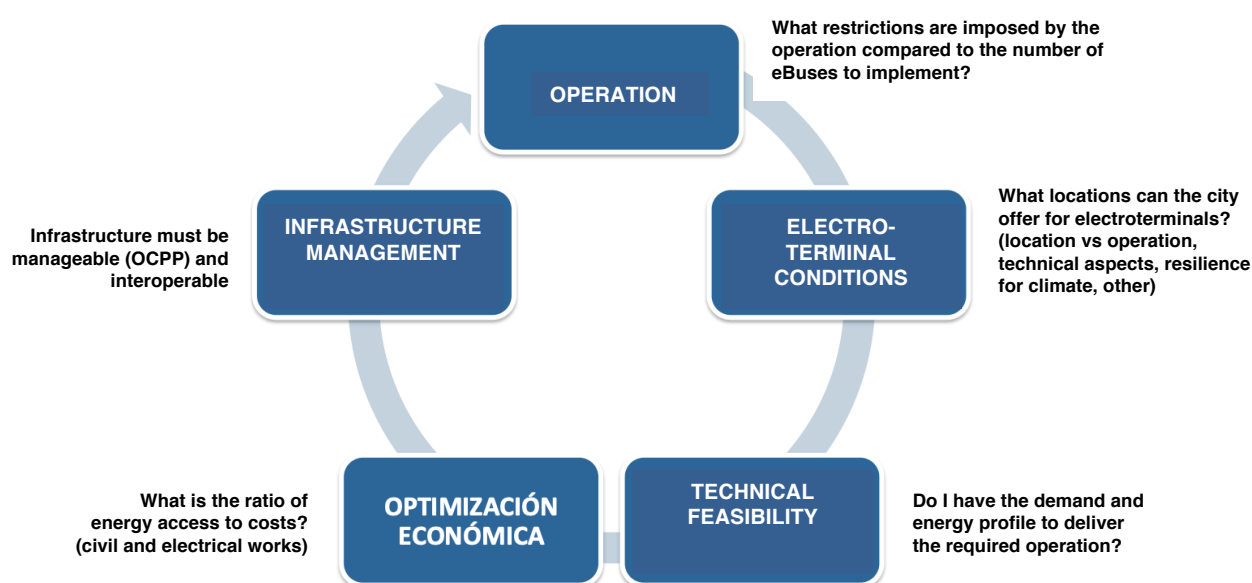


Figure 17: Minimum activities to be considered in electroterminal evaluation.

Source: Logit.

4.3. BATTERY MANAGEMENT: SECOND LIFE AND FINAL DISPOSAL

The macro analysis of batteries for electromobility indicates that 50% of the production is in China and the rest in the US, Korea, and Japan. Within China, the main suppliers are BYD and CATL.

In relation to costs per kWh, at the end of 2018 a figure of 175 USD/kWh was estimated, and it is projected that by 2030 costs will decrease between 80-120 USD/kWh.

The electromobility batteries currently offered on the market have different chemical components, depending on the charging strategy for which they will be used. For battery electric buses that use a slow, night-charging strategy, chemical components are mainly LFP (lithium-iron-phosphate) and also NMC (nickel-manganese-cobalt). However, despite enhancing energy density, the NMC battery also increase costs due to the use of nickel in the

Funding partners:

Implementing agencies:

cathode. For opportunity charging strategies, the most commonly used battery is LTO (lithium titanate).

In operational terms, the use of A/C results in between 15%-20% more energy consumption per kilometer than an operation without A/C. Also, electrochemical batteries decrease their energy performance in extreme climates, but that is not the case in Quito. Hence the importance of knowing and estimating the battery's actual output under a particular city's operating conditions, and not just the manufacturer rating.

Due to their electrochemical behavior, batteries wear over time, and a life span of around 8 years is used by the solutions currently offered in the market (2020), so it is expected they will have 80% of charge compared to their original energy rating. To reach this number of years of life span, it is essential to follow the manufacturer's recommendations, which will depend on the battery's chemical components, appropriate control of maximum discharge levels (DOD), and keeping proper maintenance and balance.

Once the life span of the batteries is reached, they have about 80% of their nominal capacity, as previously mentioned. Figure 21 summarizes the alternatives that can be managed with this active high residual energy value. The first idea is to give a **second life to batteries**. There are already stationary applications that use this residual energy from electromobility solutions. This type of asset will require technical adaptations to be used in stationary energy storage applications and, therefore, specialized human capital will be required. In their second life, batteries can be used for another 10 to 15 years.

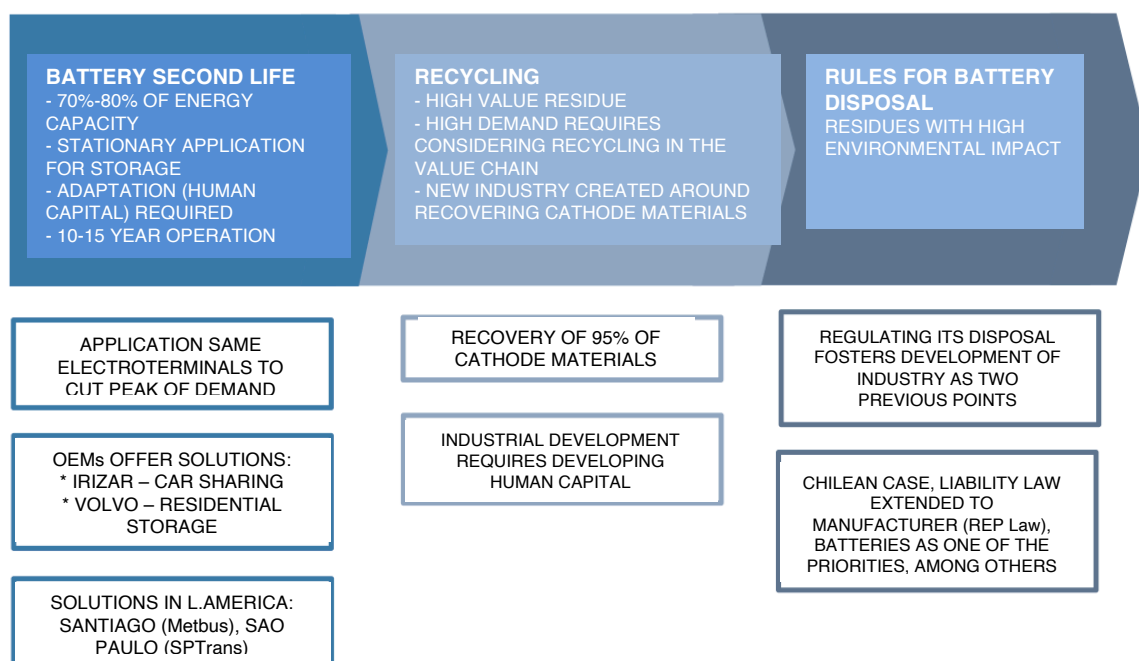


Figure 18: Summary of alternatives for electric bus batteries second life, recycling and recommended regulatory requirements.

Source: Logit

As can be seen from Figure 21, another alternative to manage batteries from electromobility solutions is **recycling**. Given that a high demand of batteries for electric vehicles is projected,

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Implementing agencies:

another alternative is their recycling in order to meet the demand for mobile applications, without waiting to be recycled until the end of their application as second life.

Finally, setting forth regulations for this type of waste or residue is highly recommended, as they are toxic to the environment and may be dangerous due to their thermal runaway effect

4.4. CONCLUSIONS AND RECOMMENDATIONS

As a general conclusion, the offer of electric articulated buses is already a mature solution under the European standard: over the last couple of years, there has been a growing introduction of 18-m electric buses, in addition to new purchase orders to be fulfilled between 2020 and 2022. The maturity of this solution is associated with the operational characteristics of these countries, where demand levels are not as massive as in Latin American cities where frequency plans, stop times and maximum distances travelled are more demanding. This is the reason articulated electric buses are frequently seen in Europe transporting between 100 and 130 passengers on average; they also have better battery autonomy since charging strategies are combined: both pantograph and night charging at the terminals.

When these buses are required to have higher autonomy and, therefore, their operation is based on night-charging strategies, there are some inconveniences caused mainly by the climatic factor, as shown in the cases reviewed from the US. In the case of Quito, temperatures are moderate throughout the year, which favors adopting the expected operation from high electric autonomy buses, in addition to the fact that they do not need to be equipped with A/C. The 18-m electric bus market offers several alternatives for fleet acquisition by the city of Quito.

In relation to trolleybuses, recent implementations made in cities in Europe, the US and in Mexico City indicate that this technology's new generation is also mature and allows the operation in off-wire mode, as batteries are recharged while connected to the catenary and during braking. The autonomy range for trolleybus will depend on how much kWh it comes equipped with, but manufacturers are flexible in meeting operator's requirements. In the case of Quito, the possible extension of Labrador - Carapungo requires at least 20 kms of continuous off-wire operation. In Mexico City, the articulated trolleybuses had to comply with 25 km per base, and the awarded model has a range of 75 km, so the market will be able to adapt to what Quito requires, and offer models that respond to the needs of the renovation plan.

On the cases reviewed for trolleybus, operating the new generation of trolleybus **with the “in motion charge” system does not require chargers at the terminal**, and only a few units are installed for purposes of maintenance and balancing the battery bank. Additionally, operating the **new generation trolleybuses with older technologies should not be an issue** while transitioning to a complete renewed system.

Batteries have a high recycling rate for their raw materials. This condition points to the development of a new industry specialized in providing this service. Also, since the increase in electromobility predicts a high demand for raw materials, recycling will be an essential part of the manufacturing value chain.

RECOMMENDATIONS

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- Charger standardization: consider this transformation process under a long-term vision, and avoid having too many different charging solutions that are not interoperable. The City of Santiago, in order to scale up towards May of 2020 with more than 750 e-buses, has already set up a standard (CCS type 2, DC).
-
- Battery management: since Ecuador does not yet have a legal framework to regulate batteries (second life and/or final disposal), the recommendation is giving a higher score to suppliers that offer traceable, sustainable solutions that add value to this equipment.
-
- Rules/regulations that provide on the final disposal of electric vehicle batteries in Ecuador. The existence of a legal framework will encourage development of solutions and innovation, as well as the creation of human capital to meet both a second life for batteries and their recycling after their life cycle. This is essential for technology sustainability, due to the potential scarcity of cathode raw materials.

Funding partners:



Implementing agencies:

5. MARKET STUDY

5.1. OPERATORS MARKET

The purpose of this chapter is to discuss the operators market in Ecuador, Latin America and Europe, and the most important conditions to satisfy while implementing a potential project to award contracts for the operation of the BRT corridors considered in the global study.

In order to present a current outlook of the operators market, eight operators were selected from Ecuador, four from the city of Quito, three consortia from the city of Guayaquil, and a consortium of eight companies from the city of Cuenca.

Internationally, companies from Colombia, Chile, Peru, and Spain were considered, of which four were selected. Through surveys and interviews, information was obtained on their operating records, types of systems operated, potential interest in bidding, and the most relevant barriers to operating the BRT corridors.

In Quito, two corridors were identified as candidates for the replacement of diesel units with electric units: Ecovía, which has been in operation for two decades, and the Trolleybus Northern Extension, scheduled to be implemented soon. It is estimated these corridors will require 193 and 152 electric buses, respectively. Also, the operation of the trolleybus corridor that is currently in the process of replacing its electrical units cannot be disconnected.

In the following sections an updated review of the market is developed that identifies the potential operators, with their respective characteristics and experience, as well as the conditions that would allow them to participate in the concession processes.

5.1.1. IDENTIFICATION OF ACTORS

In Quito, four main consortia were identified, operating in different areas of the city.

- ✓ Consorcio Corredor Sur Occidental (Southwest, open BRT);
- ✓ Consorcio Corredor Central Norte (Northwest, BRT);
- ✓ Consorcio Cometra (Northeast, conventional service);
- ✓ Consorcio UnitransQ (Southeast, conventional service)

In Guayaquil, three main consortiums were identified, which operate the BRT systems (Metrovía):

- ✓ Consorcio Metro-Bastión (BRT);
- ✓ Consorcio Metroquil (BRT);
- ✓ Consorcio Metroexpres (BRT);

In Cuenca, a single consortium was identified, which brings together all the operators in the city:

- ✓ Consorcio Concuencia (conventional buses)

At the regional level, actors were identified in Colombia (Transmilenio), Peru (Metropolitano) and Chile (Trans-Santiago)

- ✓ Transmilenio, Bogotá (BRT);
 - Bogotá Móvil Conexión Móvil

Funding partners:

Implementing agencies:

- Si18
- Consorcio Express
- GMOVIL S.A.S
- Transdev/Fanalca
- ✓ ☐ **Metropolitano, Lima (BRT)**
 - Consorcio Perú Masivo
 - Consorcio Lima Bus Internacional
 - Consorcio Colombiano Lima Vías Express (LVESA)
 - Transvial Lima SAC
- ✓ ☐ **Trans-Santiago**
 - Transdev
 - Metbus

Additionally, an European operator was selected (ALSA, in Spain), in order to have general comparison parameters regarding operations in developed countries.

5.1.2. SELECTION OF OPERATORS AND COLLECTION OF INFORMATION

To collect baseline information, national and international operators were selected. The selection format was developed based on the representativeness of each operator in the sector and the characteristics of their current operations. Two local operators were selected in Quito (Consorcio Sur Occidental and UnitransQ). These two operators have characteristics directly related to bus corridors with exclusive lanes and a significant number of operating buses. Furthermore, UnitransQ has a project to take on the operation of the Ecovía corridor. In Guayaquil, the consortium most experienced in BRT operation was selected: Metroquil, which operates the trunk service of the Metrovía system. In Cuenca, the consortium that operates all city lines was selected: Concuenca (combining eight operators).

As for international operators, those with comparable operations (BRT corridors and electric buses) in cities with characteristics similar to Quito (i.e., Bogotá, Lima, Santiago) were selected, plus an additional operator which has no direct operations in the region, but will be useful as a foreign reference point. The selected international operators were: Metbus (Chile), Transdev (Chile and Bogotá), Transvial (Lima) and ALSA (Spain). This provides a good sample of large international companies (Transdev and ALSA), as well as smaller local companies (Metbus and Transvial).

The systematization and evaluation of operator characteristics was performed based on the primary and secondary information collected. Table 5-1 details selected operators, as well as their operations and experience.

Table 12: Operator's information

Name	City Country	Operation	Fleet	Daily passenger demand *	Experience (years)	Knowledge of electric buses	Direct experience with electric buses
South Western Consortium	Quito, Ecuador	BRT open	249	230M	10+	Yes	No
UnitransQ	Quito, Ecuador	conventional	900	864M	10+	Yes	No
Metroquil Consortium	Guayaquil, Ecuador	BRT	108	135M	10+	Yes	No
Concuenca	Ecuador	conventional	475	403M	10+	Yes	No
ALSA Group	Madrid Spain	Various (conventional, BRT)	4,446	930M	10+	Yes	Yes
Metbus	Santiago, Chile	Various (conventional, BRT)	1,204 (285)	1MM	10+	Yes	Yes
Transdev	Chile / Colombia	BRT, conventional	5000+	18MM	10+	Yes	Yes
Transvial / EMT	Lima, Peru / Madrid	BRT, conventional	154	180M	10+	Yes	No

M: thousands (000) MM: millions (000,000) * Before the pandemic

Funding partners:

Implementing agencies:



5.1.3. REVIEW OF REQUIREMENTS FOR PRIVATE OPERATOR PARTICIPATION

National operators are interested in participating in potential bidding processes to award electric-bus corridor concession contracts. Operators in Quito are much more interested than those in the other two cities, but they have the lowest level of formalization since they still depend on a manual fare collection system. The implementation of single box systems is underway, but it has proven to be difficult to overcome. Vehicles are still owned by individuals, not legal entities, each individual owning and operating a bus unit. Among the reasons for lagging behind other local operators is the absence of a clear public policy regarding fare collection and single box, as well as full coordination among partners.

Following are the main barriers to and conditions required for the participation of local operators, as they see it:

Concession terms. BRT corridor operation concession terms vary between 10 and 12 years in Ecuador (Quito and Guayaquil). Operators recommend these terms be extended to 15 years, for two main reasons: (a) the investment is higher in electric units, so returns take longer (b) electric vehicles have an estimated 15-year life span, so concession terms should match such life span.

Clear fare policy. Quito's public transportation fare has remained at 25 cents for more than a decade, while Guayaquil and Cuenca have updated their rates to 0.30 cents for diesel buses and 35 cents for electric buses in Guayaquil. To reduce revenue uncertainty, operators recommend correcting the rate according to a technical calculation or directly to inflation, thus avoiding being subject to political will.

Quito's transportation system is about to undergo major changes with the start of metro operations. This implies changes in routes and demand related to the corridors, especially since passengers may transfer from one corridor to another. For operators it is important to be clear on this point, since it directly affects their revenues.

Operators lack of capital becomes a barrier, since bus ownership is by each partner, not the company or cooperative. This is an obstacle to obtaining financing. Additionally, financing costs in Ecuador are quite high (above 8%), leading operators to seek foreign financing sources.

These are the main aspects raised regarding international operators:

Concession terms should be adjusted to the life span of batteries (approximately 8 to 10 years), buses (15 years), and financing terms (10 years).

12-meter electric buses have been shown to be very reliable, and more efficient than diesel buses.

Articulated electric buses have not performed as well as 12-meter buses. Further development is required for them to achieve similar efficiency, especially in view of the occupancy levels they reach during peak hours.

The operational program for electric buses is significantly more complex and quite different from that of diesel. The recharging time in off-peak hours and during the night must be carefully programmed, as well as the remaining battery. This component directly affects the operator's financial performance.

Funding partners:



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Correct design of recharging systems (number and specifications of terminals, power output, chargers) is of utmost importance to reduce operating costs.

Strategic alliances between bus suppliers, operators and power utilities are key to promoting electric bus corridors.

It is not feasible for operators to take on risks of demand. This was the main factor in their decision not to participate in the Guayaquil concessions. They recommend operators be compensated based on kilometers traveled, together with adjustments for the number of passengers transported.

They see an important opportunity in the Quito trolleybus, since they have developed technology for electric buses that are charged through catenaries (similar to trolleybus) in certain sections of the corridor.

A concession period of 8 to 10 years is adequate for this type of system. However, in Chile they handle contracts of less than two years, which can be solved by using leasing systems before acquiring the vehicles.

5.1.4. CONCLUSIONS AND RECOMMENDATIONS FROM THE OPERATOR'S MARKET

Seventeen urban public transport operators were identified. Of these, four national operators (Quito, Guayaquil and Cuenca) and four international operators with extensive experience (Colombia, Chile, Peru, Spain) were interviewed. Information received allowed the creation of a database with contact information, experience details, including details of operations, and a review of barriers and conditions to participating in the concession processes for electric BRT corridors.

Two main results were generated: first, opening a communication channel with potential suppliers and operators; and second, obtaining a general view of the operator's market with respect to the barriers to participate in potential concession bids or similar processes. These results are relevant, as they contribute to the analysis and development of specifications, identifying conditions that would be difficult to meet otherwise, or that would have negative effects on the corridors.

In general, all national and international operators were interested in possibly participating in the electric BRT corridor concession process. The corresponding conclusions and recommendations are detailed below.

Difference between national and international operators

Financing capacity: international operators have an advantage over national operators, because they have access to more financing alternatives, even though they must also face country-specific risks.

Electric bus operation: the knowledge of local operators is superficial. The international operators have already faced and solved many of the operational and technological problems.

The responses to the inquiries made with operators indicate that the best alternative is to seek the association of local operators with international operators. This alternative promotes the growth of local operators through technology transfers from international operators. International operators must be knowledgeable on the design of electric bus infrastructure, battery charging and recharging requirements, and electric bus implementation and operation.

Funding partners:



Implementing agencies:



Technology

There is a greater experience in the operation of 12-meter electric buses with already proven efficiency levels in different conditions.

Articulated and bi-articulated buses do not have the same experience, and operators have shown indications that there are still factors to consider in the operation of BRT corridors. Alza de España, for example, responded with the need for 30% more fleet in operation to deal with issues of autonomy and logistics for recharging batteries. These problems are related to the increase in consumption during peak periods due to the high occupancy of vehicles.

The operators indicate a careful review of the conditions for overnight recharging and the possible need for fast charging in some sections of the routes. They consider that the logistics of recharging batteries still needs further development.

There are no universal indicators for electric articulated buses. Autonomy is closely related to recharging while in operation. This depends on the conditions of terrain, temperature, rainfall, and street layout, so it requires that bus operators/suppliers do tests to ensure the performance is adequate for the conditions of Quito, and that energy consumption and autonomy indicators can be attained.

Trolleybuses do not present the same problems since they have already been in operation in Quito for almost 25 years, and EPMTPO already controls the technology. There is no longer a problem for battery charging, since there is already an infrastructure of catenaries, substations and depots. The extension to Carapungo is at the limit for operating with catenary where there is the infrastructure today and at the final section of the corridor. The solution indicates that to operate with trolleybuses in the extension, the catenary must be extended to Labrador where there is already a metro substation.

Operational performance is key to battery recharging logistics. Scenarios have to be very well-defined according to the concession term, with operational plans, depot location, power supply system for recharging systems (power output), power supply availability during all recharging periods, the required autonomy, kilometers in operation daily for each route (this information must exist per route, not system averages).

The transport authority must provide detailed information on the operation and conditions of the system, using an information portal that all interested parties can access.

Bidding Conditions

Clarity in calculating demand: The demand depends on the scenarios of operation and physical and fare integration. Operators consider that the clarity of scenarios is particularly important as a demand calculation methodology.

Integrity in the bidding and concession process: From the start, the integrity of the concession process is very important to ensure that operators, especially international ones, decide to participate. Experience in the region shows that analyses presented by the local technical teams to inform operators' matrices usually require modifications due to constant changes in the requirements and processes of public institutions. This creates uncertainty and makes participation difficult. It is recommended that a clear roadmap be developed containing exclusively modifications resulting from questioning by the bidders. All procedures preceding the concession should be developed fully, and feedback mechanisms (e.g., process of expression of interest, availability of technical information) should be established among

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actors to allow launching a process that undergoes no further modifications. Specialized technical support will be required in this type of operation.

Fare policy and operator compensation: Local operators consider that the fare paid by users determines their income. International operators consider that the concessionaire's income is a function of several parameters, among which is the fare paid by the user. There are other compensation systems (i.e., subsidies, payment per kilometer traveled) that entail a profitable operation. It is recommended that the business model evaluates alternative fare and operator compensation policies, based on experiences from Bogotá and Santiago, in addition to local experience.

Demand Risk: Local operators are more willing to take on the risk associated with the existing fare policy, when it follows political interests instead of being associated with operating costs. It is recommended that the fare policy be associated with costs and performance indicators. It is also recommended that the scenarios of demand are clear and do not change, unless this is necessary to improve performance.

Risks of Social Conflicts: International operators value being awarded concessions that do not include social conflicts (historic operators, personnel). They recommend these be handled by the authorities, and not transferred to the concessionaire, since, in their experience, this generates problems and eventually the failure of the concession. It is recommended that concession reviews include the cost of compensating historic operators and/or personnel working in the corridor. This will provide information on the total cost to be incurred and to whom attribute social costs.

Association with power suppliers: The experience in Chile, where the largest number of electric buses are operating, shows the importance of a partnership between the bus suppliers, operators, and electric power suppliers. Such partnership allows for an alignment of interests among actors and benefits from their strengths. It is recommended that, in the case of Quito, the Empresa Eléctrica Quito (EEQ) be included in the analysis of the corridors. This will allow incorporating information and providing feedback on the electrical systems available and the possible participation of EEQ in the project, since EEQ will be the power supplier

Regulatory framework: There is a level of uncertainty among local operators regarding the regulatory framework for a bidding process that includes electric buses. Both the national regulatory framework (laws and regulations) and the municipal (ordinances) do not contemplate this type of operation. It is recommended that an analysis of the regulatory framework related to the bidding process be submitted, once the main characteristics of the latter have been developed, to ensure that the required support is in place.

Concession time: Operators consider that the concession term should be related to the life span of the vehicles and batteries. Santiago and Bogotá have delinked the ownership of the buses from the operation. This allows for different contract terms for bus providers and operators. The concession terms for operators can be shorter, under the option of leasing the vehicles. It is recommended to consider this alternative in the business model.

Finally, it is relevant to indicate that no BRT corridor has been offered to bids and operated by international companies in Ecuador; only historic operators have been able to access this operation. The only comparable experiences, but with different technologies (cable and rail), are the Aerovía project (cable in Guayaquil) bidding, which has already been awarded, and the Quito metro, which is preparing the process to submit the operation to bids. These two

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projects represent important opportunities for the analysis of the concession processes with the participation of international operators.

5.2. SUPPLIERS MARKET

Based on the results and conclusions of the review of technologies of interest to the city of Quito (see Chapter 4), a market study of suppliers was carried out on the 18-m bus typology, both electric buses and trolleybuses, who might be interested in submitting offers to Quito. This study considered in-depth interviews with eight (8) OEMs for articulated electric buses and six (6) OEMs for 18-m trolley buses. These interviews delved into technical aspects, commercial aspects and, finally, post-sale and the operational record.

In methodological terms, selection criteria were defined to identify OEMs with high potential to supply Quito with 18-m buses and trolleybuses. These were then contacted and interviewed and results generated. Figure 19 outlines four (4) criteria to guide the OEM selection strategy: the bus/trolley brand should be represented in Ecuador (criterion 1), and have an operational record – preferably operating in Latin America – regardless of whether the typology was articulated or not (criteria 2 and 3).

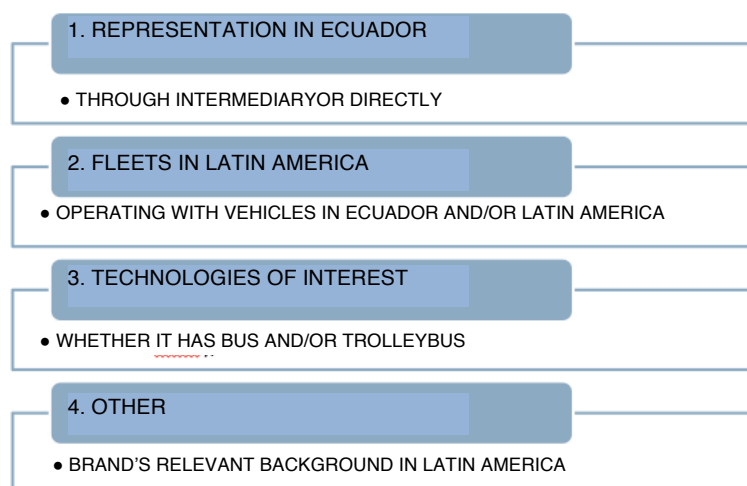


Figure 19: Criteria to select OEMs to be interviewed for a market study of 18-m electric bus and trolleybus suppliers.

Source: Logit.

Another methodological aspect to mention was the set up of a matrix relating the OEMs' current offers and the level of effort (expressed in time) required to adapt said offers to the City of Quito's basic requirements for both buses and trolleybuses. For this, an indicator of "adjustment to model" was set, with values from 1 to 4, as shown in Table 13.

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Table 13: Setting the "Model Adjustments" indicator

Value	Criterion
1	It has a high floor model, requires marginal adjustments, easy to implement
2	It has a high floor model, however it requires adjustments according to the demands of the city (for example, number of doors), easy to implement
3	It does not have a high floor model, it requires a new development. However, it declares feasible to carry out
4	It does not have a high floor model, it requires a new development. It is declared as NOT feasible to carry out for deliveries to 2021-2022

Source: Logit

According to the matrix plotting the Table 13 ranking against delivery time, **the brands closest to the origin** are better positioned to **offer a model in the short term to meet the minimum requirements** imposed for the operation of articulated electric buses in Quito.

5.3. TOP OEM RESULTS FOR 18-M BATTERY ELECTRIC BUSES

Figure 20 shows the results for eight (8) OEMs interviewed according to the model adjustment versus delivery terms matrix. The Yutong brand requires the least effort and the shortest time delivery (6 months). The next lower indicator for "Model Adjustments" is for the BYD brand, with a stated delivery time of 8 to 9 months. In third place would be SunWin, with an adjustment indicator of 2 (mainly due to adjustments to the number of doors), and a 6-month delivery period. Foton, Eletra and Zhongtong are concentrated in adjustment indicator 3, since they all need to develop new models with a higher floor, which they declared as feasible to deliver an order by 2021-2022. Finally, Solaris and Volvo, two (2) European suppliers, remained in adjustment indicator 4, as they are unable to submit a short term plan to deliver a high-floor model to Latin America and Ecuador.

Regarding **technical aspects**, no articulated electric bus model exceeded the maximum gross weight per vehicle required by Quito (31 tons); capacity ranged from 145 to 160 passengers; stated road slopes handled were 18% to 20%, but they noted that adjusting engine parameters to meet this requirement is feasible. As for the number of doors, reported versions ranged from 3 to 6 doors, and with the exception of Solaris, they could all make adaptations to comply with this requirement.

Funding partners:



Implementing agencies:



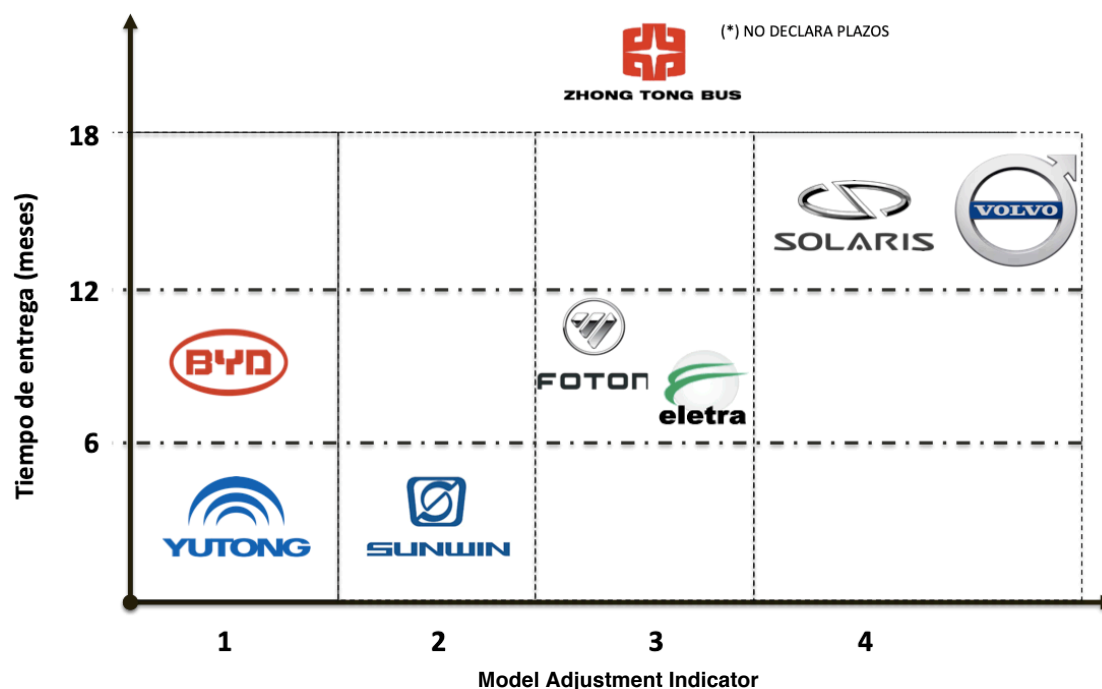


Figure 20: Model adjustment indicator versus delivery times matrix

Source: Logit

Regarding powertrain specifications, except for Foton and Eletra, all brands offer an engine power rating equal or higher than the City of Quito's requirement of 230 kW, in a 1 or 2 motor configuration. Autonomy was reported at 130 kms to 300 kms, this last figure reached by four (4) providers (BYD, Foton, SunWin and Yutong), thus complying with preliminary requirements by the City of Quito. Battery banks have a 8-year warranty in all cases, and the reported energy performance values were (without A/C): 1.5 kWh/km (FOTON), 1.4-1.8 kWh/km (BYD, actual operation in Quito), 1.3-1.6 kWh/km (SunWin), 1.3-1.7 kWh/km (Yutong). Solaris reported consumption (with A/C) of 2-2.5 kWh/km. Regarding charging standards, they were all DC and ranged from European CCS Type 2 to Chinese GB/T. However, the Chinese suppliers claim they would be able to adapt their models to the European standard, noting that the charger would then double its price. The power output of plug-type chargers used by OEMs vary from 90 kW to 200 kW, indicating that this part of the solution is adapted according to the time available for charging and the number of electric buses in the fleet.

All manufacturers interviewed report following up on operators for at least 1 year, sending technical staff to work with and train client's personnel. Also, a stock of key spare parts is made available at terminals and depots.

Finally, **regarding commercial aspects**, the CAPEX reported by Chinese OEMs ranged from 450,000 USD (CIF Ecuador) to 640,000 USD (CIF Ecuador). In the case of the European OEM Solaris, the CAPEX was 897,000 USD, price in Europe. All manufacturers report that 40% of CAPEX is on account of the batteries. Regarding the flexibility to supply models to Quito on a short-term basis (2021-2022), 5 out of 8 brands interviewed indicated they could be able to comply. In the medium term (2021 to 2030), 7 out of 8 OEMs would comply. Finally, 3 manufacturers report working with the battery leasing business model.

Funding partners:



Implementing agencies:



5.3.1. MAIN RESULTS FOR 18-M TROLLEYBUS OEMS

Figure 21 shows the results of the model adjustment indicator x delivery time matrix for the six (6) articulated trolleybus brands interviewed. The 90-cm floor height (high floor) requirement was a restriction that none of the brands could meet with a model already available on the market. However, Yutong reports having a high-floor model for articulated electric bus and, since the trolleybus development uses the same platform, implementation will take less time.

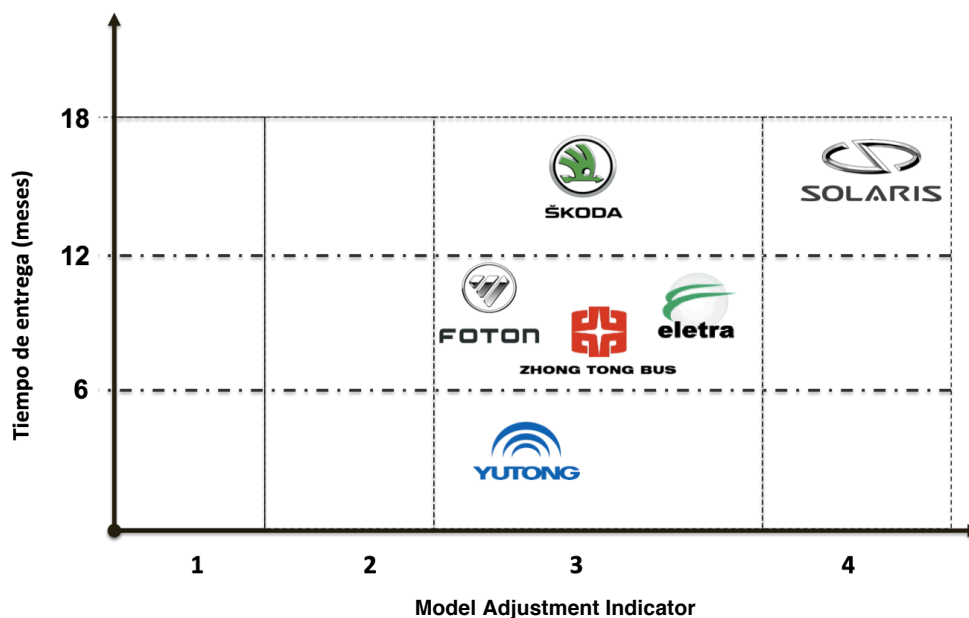


Figure 21: Model adjustment indicator versus delivery times matrix

Source: Logit

Regarding **technical aspects**, no articulated trolleybus model exceeded the maximum gross weight per vehicle required by Quito (31 tons); capacity ranged from 124 to 160 passengers; stated road slopes handled were 18%, but they noted that adjusting engine parameters to meet this requirement is feasible. As for the number of doors, reported versions ranged from 3 to 6 doors, and with the exception of Solaris, they could all make adaptations to comply with this requirement.

Regarding powertrain specifications, except for Foton and Eletra, all brands offer an engine power rating equal or higher than the City of Quito's requirement of 230 kW, in a 1 or 2 motor configuration. Autonomy was reported at 20 km to 75 km, and all manufacturers have the **in motion charge** system which recharges the battery bank after connecting back to the catenary. In Eletra's case, the bus off-wire operation implied a speed limit, the rest of the brands could operate normally as an electric bus. Battery banks have a 8-year warranty in all cases, and the reported energy performance values were (without A/C): 1.5 kWh/km (FOTON), 1.3-1.7 kWh/km (Yutong). Solaris reported consumption (with A/C) of 2.5-3 kWh/km. On sizing the battery backup system, Skoda and Solaris recommended not exceeding the time ratio of 60% and 40% in catenary connected mode and off wire mode, respectively, to avoid accelerating battery wear. It is also recommended not to put too much weight on battery charging, as this would mean disregarding trolleybus as a technology. Finally, where intensive use is made of trolleybus batteries, as may be necessary in the possible extension of Labrador-Carapungo to the Quito trolleybus service, replacing the batteries should be considered at year 8, as they would be done on an electric bus.

Funding partners:

Implementing agencies:

All manufacturers interviewed report following up on operators for at least 1 year, sending technical staff to work with and train client's personnel. Also, a stock of key spare parts is made available at terminals and depots.

Finally, **regarding commercial aspects**, the CAPEX reported by a single Chinese OEM (Yutong) was 440,000 USD (CIF Ecuador). In the case of the European OEMs Skoda and Solaris, the CAPEX reported was 732,000 to 1,000,000 USD, respectively, considering the European price. Some of the manufacturers stated that 20% of the CAPEX is on account of the batteries. Regarding the flexibility of offering models to Quito in the short term (2021-2022), 5 of the 6 brands interviewed indicated that they could comply with it. In the medium-term case (2021 to 2030), all 6 would comply. In relation to the battery leasing model, 4 manufacturers report offering this business model.

5.3.2. CONCLUSIONS AND RECOMMENDATIONS

As a general conclusion, suppliers of electric articulated buses are better prepared to make models available to the City of Quito in the short term. In the case of articulated trolleybus supply, the development of a new prototype by the brands interviewed will be required, especially in order to comply with the 90-cm floor height requirement. However, in the case of articulated electric buses, there are already at least three (3) interested suppliers that have high-floor models and autonomy of 300 km. Following are other specific conclusions:

- Electric bus and trolleybus projects for Quito have a market that would respond to the minimum requirements demanded by the city. Of the nine (9) suppliers presented, at least seven (7) have technologies of interest.
- All suppliers interviewed indicate that a team of factory engineers is sent for surveys in the field and can then make adjustments to the models according to the demands of each city (power outputs, slopes, suspension, correct adaptation to increase height to 90 cm, sizing batteries, chargers, among others)
- The high-floor requirement is the main barrier to entry by European brand suppliers. For electric buses, there would be no offer by the interviewees (Volvo, Solaris); in the case of trolleybuses, Skoda would be able to make an offer, since they have a chassis + body strategy for local offers.
- All interviewees offer after-sales, capacity transfer, access to bus data (ex post data or through telematic platforms), spare parts stock, and the presence of brand technicians in operators' terminals (also in separate facilities, as the client may require).
- In the case of electric buses, all suppliers point to savings in maintenance costs over 50% compared to the operation of an equivalent diesel bus. However, this figure will vary depending on what technology it is being compared to.
- Interviewed suppliers are aware of the heavy rains and potential floods, but report vehicles undergo flood tests.
- The impact of floods on terminal and bus depots must be considered when selecting locations and/or evaluating improvements to rainwater collection systems.
- Suppliers point out that a ratio above 60% connected to catenary and 40% in off wire mode is not recommended, otherwise the trolleybus becomes heavier from the need to include more batteries. The case of the Labrador-Carapungo extension is borderline, but feasible.
- Since off-wire mode is considered for the trolleybuses as part of the operation and not as a backup, batteries would be subject to high wear and tear and, therefore, their replacement should be considered for year 8. If the batteries are more for

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contingency use (as the Mexico City example shows), batteries would be used less and, therefore, such replacement would not be necessary.

RECOMMENDATIONS

Below are recommendations to the city that may contribute to the supplier selection process for both articulated electric buses and trolleybuses:

- Begin participatory work, at least with the brands identified in this study, in order to provide as soon as possible the information that needs to be studied and analyzed by the suppliers. Providing and making official information available on the city's processes transparent to suppliers will also signal that the renovation is being taken seriously. The reason we mention this is that a certain degree of disbelief on the part of suppliers was perceived in several interviews, mainly by those who had already been to Quito previously to respond to a similar call for trolleybuses, which never materialized.
- It is highly recommended that the city of Quito defines a standard of chargers to which the electric bus industry can align itself, so that the city can ensure that the charging infrastructure at the terminals is interoperable.
- Although brands that follow the GB/T charging standard involve lower charger costs, the city will have to decide between cost or open the offer and not restrict the electric bus market in the medium to long term to only buses of Chinese origin. Notice also that Chinese suppliers claim to be flexible in adapting charging requirements to the European standard. However, the European market, despite the large number of providers of electric buses and trolley buses, does not have such flexibility.
- The supply of 18-m, high-floor trolleybuses is not currently offered by brands that have shown interest and potential to offer their products to Quito. The recommendation is then to initiate this call with higher priority, signaling the market and allowing prior studies to begin.
- In general, delivery times of six (6) months could only be met by one or two suppliers, so it is recommended that these terms be increased, if the city is to give priority to more competition among suppliers over delivery times.
- Regarding after-sales requirements, brands have very standard procedures to provide training and transfer of skills; in addition to having expert personnel in the terminals themselves, they have their own shops where they store and manage spare parts.
- Considering that Ecuador still does not have regulations on the disposal of batteries as waste, it is recommended that a special score is given to those suppliers that better handle the matter of battery life cycle. Suppliers who can offer concrete solutions for disposal of batteries in their second life that are traceable, sustainable and indicate the potential purchase value of the battery as an asset at the time of renewal (year 8) should be scored higher. This will potentially push the industry to innovate and provide solutions that are attractive to stakeholders.

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6. MANAGEMENT AND OPERATION MODEL

6.1. INTRODUCTION

The management models for transportation systems are related to the institutional structure. The first principle is transparency in the roles and responsibilities of all actors in the system. Sometimes agencies lacking a clear purpose are created by governments, with little flexibility to make the necessary adjustments for system optimization.

At the same time, private bus operators have not sufficiently developed their business capacities, and the search for efficacy has not been accomplished. The private companies were built around family businesses with a tendency to form oligopolies.

There are also no regulatory or management bodies that are able to promote more efficiency or universities to research the topic and contribute and guide toward the required changes. Only the connection between organizations, operators and universities can foster an environment where knowledge increases and new solutions appear for better quality and efficiency of the systems. The emergence of transport apps requires a new vision towards mass transportation.

The regulation and management of the system are the responsibility of the public administration. The operation of the services can be public or provided by private companies under concession contracts.

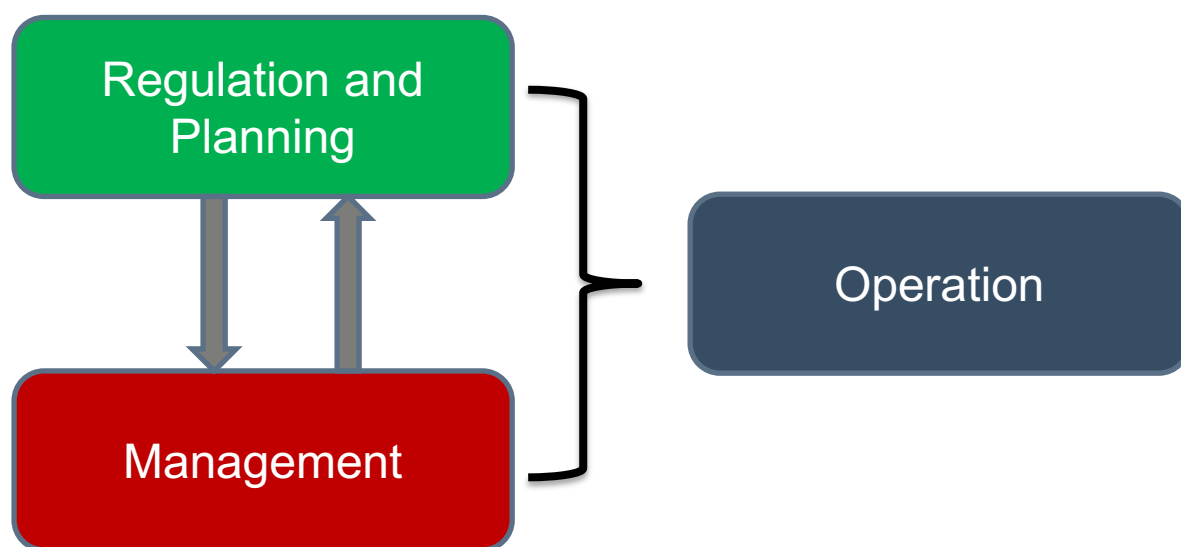


Figure 22: Regulation, management and operation

The regulation and planning of the system are functions of the Mobility Secretariat.

Such regulation should include vehicle regulation, standards for the design of terminals, stations, shops and terminals, service quality indicators, and the bases for awarding concession contracts.

Management and operation must be carried out by independent organizations/companies.

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The role of management is to plan the operation and ensure that the plan is carried out. For this, the manager needs a good database, simulation tools (model), monitoring tools (fare collection system, fleet operation and management), infrastructure management (stations and terminals), security (cameras), and all other tools to ensure the delivery of a quality service. Management needs to be able to optimize services and increase productivity and quality of service. In management, knowledge is built in close relationship with the operators.

6.2. BASIC MANAGEMENT ISSUES

6.2.1. PUBLIC TRANSPORT OPERATION

Quito still has operators that are not organized as companies and follow a model like Mexico's, where buses are individually owned but under cooperative or transportation company names. Bus owners and drivers internalize costs and adjust services to meet operational costs and make a profit. Drivers work an excessive number of hours, under strenuous working conditions.

The model needs a change, not only to solve traffic conflicts and have better regulation, but also aims to offer better conditions to transport workers.

In all the countries of Latin America, great efforts have been made to organize public transport operators into private companies, where service concessions are regulated and an orderly service is provided. However, this type of action often results in higher operational costs.

In general, the model adopted involved government management and operation by private companies. The management and operating role must be well understood. Management ensures that the entire operation is planned in an integrated manner, while monitoring it to make sure what was planned is delivered at the desired quality levels. Operation meets the requirements and deliver the services with the required quality. Fare collection can be handled by an operator that performs the tasks of operating services related to credit sale and fare collection to be used by the system.

6.2.2. MANAGEMENT AND OPERATION QUALITY

Nothing works well without everyone being well trained. It is essential that both management bodies and operators are well trained. Training is the mix of knowledge with experience.

The experiences of Bogotá and Santiago show that even with trained management agencies and efficient operators, there are still many issues of non-compliance and poor management. One of the causes is the high turnover of technical staff in the management organizations and contract deficiencies.

The example of the SITP implementation in Bogotá is interesting. Companies succeeded in operating trunk corridors efficiently with fleets of around 200-300 buses. But when they had to change from 300 to 3,000 buses, they failed to adjust to the new business and almost went bankrupt. They were trained to operate smaller fleets, and were not able or ready to operate larger ones. At the same time, Transmilenio was not ready for the changes that were required. The impact is still felt today in the quality of the system and overcrowded buses.

Results are even worse if one of the parties is not equipped to perform its functions, as shown in Figure 23.

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manager weak	Operator strong	Manager strong	Operator weak	Manager strong	Operator Strong
>high pressure on management		>risk of arbitrary management		>relationship management- operator on same level	
>Decisions more political		>Decisions more technical		>Transparent relations	
>Operators interests prevail		>Operator will not have capacity to fulfill obligations		>Probability of corruption reduced	
>Higher probability of corruption		>low level of service		> better level of service	
>Higher operational costs and low quality services		>management pressure to lower operator's profit		>user interests better preserved	
>Non satisfied user		>Non satisfied user		>Satisfied user	

Figure 23: Relationship between Manager and Operator

6.2.3. OPERATION CONTROL

In addition to planning the operation, making adjustments, and verifying events, it is necessary to monitor service provision and provide timely information to users. A Control Center should be installed with tools for fleet management, terminal and station operation, and user information. The Control Center must be shared between the managing body and the operators at different levels. With electric buses, the system must include checking on battery charge and on the autonomy available to complete the day's operation.

Fleet management must be handled by the operator with control from the manager. Systems must be integrated. The operator manages bus operation and management integrates the management of different operators, as well as of planned or unforeseen events. The Control Center under the public transport management system can be integrated with the traffic control center, using the same CCTV cameras and vehicle flow data collected in streets and intersections.

The Control Center integrates bus operations with street traffic, allows communication with the bus drivers, checks out occupancy levels in stations and terminals, conducts security surveillance, and sends real time information to service users. The system requires a wide and quality communication network.

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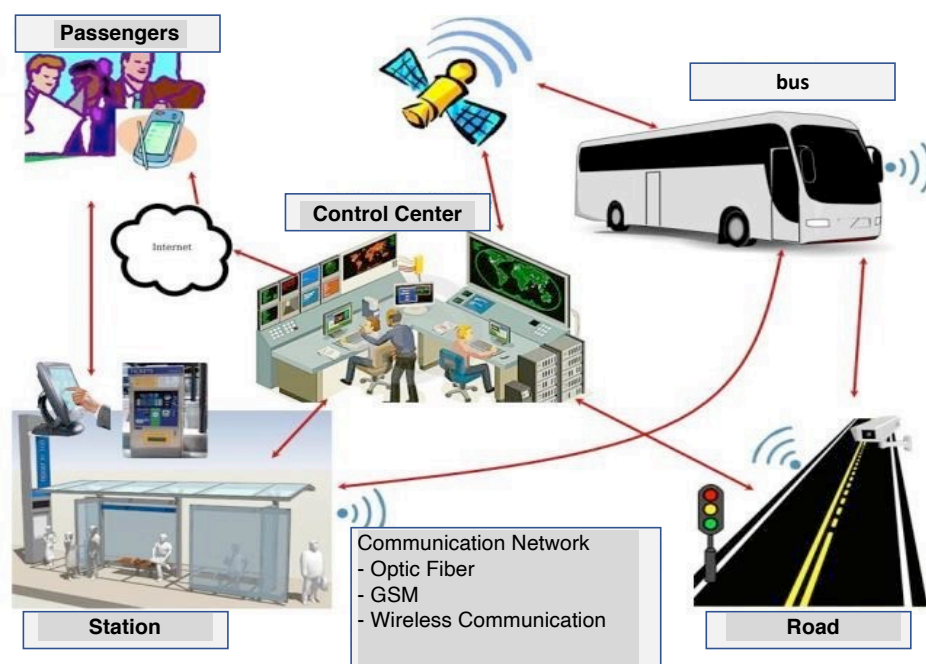


Figure 24: Operational Control and User Information System

6.2.4. FARE COLLECTION SYSTEM

Fare collection cannot be an independent system left to a private operator. The management body needs to have all the information from the points of sale and validation equipment in real time, before it is even reviewed by the operator. Management must have information processing tools and develop its own figures and statistics.

Data from the cards is also important information to develop trip matrices and the demand profile in the system during the day. The card information system must be integrated with the AVL system to identify location and time of transaction.

This service may be provided by a public organization, by the bus operators, or by a private operator under a service concession. Experience shows that the best solution is for the service to be provided by a specialized company for this purpose.

Technologies are changing amazingly fast and smart cards are no longer the most advanced technology. Operators or government agencies are not sufficiently agile and flexible to promote dynamic, multi-platform technologies. This is a function that can only be performed by specialized companies that have this dynamic capability.

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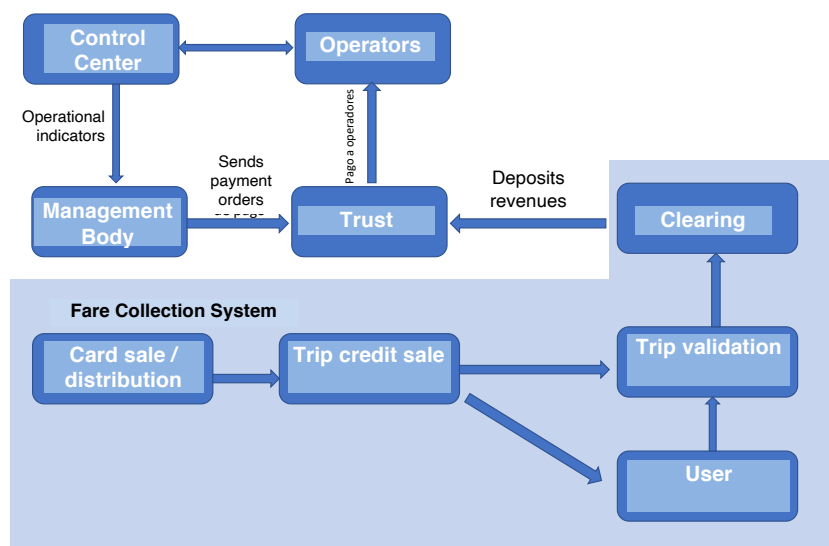


Figure 25: Management relationship with the collection system and operator compensation

6.3. MANAGEMENT AND OPERATIONS MODEL ALTERNATIVES FOR QUITO

6.3.1. MANAGEMENT MODEL

The projects model must be placed within the context of a comprehensive management model. The project can be the seed for the implementation of Quito's comprehensive transport management model.

Discussions are currently underway to set up a Single Transportation Authority which may be fully in charge of as the system's effective management body.

Even if this Single Authority is implemented in a few months, the organization will take one to two years to be fully trained and ready to take on full responsibility for managing Quito's transportation system.

Three basic alternatives are considered for project management:

Implementing a Project Business Unit: The Unit would be part of the structure of the Mobility Secretariat and would be responsible for all project implementation activities: development in full of terms of reference, managing the bidding process, providing support in the discussion and implementation of the business model, developing financial analyses, introducing adjustments to study results, making information available to bidders, evaluating bids, negotiating contracts, and launching the project. The Business Unit can be the basis for the implementation of the Single Authority.

Implementing the Single Transportation Authority from the beginning: The Project Business Unit would be a group within the Authority with the same functions and responsibilities. Upon completion of the implementation, the Business Unit would join the Authority's activities.

Implementing the Project through its own Trust, under the supervision of the Single Authority, in charge of managing the operation. The Trust works as provider of the operational fleet (buses + batteries), either through financing or leasing, and contracting operators for the bus service and the fare collection service. Fleet management is conducted in a coordinated

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manner by the Single Authority, the Trust, and the bus operators. The Authority is responsible for paying Trust costs.

While the decision to contract the operator is made by the Authority or the Trust, the alternatives available must be reviewed beforehand by EPMT PQ.

Table 14:.. Alternative Management Models

Project Management Alternatives	Description
Project Business Unit – PBU	Unit does management before being incorporated into the Single Authority
Transport Single Authority	Project management is part of the Single Authority
Authority + Management Trust	Authority manages the operation of services and trust manages contracts, construction and additional operation activities in terminals and stations

6.3.2. OPERATION MODEL

The operation model contemplates: (a) continuity of the Quito Metropolitan Public Passenger Transport Company (EPMT PQ), (b) concession of the Ecovía corridor to a private operator and (c) total concession of the two corridors to one or more private operators.

Buses can be owned by the operator or by a private investor. There is still the alternative of separate providers for buses and batteries (Shenzhen, China model). In the Chinese model, the energy company is the supplier and maintains the batteries and the entire battery charging infrastructure.

The alternatives are shown in Table 15 below.

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Table 15: Alternatives for operation

Alternatives to operate bus services and bus acquisition		
Operator	Bus Acquisition	Operation Model
Operation done totally by EPMPQ	1. City acquires buses with batteries	EPMPQ in charge of bus operation and maintenance
	2. EPMPQ does direct leasing of buses	a. EPMPQ in charge of bus operation and maintenance under leasing company supervision
		b. EPMPQ operates and leasing company does maintenance
	3. Acquisition shared	
	EPMPQ purchases/ leases buses	•EPMPQ operates and maintains buses
EPMPQ operates Central corridor Ecovía is privately operated	Energy company buys batteries	•Energy company maintains batteries
	•City buys trolleybuses and e-buses for Central corridor	•EPMPQ operates and maintains trolleybuses and e-buses of Central corridor
	•Private company buys/leases buses for Ecovía's Carapungo extension and takes on current diesel buses	•Private company operates and maintains buses e-buses of Ecovía Corridor – Carapungo Extension
	•Buses are purchased with the batteries or the energy company purchases batteries	•Private operator maintains batteries
Operation exclusively by private operator	•Battery supplier is also the supplier of charging stations and chargers for batteries	•Energy company maintains batteries
	•Private operator purchases/leases buses and "inherits" current diesel buses	Private operator operates and maintains trolleybuses and e-buses of Central Corridor and Ecovia Corridor – Carapungo Extension
	a. Private operator buys buses and batteries	• Private operator maintains batteries
	b. Energy company buys batteries	•Private company maintains batteries
Operation shared by private operator and EPMPQ	• Battery supplier is also supplier of charging stations and chargers for batteries	•EPMPQ would become management body or the Transport Single Authority
	Private operator buys trolleybuses and e-buses	•EPMPQ operates and maintains diesel buses
	Private operator buys batteries	Private operator operates and maintain electric buses (trolleybuses and e-buses) and batteries
	Energy company buys batteries	Energy company maintains batteries

6.3.3. ADVANTAGES AND DISADVANTAGES OF OPERATING ALTERNATIVES

All models have advantages and disadvantages, but consultants recommend delegated management with partial concession (Ecovía Corridor).

The justification for this recommendation is that the Ecovía Corridor had already been conceived for private operation, even though this did not happen then. This option would have lower impact on EPMPQ's labor liabilities and would attract private investment for the acquisition of electric buses.

This recommendation does not avoid the question of fare adjustment and the financial sustainability of the concession and EPMPQ's workers compensation debt.

The advantages and disadvantages of each alternative are summarized in Table 5.

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Table 16: Advantages and disadvantages of operation models

Model	Advantages	Disadvantages
Operation totally done by EPMPQ	a. No change to existing model	a. Public company inefficiency is maintained
	b. Easy integration with Metro	b. Subsidies to the company is maintained
	c. Maintains experience in trolleybus operation and maintenance	
Delegated management and partial concession, shared operation	a. Investment by private operator	a. Performance in shared operation is 20 to 30% less than operation by single organization
	b. Maintenance and operation by private operator	b. Requires a mechanism to compensate operator for services provided
		c. Operator has limited responsibility for planning the services
		d. Conflict of interest between private and public companies
Delegated management and partial concession of Ecovía Corridor	a. Partial investment by private operator	a. Requires transferring diesel buses to private operator
	b. Operation of Ecovia Corridor done totally by private operator	
	c. Maintenance by private operator	
	d. Maintains independent operation of Central Corridor and Ecovia Corridor	b. Requires shared operation of EPMPQ's shops and depots
	e. Training of EPMPQ as contract manager	
	f. Partial impact on EPMPQ labor liability	c. Requires a contract with private operator for services provided and for passengers carried
	g. Partially solves the city's financial issues	
Delegated management with total concession	a. Transfers entire system to private operator	a. EPMPQ's labor liability needs to be settled in a single stroke
	b. Operation is more efficient	b. Strong reaction from unions
	c. EPMPQ becomes a management body	c. High political risk
	d. Solves the issue of lack of investment by City Administration	d. Transferring EPMPQ assets to private operator may be complicated

6.4. MODEL CHOSEN BY THE QUITO ADMINISTRATION

The City of Quito Administration has decided to maintain EPMPQ operation and acquire the fleet through leasing. The leasing operation will be carried out by EPMPQ, even though 70% of VAT could be recovered and saved if it was carried out by the Mobility Secretariat.

Consultants respected the decision and went ahead to develop the terms of reference and the bidding documents under this modality.

The arguments presented by the consultants in different discussions on bus acquisition included the general conditions previously analyzed.

1. Fleet acquisition by direct purchase

- This is the option with the lowest cost since it can be carried out with supplier credit or low interest credits provided by multilateral banks or the IFC.
- It is the option that requires more time to process credits, sign contracts, bidding process, and sign the contracts.
- The company assumes all the risks
 - technical problems with the vehicles after the years of warranty
 - handling the learning curve on new technology
 - Issues with the company's lack of technical capability

2. Leasing operation by the Mobility Secretariat

- Not much time required to obtain credits
- But needs council approval and identification of payment sources

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- c. Leasing costs are 3 to 5 points above interest rate on the loans for the acquisition of buses.
- d. Maintenance will also have extra costs and will be between 10 and 15% above regular costs, including administrative costs and capital required to purchase spare parts to ensure vehicles are always available.
- e. The leasing company will have to maintain a stock of products to avoid running out of imported spare parts.
- f. 70% of the VAT payment can be recovered.

Leasing operation by EPMPQ

It is the most expensive option. In addition to all the leasing costs, the VAT cannot be recovered, which means 8.4% additional cost to the contract (70% of the VAT amount can be recovered by the Mobility Secretariat).

It is also necessary to consider that EPMPQ can only sign a leasing contract if the City Administration approves monetary transfers to the company if fares are not enough to pay for the services.

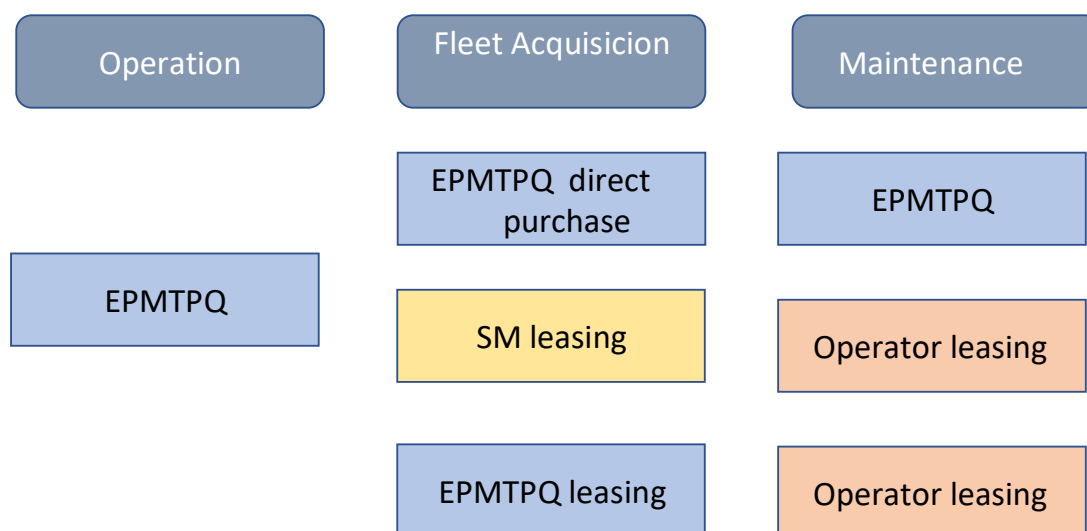


Figure 26: Fleet acquisition alternatives

The advantages and disadvantages of hiring a fleet by leasing contract are:

- a. Advantages
 - i. Guarantees better availability of buses
 - ii. Better maintenance.
 - iii. Assumes risks before suppliers for manufacturing defects or bus performance problems.
 - iv. Assumes part of the electric bus technology risks.
 - v. Contract for the life span of the vehicle; the incorporation of new vehicles are done through new leasing contracts.
 - vi. Warranty for practically the entire life span of the vehicle.
- b. Disadvantages
 - i. Higher cost.

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- ii. Conflicts that can be created with drivers' performance.
- iii. Requires keeping funds to pay for at least six months of leasing (the investor may require funds equivalent to one year). That time window is necessary as a buffer to deal with late payment problems and conflict resolution in the case of breach of contract.

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7. INSTITUTIONAL AND LEGAL FEASIBILITY

7.1. INTRODUCTION

Public transport is a fundamental element for the development and competitiveness of cities. It is an important component in the investment budgets of each city, and usually requires subsidies to be properly provided. Public transport also impacts the population in many ways, among them impact on public health and the environment, especially when their use is based on non-renewable fossil fuels, as is the case of the Metropolitan District of Quito.

This study reviews the current legal framework at both the national level and at the level of the Metropolitan District of Quito, as well as the institutional framework of public passenger transport, as they relate to the acquisition of articulated buses and electric trolleybuses.

Following that, the feasibility of possible models of implementation and operation is analyzed in the context of the allowed institutional and legal framework, the possible advantages and limitations of each model are pointed out, and an option is made for the scenario decided upon by the municipal authorities within the process of developing this study.

7.2. IDENTIFICATION AND ANALYSIS OF THE LEGAL FRAMEWORK AND INSTRUMENTS FOR THE IMPLEMENTATION AND OPERATION, INCLUDING THE INTERNATIONAL, NATIONAL, AND LOCAL LEGAL CONTEXT

The Paris Climate Change Agreement (PA), signed in 2015, is the main binding commitment signed within the framework of the United Nations, to respond globally to the causes and consequences of climate change. Within this framework, Quito is a member of international networks of cities that fight climate, among them C40, Global Agreement of Mayors for Climate and Energy, ICLEI and UCLG.

In October of 2017, the Metropolitan District of Quito (DMQ) joined the C40 Fossil Fuel Free Streets Declaration whereby each city commits to take action to reduce vehicle emissions. Among proposals to fulfill this objective is transitioning vehicles that use fossil fuels to clean technology vehicles in the Metropolitan District of Quito's transport system.

Two subprojects comprise the energy efficiency policy that seeks to promote the competitiveness of the national economy, support the construction of a culture of environmental sustainability and energy efficiency, contribute to the mitigation of climate change, and guarantee the rights of people to live in a healthy environment.

The legal framework for regulating public transport includes: the Constitution of the Republic of Ecuador, the Organic Code of Territorial Organization, Autonomy and Decentralization (COOTAD), the Organic Law of Land Transportation, Traffic and Road Safety (LOTTTSV) and its regulations, the Energy Efficiency Law, the Codification of the Organic Law of the Municipal System, the Organic Law of the System for the Metropolitan District of Quito, the Municipal Code for the Metropolitan District of Quito, the ordinances and resolutions that have been issued in the institutional instances responsible for the management of transport in the MDMQ, such as the Metropolitan Council of Quito, the Metropolitan Mayor's Office and the Mobility Secretariat and by the Metropolitan Public Company of Passenger Transport of Quito itself.

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The Ecuadorian State considers that transportation is a strategic sector and therefore reserves its management to the public sector. However, it may delegate participation in strategic sectors and public services to joint ventures of which it is a major shareholder. It also may, exceptionally, delegate to the private initiative and to the popular and solidarity-based economy the performance of these activities, in the cases established by law.

The regulations indicate principles for energy efficiency, development and use of environmentally clean and healthy practices and technologies, as well as diverse, low-impact and renewable energy that do not put at risk food sovereignty, the ecological balance of ecosystems, or the rights to water.

LOTTTSV and its regulations determine that municipal governments have exclusive jurisdiction to *"Plan, regulate and control traffic and public transportation within their municipal territory."*

The promotion of mass public transport and the adoption of a policy of differentiated transport fares will be a priority.

All forms of monopoly and oligopoly in land transportation service are prohibited.

7.2.1. LEGAL POSITION, RESPONSIBILITIES AND JURISDICTION OF EACH ENTITY INVOLVED IN THE IMPLEMENTATION AND OPERATIONS

The main government agencies involved are:

The National Agency for the Regulation and Control of Land Transport, Traffic and Road Safety, which regulates and controls all transport matters nationally; its provisions must be obeyed by the country's municipalities.

The Municipality Council of the Metropolitan District of Quito, which sits at the highest level of municipal government, among other matters under its jurisdiction, can issue cantonal ordinances, agreements, and resolutions.

The Metropolitan City Administration performs management functions through the Mobility Secretariat who oversees the regulation and planning of transport in the city. Finally, on the operational level, appears Quito's Metropolitan Passenger Transport Company.

7.2.2. MAPPING THE PATHS OF PROCUREMENT BY DECISION MAKERS INVOLVED

For bus acquisition, the unit that requests the good or service has to carry out the following activities, among others: a) issue the contracting request; b) evaluate offers submitted by suppliers; c) if there is a Technical Contracting Commission, such commission must be part of the process, as would be the case here; d) recommend awarding or forfeiting the process, and e) sign the delivery/receipt of the contracted good or service.

There is a preparatory stage for obtaining and preparing requirements for the bidding process, and contracting after the award is given. Before initiating pre-contractual procedures, and according to the nature of the contract, the entity must have the complete, definitive and updated studies and designs, as well as plans, calculations, and technical specifications, all duly approved by the applicable administrative bodies. These projects must be included in the entity's Multi-Year Investment Plan and Annual Contracting Plan. As a prior condition to their approval and to start the contractual process, these studies and designs will necessarily include a review of technological unbundling or Inclusion procurement, as appropriate, which

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will determine the minimum level of national or local participation, in accordance with the methodology and the parameters set forth by the National Public Procurement Service.

All corresponding authorizations and certifications by decision makers must be obtained to avoid that the desired procurement process be declared void.

The working path will be chosen according to the modality the municipal authorities or EPMTF decide to choose, whether direct acquisition, leasing, supplier credit, special regime, partial concession (partial PPP), or total concession (total PPP). Whatever the modality chosen, for transparency purposes and in compliance with the law, government procurement must be carried out through a call for companies to bid according to previously disclosed bidding documents. An appointed Technical Commission will review and qualify the bids, choose the best offer, then award the bid and proceed with the signing of the corresponding contract, the appointment of a contract administrator, and registering it at SERCOP (Public Procurement Office).

7.2.3. CURRENT RESPONSIBILITIES IN IMPLEMENTATION AND OPERATION

These responsibilities include: (1) summary of the implementation structure currently proposed; (2) identification of advantages, weaknesses, and risks of the current structure; (3) review of capabilities capacity and roles of each entity involved.

The main steps are:

- Conducting the studies required to show the project's feasibility in all its components; this is also required for the issuance of technical, legal, and financial reports and their corresponding approval.
- Developing terms of reference for the acquisition of electric buses. This instrument is a necessary condition to establish the technical and technological requirements for the procurement of electric buses.
- Apply for the certification of the multi-year budget item, in accordance with the provisions of the Organic Code of Planning and Finance; this is required in preparation for the pre-contractual procedure.
- Review by the Administrative Board, or office responsible for preparing bidding specifications for the procurement of the equipment, as the case may be.
- Review of the bidding specifications by the Metropolitan Attorney General's Office and drafting of the conditions to be included in the contract sent along with the specifications.

It is important to note that for both the acquisition, in view of the amounts, and the concession (in view of the delegation), the authorization is required from the Board of the Metropolitan Public Transport Company of Quito and the Metropolitan Council of Quito.

7.2.4. CURRENT AND ANTICIPATED LAWS AND REGULATIONS THAT MAY AFFECT PROJECT IMPLEMENTATION

Following are the rules that must be considered for acquisition, leasing or concession procedures:

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The Constitution of the Republic of Ecuador; the Organic Law of the National Public Procurement Service and its Regulations; the Organic Code of Territorial Organization, Autonomy and Decentralization (COOTAD); the Organic Code of Planning and Public Finance; the Organic Law of Land Transportation, Traffic and Road Safety, and its regulations; the Law of Metropolitan Regime of Quito, the Law of Public Companies; the Charter of Public Companies, any delegations in force which relate to the bidding matter, the Organic Administrative Code, the Organic Monetary and Financial Code, and the Municipal Code.

7.3. THE FEASIBILITY OF POSSIBLE IMPLEMENTATION AND OPERATION MODELS, GIVEN THE INSTITUTIONAL AND LEGAL FRAMEWORK

This chapter reviews the feasibility of the possible models of implementation and operation within the legal and institutional framework in force at the Municipality and Metropolitan District of Quito. It also develops a proposal of specifications for the international public bidding related to the procurement of articulated buses and electric trolleybuses for Quito's public transport service.

Each of the possible modalities is analyzed as a solution for the acquisition of articulated buses and electric trolleybuses, such as direct acquisition, leasing, supplier credit, partial or total concession, as envisaged by means of a PPP (Public-Private Partnership), and considering the advantages and limitations of each of these alternatives. A further review is conducted of the modality that, in the opinion of the consultants, would be more appropriate for the partial concession of the corridor called "Ecovía and the direct acquisition of trolleybuses for the Central corridor.

In view of the decision and the needs expressed by the authorities, the leasing modality was further investigated, and it includes maintenance of the electric buses and the loan of at least one property to be used as a workshop for maintenance and electric recharging of the buses.

7.4. RECOMMENDATIONS FOR THE IMPLEMENTATION AND OPERATIONAL STRUCTURE

Financial, institutional, and technical barriers that exist now or in future must be considered always, but especially now since the start of a pandemic that generated not only a financial but also an institutional crisis.

It is very difficult for any modality to operate successfully if a management model is not in place for the transportation system. As mentioned before, the management model is exhausted and must be replaced with a more comprehensive and current model that takes into consideration developments such as the start of Metro service, the electric bus system, fare updates, the revision of a bus life span, the conditions of operation contracts, and the fare collection system, among other topics. All these are essential conditions for the success of the acquisition modality they end up choosing.

On the other hand, it is necessary to have a work team of leaders responsible for the entire process of preparation, authorization and execution. Equipped with the right roadmap, they will comply with their obligations, terms and conditions, and will be able to render an account of process advances.

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The City's governance regulations, including its comprehensive transport management system, must be reviewed and updated within the framework of a new institutional framework, one that responds to the current and future needs of transport management in the Metropolitan District of Quito. This review should include an electric bus system that can help to ensure the city has a good public transport system, whether through the city's direct management or private operators.

7.4.1. HIGH-LEVEL RECOMMENDATIONS FOR THE OPERATIONAL STRUCTURE

For good governance, the recommendation is to have a Project Management Unit that, under its leadership, prepares, reviews, and presents to the corresponding authorities a proposal regarding the mode of execution, and carries out all actions required to fulfill this mission. The study document sets forth the outline of an institutional framework that allows maintaining a long-term vision, its strategic role, and the connection with other areas of governance. It also includes a plan to manage system operation risks, and a draft plan for the management and best use of the data collected in the operation of the system.

7.4.2. DEVELOPMENT OF TECHNICAL AND OPERATIONAL CAPABILITIES AMONG EXECUTING AND OPERATIONAL ENTITIES

A proposal is made to train human resources so they can carry out the necessary and indispensable process. The purpose is to have a strong technical team that is able to carry out the preparations, adjustments, and corresponding execution. The transport service with electric buses is something new for the City of Quito and, as a new technology, it requires special attention so the city can reap its benefits, but also be prepared to handle its technical difficulties. It is essential to have a sufficiently strengthened operational team in Quito's Metropolitan Public Transport Company.

7.4.3. RECOMMENDATION TO ENSURE CONTINUITY IN THE NEW ADMINISTRATION

To ensure continuity, it is necessary to:

- (1) identify priorities and requirements of the new administration,
- (2) prepare a high-level summary of project progress to present to the new administration,
- (3) monitor and facilitate high-level meetings between the outgoing implementation team and the new administration.

The Municipality is committed to provide sustainable mobility to its citizen, which is why a set of measures should be adopted to have a change management process with a comprehensive and long-term vision. This would lead to institutional, financial, legal, and environmental sustainability of the transport management system. While it is true that the authorities on duty will change, the commitments and the institutional framework for a better service to the citizenry must not do so. The Project does not address all the problems of transportation management, but it does help to generate a process of change that needs to be implemented as a cross-sectional management policy.

Funding partners:



Implementing agencies:



8. FINANCIAL FEASIBILITY

8.1. INTRODUCTION

The financial feasibility review of the project is not a direct analysis in view of the problems the city faces after starting the metro operation and the impact of the pandemic on the public transport system and public finances.

This report presents the results of the financial analysis based on assumptions derived from information provided by the Mobility Secretariat and EMPTQ. It will be adjusted accordingly as more information becomes available about the city's financial situation.

Feasibility considers only the impact of each alternative's assumptions modeled in the demand analysis on the financial impacts of investment in new buses.

8.2. FINANCIAL MODEL

The financial modeling was structured using Microsoft Excel to create a specific analysis file for the city system. The model spreadsheets are mainly divided into time-related premises and non time-related premises for the operating company and general aspects of the system.

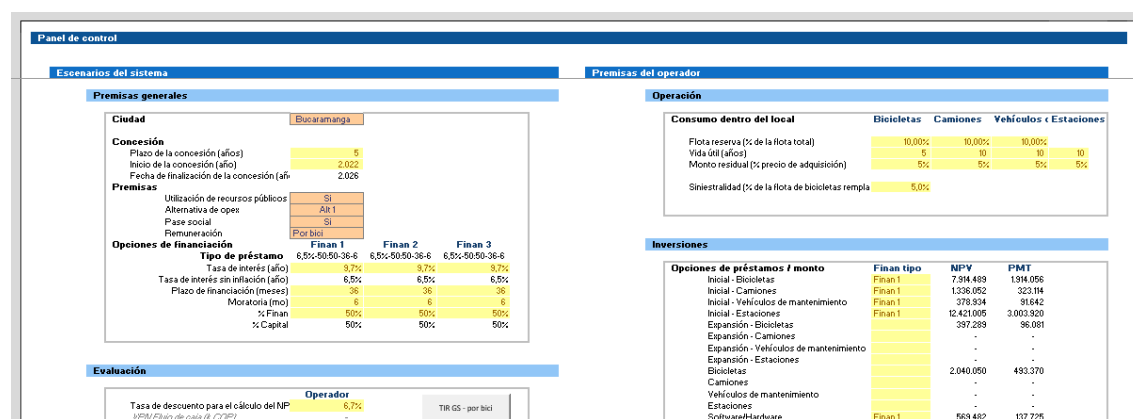


Figure 27: Financial Model Control Panel

Source: Logit

In order to develop conditions for the system's business model, an ample, dynamic and iterative process needs to take place, from successive qualitative and quantitative evaluations, and adjustments and successive estimations of the study premises until optimal business conditions are obtained, as well as discussions between multidisciplinary teams of consultants and city representatives, among other processes.

Funding partners:



Implementing agencies:



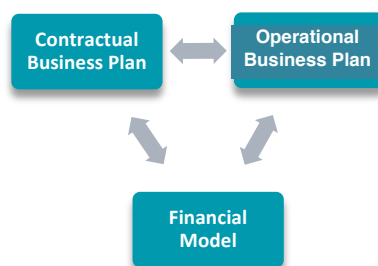


Figure 28: Integrated iterative process between different study areas

Source: Logit

8.3. METHODOLOGY

The methodology used for the evaluation and financial viability review is that of the Discounted Cash Flow (DCF), traditionally applied in the financial world for the analysis of companies and projects of multiple sectors of the economy. To calculate cash flows, projections are made of Income Statement, Balance sheet, and Cash Flow Statement and from these, the calculation is made of project cash flows (without financial leverage, or Free Cash Flow), and the shareholder's cash flow (with financial leverage).

The modeling focuses on project cash flow, base on which evaluation indicators are calculated, such as Internal Rate of Return (IRR), Modified Internal Rate of Return (MIRR), payback (time till operator breaks even), and Net Actual Value (NAV). Project finance is reached when its Net Actual Value results in a null value. Thus, the operator's required remuneration is determined and the target profitability can be achieved.

As soon as the Net Present Value becomes a null value, this means that the Project's Internal Rate of Return equals the Opportunity Rate (WACC-Weighted Average Cost of Capital) with which cash flows are discounted.

8.4. FINANCIAL ANALYSIS ASSUMPTIONS

8.4.1. PREMISES OF THE DEMAND AND OPERATING MODEL

The parameters that have the most impact on demand and financial results are the system's fare levels and integration between modes.

With the start of metro operations, fare levels are being discussed and it was agreed to consider two scenarios for the financial analysis:

- Scenario 1
 - 0.35 fare for BRT and conventional transport
 - 0.50 fare for the metro
 - Rate of 0.67 for the integration between CRT and metro
 - No fare integration between BRT and metro with conventional transport
 - Bus average occupancy: 140 passengers

Funding partners:



Implementing agencies:



-
- Scenario 2
 - 0.25 fare for BRT and conventional transport
 - 0.50 fare for the metro
 - No fare integration between BRT, metro and conventional modes
 - Free transfer within the BRT system (trunks and feeders)
 - No fare integration between the Ecovía and Trolleybus corridors
 - Bus average occupancy: 140 passengers

The starting operation of Labrador- Carapungo extension was initially considered for the end of 2021. With the pandemic, the analyses will consider the year 2024 for starting operation of the extension. Since the City of Quito has stated that the construction would not be possible before 2026, a new analysis was conducted considering this new date.

The parameters for bus replacement are:

- Life span of 15 years for Diesel buses, trolleys and e-buses
- Battery life span of 7.5 years
- All Diesel buses are replaced by e-buses at the end of their service life
- The routes share the operation between Diesel buses and e-buses until all Diesel buses reach their life span
- All new electric buses will be 18-m articulated
- Trolleybuses operate mainly on catenaries
- The Carapungo extension will use e-buses since the reorganization of services leaves too short a section on the catenary.

8.4.2. PREMISES OF THE FINANCIAL MODEL

The operator may be private or the public operator EPMT PQ. Both are considered under the same conditions as a private company. EPMT PQ does not seek profits, but a public company has other costs that exceed a private company's profits.

- Concession terms to operators are 15 years
- Existing diesel buses are transferred as a loan (without capital cost) to concession operator
- Investment Rate of Return in this model - 14.5%
- Interest rate 7.4% pa.
- Financing grace period: 6 months
- Percentage of capital financed - 70%
- Battery life - 7.5 years
- Beginning of the award: 2022
- End of the concession – 2036
-

8.5. CAPEX ESTIMATES

8.5.1. BUS PRICES

Costs were compiled by expert Pilar Henríquez in interviews with suppliers. The only price reference for Ecuador are from BYD buses. The price reference for the admission of buses is from Chile, with approximately 80,000 dollars corresponding to 18% of the CIF price of the bus. This was used for Quito when only the external CIF was known.

Funding partners:

Implementing agencies:

Considering 20% of the price as the cost to admit buses into Ecuador, we can estimate the possible cost of buses in Ecuador.

For the financial analysis, the price of 600 thousand dollars is being used.

Table 17: Cost of e-buses

Brand	Capex (kUSD)	Final estimated cost in Ecuador (kUSD)	Reference
BYD	595	595	Final benchmark value - Ecuador
Solaris	897		Price in Europe
Sunwin	450	540	CIF in Ecuador
Yutong	440	528	CIF in Ecuador

Source: Logit supplier's interviews

The price of trolleybuses has only one reference to price in Ecuador: it is from Yutong and quotes the same price for the articulated e-bus. The Solaris reference price is higher for trolleys and Skoda has a slightly lower price, but both are prices for Europe.

Since the data does not provide a more solid reference, the price used in the financial analysis is 600K USD for e-buses and 527K USD for trolleybus.

Table 18: Cost of trolleybus

Brand	Capex (kUSD)	Final estimated cost in Ecuador (kUSD)	Reference
Skoda	732 to 900		Price in Europe
Solaris	1000		Price in Europe
Yutong	440	527	CIF in Ecuador

Source: Logit supplier's interviews

8.5.2. BATTERY PRICES

Batteries are considered as 40% of the bus price for articulated e-buses and 20% of the price of articulated trolleybuses.

The price of batteries in 2019 was 198 USD / kWh. Bloomberg's estimated prices for 2030 are slightly more than 30% of the 2019 price. However, some analysts argue that the price cannot reduce so much because manufacturers' margins will be maintained, and metal prices will increase.

With more accuracy in the financial analysis, a 25% reduction in battery price is estimated for the first replacement in 2029. The cost of the first battery is 240,000 Euros. The second battery has a 25% price reduction, and 50% residual value for the second service life. After this, the price of the second battery will be 90,000 Euros.

For trolleybuses, the cost of the battery is 20% of the bus price.

Funding partners:



Implementing agencies:



8.5.3. COST OF BATTERY CHARGING INFRASTRUCTURE

The cost of infrastructure is variable depending on the charging technology and the power output of the charger. For this project, low power output chargers are indicated for overnight charging. The estimated cost for cabled infrastructure and chargers is 30,000 Euros per bus, using one charger for two buses.

8.6. OPEX ESTIMATES

The following main components were considered:

- Labor: wages and labor benefits
- Running: bus costs from running
- Maintenance: bus maintenance
- Other costs

8.6.1. LABOR COSTS

Labor costs were estimated based on EPMT PQ wages posted on the company's website. The average number of workers per bus were numbers used by Logit in other studies for Latin American countries.

Table 19: Labor costs

Class	Workers/bus	Base wage (USD)
Conductor	2,507	758
Mechanics	0.52	758
Backoffice	0.245	793
Supervisors	0.02	2,624.00
Directors	0.015	3,552.00

Source: Logit and EPMT PQ

Regarding benefits and obligations, the following premises were considered:

Funding partners:



Implementing agencies:



Table 20: Benefits and Obligations

Parameter	Value
Private Sector Sponsorship	11.15%
Insurance for disability, old age, death	3.10%
Organic disability law	0.00%
Health insurance	5.71%
Work insurance	0.55%
Furlough insurance	1.00%
Rural worker social insurance	0.35%
Administration fees	0.44%
Thirteenth Salary (Christmas Bonus)	8.33%
Forteenth Salary (% of minimum wage)	8.33%
Reserve Fund	8.33%
Vacations	4.17%
Total	40.31%

Source: Logit

8.6.2. MAINTENANCE COSTS

To estimate costs related to maintenance of the equipment, the basic information was provided by suppliers / operators consulted during the study. Maintenance costs are already expressed as cost per km traveled by buses, considering an average of 64,000 kms traveled per year.

Table 21: Maintenance costs for diesel buses

Variable Cost / Diesel bus	Articulated	Bi-articulated
Air System	0.057	0.057
Steering - Suspension of Chasis	0.077	0.077
Lubrication System	0.031	0.052
Air Conditioning System	0.041	0.041
Electrical System	0.046	0.046
Braking System	0.142	0.142
Transmission System	0.018	0.018
Differential System	0.01	0.01
Body System	0.02	0.02
Bodywork maintenance	0.008	0.008
Scheduled Maintenance	0.087	0.087
Tools	0.03	0.03
Cleaning System	0.006	0.006
Total	0.573	0.594

Funding partners:

Implementing agencies:

Source: Logit

Table 22: Maintenance seats for electric buses

Variable Cost / Electric bus	Trolleybus	E-bus
Lubrication	0.017	0.017
Consumables	0.043	0.043
Braking System	0.021	0.021
Suspension	0.061	0.061
Steering	0.007	0.007
Air compressor	0.007	0.007
Electric motor	0.066	0.066
Bodywork	0.017	0.017
High Voltage Power	0.057	0.057
Low Voltage Power	0.012	0.012
Linkage	0.013	0.013
Total	0.321	0.321

Source: Logit

For costs for maintaining and retreading tires, the following assumptions were used:

Table 23: Cost of replacing and retreading tires

Vehicle	Number of tires	Cost (USD / tire)	Lifespan	Number of retreads	Cost (USD / Retread)	Cost (USD / km)
Articulated (Diesel)	10	450	200,000	3	250	0.06
Bi-Articulated (Diesel)	14	450	200,000	3	250	0.084
Trolleybus (Tram)	10	450	200,000	3	250	0.06
E-Bus (Tram)	10	450	200,000	3	250	0.06

Source: Logit

8.6.3. ENERGY / FUEL COST

The cost of electric power is 0.06 USD/kWh and fuel is 1.037 USD/gallon (0.27 USD/liter).

The following tables show the estimated consumption by vehicle.

Table 24: Fuel Cost and Consumption by Diesel Buses

Variables	Articulated	Bi-articulated
Fuel consumption (liters / km)	0.7003	1.1983
Fuel Cost (US \$ / km)	0.1918	0.3283

Funding partners:



Implementing agencies:



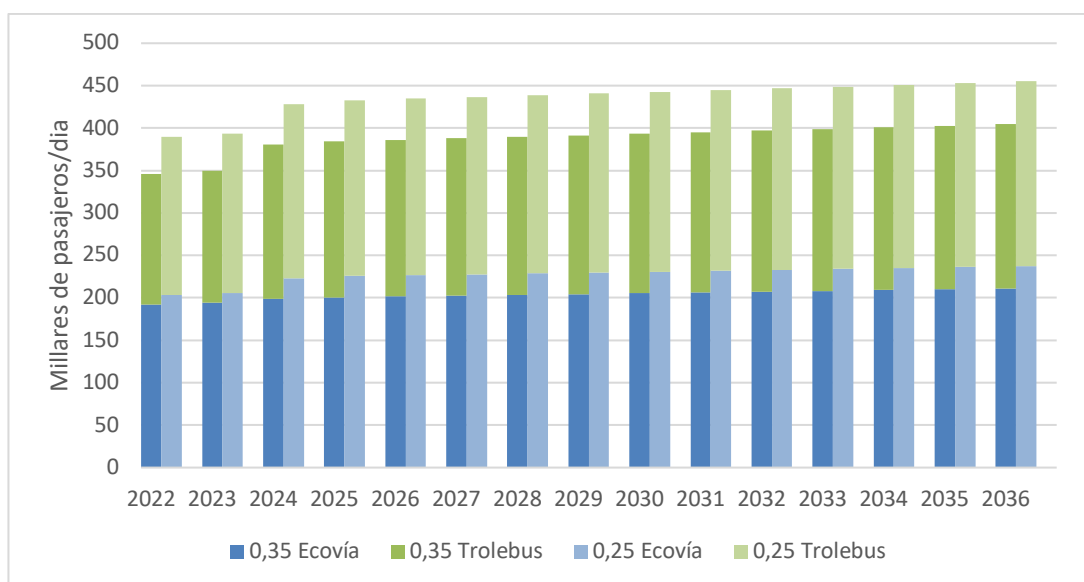
Table 25: Energy Cost and Consumption by Electric Buses

Variables	Trolebus	E-bus
Power consumption (kwh / km)	1.83	1.83
Cost of Energy (US \$ / km)	0.1098	0.1098

8.7. DEMAND IN SIMULATED SCENARIOS

The demand variation in both scenarios is a function of the difference in fare between buses and the metro. The metro fare is set in both cases as USD 0.50. The demand for the corridors was estimated considering two fare levels: 0.35 and 0.25, depending on the premises of item 2.1.

With the lower fare in BRT and conventional buses, the metro demand is also lower, considering the different fare between the modes. With a fare of USD 0.35, the difference is lower and the metro demand increases.

**Figure 29- Estimated daily demand per corridor by fare level**

Source: Logit

The estimated demand for the year 2022 is 350,000 passengers/day considering the fare of USD 0.35. The results observed, considering the fare of USD 0.25, show a demand of 390,000 passengers/day in 2022 and 455,000 passengers/day in 2036. It is possible to notice an inflection in the behavior of the demand curve in the year 2026, due to the start of operations of the Labrador-Carapungo extension.

To convert the daily demand to annual demand, a total of 302.6 equivalent days/year is used.

8.8. FARE REVENUES

Considering the demand projection, fare revenues were obtained for the two scenarios, as shown in the figure below.

Funding partners:



Implementing agencies:



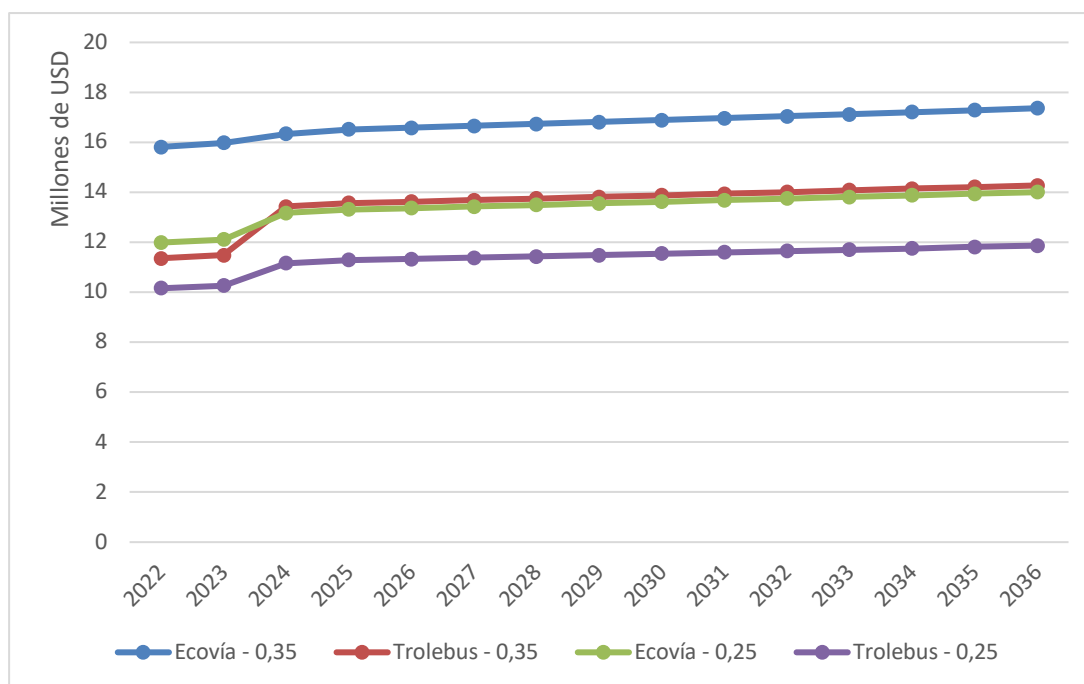


Figure 30– Fare Revenues

Source: Logit

8.9. TAX AND ACCOUNTING PREMISES

The main accounting and tax assumptions are summarized in the following table.

Table 26: Summary of accounting and tax assumptions

Type	Assumption
Value added tax (VAT)	12%
Income tax	30%

Source: Logit

8.10. DEADLINE FOR RECEIVING INCOMES OR PAYING DEBTS

Deadlines for receiving incomes or paying debts are also considered in the model. The deadline considered are number of days to receive funds or proceed to payment. Numbers used are derived from a survey with operating bus companies and are shown in the following table.

Funding partners:



Implementing agencies:



Table 27: Deadlines for receiving payments or paying debts

Type	Deadline (days)
Fare income	7
Other incomes	30
Public funds	30
Main expenses	7
Wages	15
Other expenses	30

Source: Logit

8.11. PROFITABILITY

While projecting the free cash flow in the project, the model uses the approach to calculate the amount of remuneration to the operator that is required so that its project IRR be equal to the reference profitability target rate (WACC).

Because it symbolizes the value of the company's money in time, it is used as a rate of discount for the project's free cash flow to calculate its NAV.

The rate of profitability (or WACC) adopted is 12%, as applied by EMTPQ in other projects.

8.12. FINANCIAL RESULTS

The following table shows financial results in these scenarios for Year 1. The fare and non-fare inflows are not sufficient to cover the cost of the system and there is a need to use public funds to subsidize the losses, so profitability is reached. This subsidy can be up to 20 million dollars, considering a fare of 0.35 for the corridors. A large operational margin is necessary to make the capex payment possible.

Table 28: Financial results for year 1 for scenarios without subsidy in CAPEX (amounts in thousands of dollars)

Variable	Ecovía - 0,35	Trolebus 0,35	Ecovia+Trolebus 0,35	Ecovía - 0,25	Trolebus 0,25	Ecovia+Trolebus - 0,25
Revenue	15,816.24	11,361.00	27,220.26	11,989.18	10,159.13	22,207.58
Demand	58,173.21	46,567.30	104,740.51	61,471.02	56,444.15	117,915.17
Equivalent Fare	0.2719	0.244	0.2599	0.195	0.18	0.1883
Operational Subsidy	11,393.47	8,716.27	19,835.28	19,360.52	11,941.22	31,150.61
Project Cost	27,209.71	20,077.28	47,055.54	31,349.71	22,100.35	53,358.19
Operative Cost	14,643.70	10,253.03	24,880.93	16,816.97	12,030.53	28,831.71
Operating Margin (%)	46%	49%	47%	46%	46%	46%
Technical Fare	0.4677	0.4311	0.4493	0.51	0.3915	0.4525

Source: Logit

Funding partners:



Implementing agencies:



8.13. SCENARIO FOR OPERATION OF THE LABRADOR-CARAPUNGO EXTENSION STARTING IN 2026

The pandemic had a major impact on Quito's finances. The Quito administration is predicting that the extension cannot be built before 2026. Even 2026 may be uncertain, as the recovery of the City's finances cannot yet be predicted at this time.

For this scenario, the estimated capex projection is shown in the following figures:

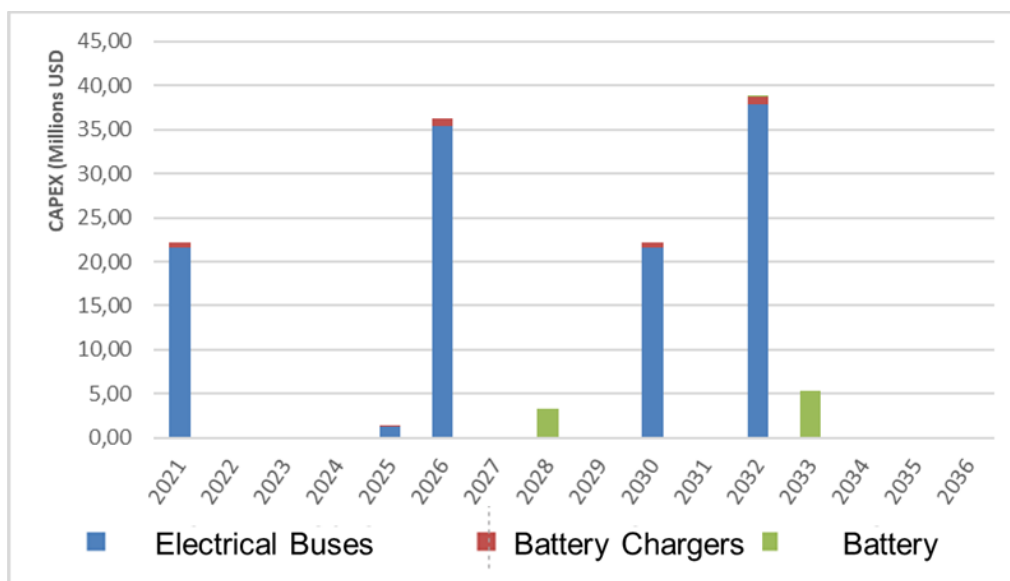
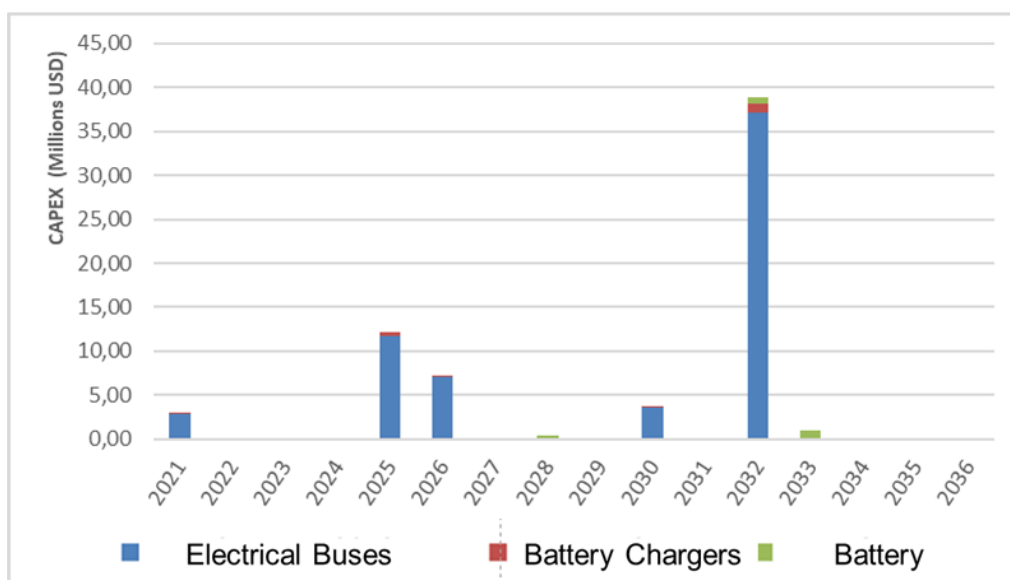


Figure 31: CAPEX projection - Ecovía Corridor

Source: Logit



Funding partners:



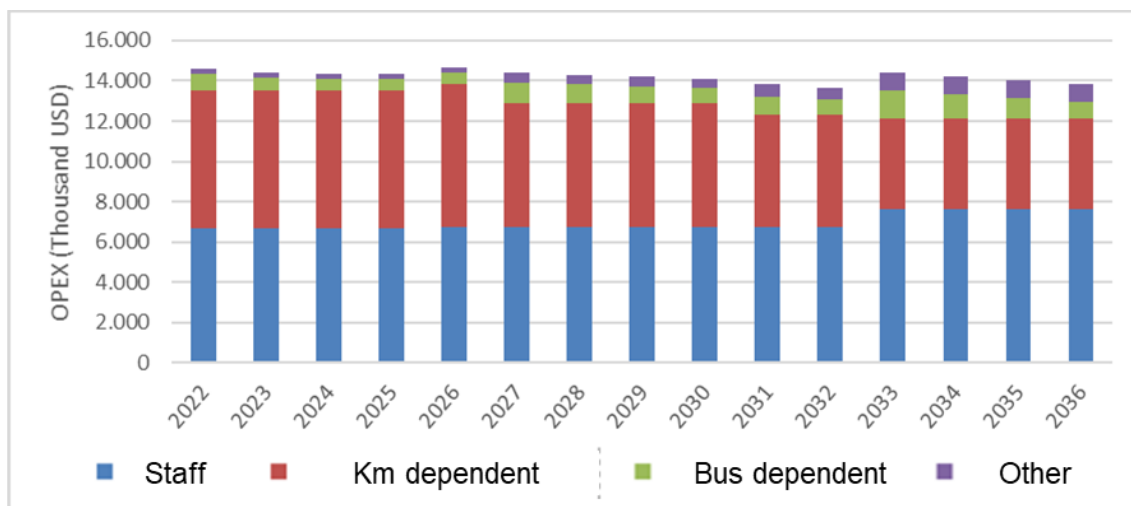
Implementing agencies:



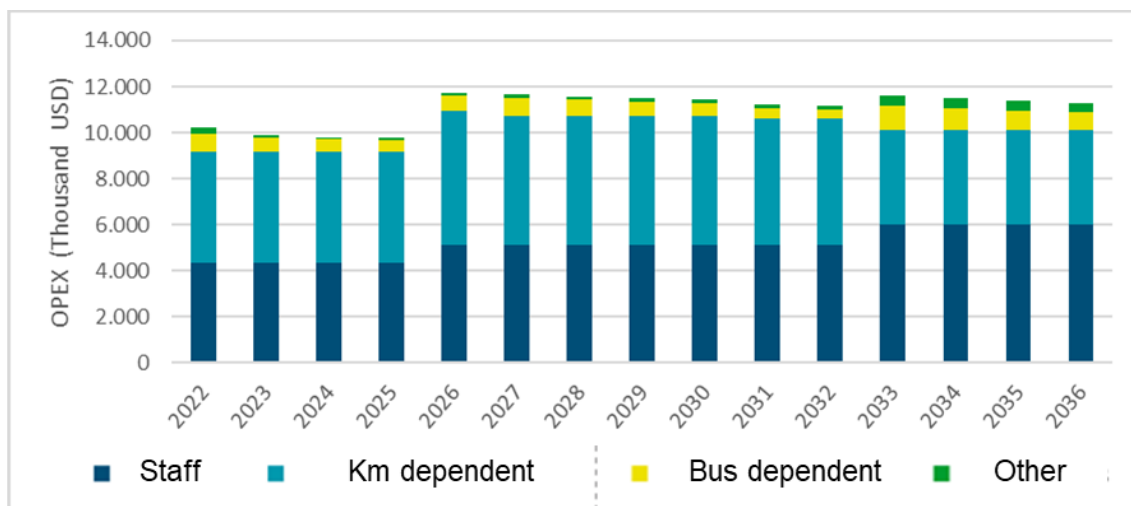
Figure 32: CAPEX projection - Trolleybus Corridor

Source: Logit

Following are OPEX projections for each year over the period of operation of the project, in thousands of dollars.


Figure 33: OPEX projections - Ecovía Corridor

Source: Logit


Figure 34: OPEX Projections - Trolleybus Corridor

Source: Logit

Funding partners:


**CHILDREN'S
INVESTMENT FUND
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UK Government

USAID
FROM THE AMERICAN PEOPLE

Implementing agencies:

giz Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH


Finally, the estimation of fare income for the two corridors shows that the trolleybus has a better result with the operation of the Labrador-Carapungo extension.

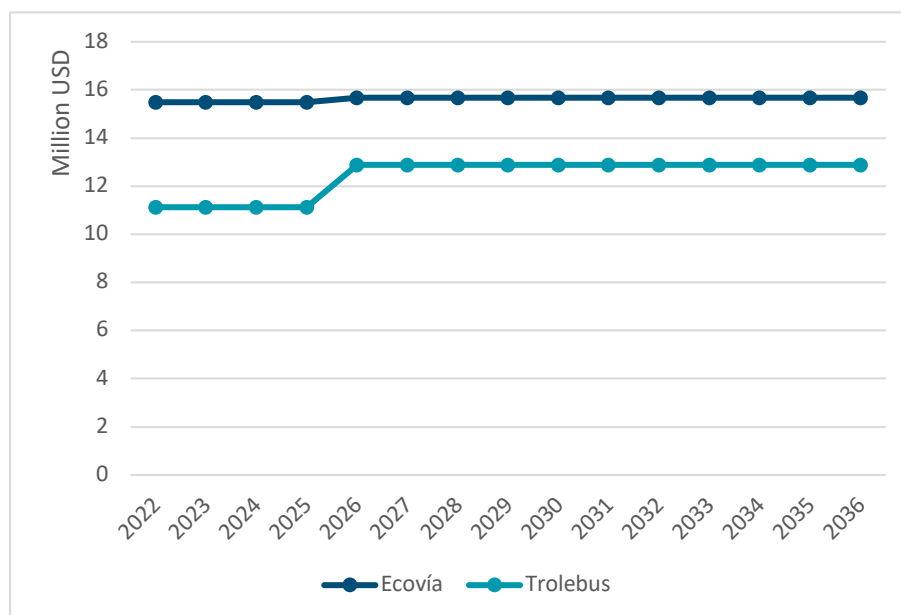


Figure 35: Fare income

Source: Logit

The following table shows the financial results of these scenarios for Year 1. Notice that the fare and non-fare incomes are not enough to cover the cost of the system and there is a need for the use of public funds to cover costs for the operator, so that the target profitability is achieved. This subsidy can be up to 14 million dollars. Also notice that a large operating margin is necessary to pay the project capex.

Table 29: Financial results for year 1 for the scenarios without subsidy in CAPEX (amounts in thousands of dollars)

Variable	Ecovia	Trolleybus	Ecovía + Trolleybus
Fare income	15,487.54	11,124.90	26,654.56
Demand	56,964.24	45,599.53	102,563.77
Equivalent Fare	0.2719	0.244	0.2599
Subsidy	10,692.60	3,885.61	14,011.62
Project cost	26,180.14	15,010.51	40,666.18
Operating Costs	14,597.85	10,250.06	24,832.11
Operating margin (%)	44%	32%	39%
Technical Fare	0.4596	0.3292	0.3965
Total Cost (remuneration + Leasing)	26,180.14	15,010.51	40,666.18

Source: Own elaboration

Funding partners:



Implementing agencies:



8.14. FLEET LEASING ALTERNATIVE

The diesel fleet still has time till the end of its life span. This means EPMT PQ can operate with electric buses and diesel buses at the same time.

The leasing contracts are for the new fleet and the analysis considered only the first fleet acquisition. The model is not sensitive if the operation is made by EPMT PQ or by a private operator as concessionaire.

If the Mobility Secretariat signs the leasing contract, there is a benefit because 70% of the IVA paid can be recovered, but this was not considered in the model.

The leasing contract disconnects the bus property from the operator. There is a fleet supplier that rents the buses to the operator and performs the maintenance of the buses.

The operator is responsible for the payment of energy consumption, drivers wages, operations planning and monitoring, fleet management, fare collection, security, infrastructure maintenance, and service monitoring and supervision. The maintenance by the leasing company introduces higher costs but also reduces risks of lower quality service.

The leasing alternative considers a 15% rate of return per year, representing a 3% spread over the IRR used for the project in the former analysis. It also considers a 33% surcharge on the prices for spare parts and 10% over the maintenance labor wages.

The cash flow for the operator is presented below.

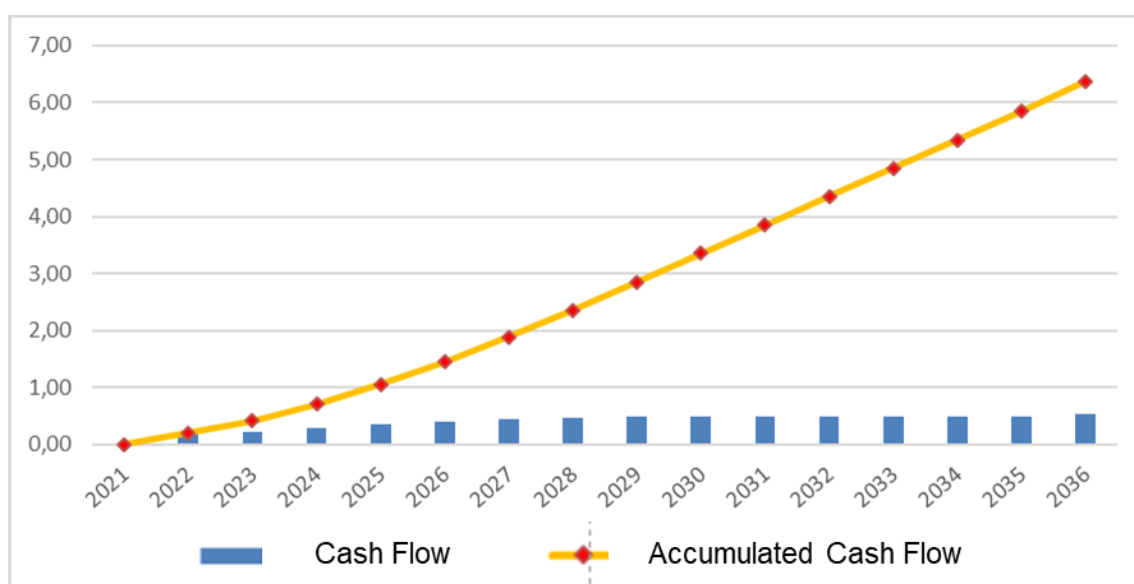


Figure 36: Operator's free cash flow for fleet leasing alternative

Source: Logit

Comparative financial results between the two alternatives studied are presented in the table below. Fare incomes are the same for both cases. The subsidy, which is a public contribution to the project, is USD6 million/year in the case of private concession.

Funding partners:



Implementing agencies:



Table 30: Financial results for year 1 for alternative scenarios

Variable	Private fleet acquisition	Fleet Leasing
Fare income	5,612.52	5,612.52
Demand	21,596.36	21,596.36
Equivalent Fare	0.2599	0.2599
Subsidy	5,948.41	-1,614.91
Investment cost	11,560.93	3,997.61
Operative Costs	5,322.40	3,791.08
Operating margin (%)	54%	5%
Technical Fare	0.5353	0.5516
Leasing payment	0	7,914.91
Total Cost (Operative + Leasing)	11,560.93	11,912.52

Source: Logit

8.15. VALUE FOR MONEY

The analysis of value for money has the objective to compare the different behaviors of the two sectors, public and private, and the consequences for project costs. In other words, this assessment seeks to find the best possible result for society, taking into consideration all the benefits, costs, and risks during the project life cycle.

The assessment of money value is based on a comparison of two contracting models. The first is the Public Sector Comparison (CSP), which considers the entire implementation and operation carried out by the public sector, including all the risks of the bus system. Second, it is the Concession/PPP model that considers that the public sector will be responsible only for annual or monthly payments for services during the period of operation, which would be included in the contract in the form of subsidies. In third place, there is the consideration of the Leasing model, whereby the fleet is acquired and maintained by a supplier and a third party is responsible for the operation. The following figure illustrates these two models before considering the concept of value for money.

Funding partners:



Implementing agencies:



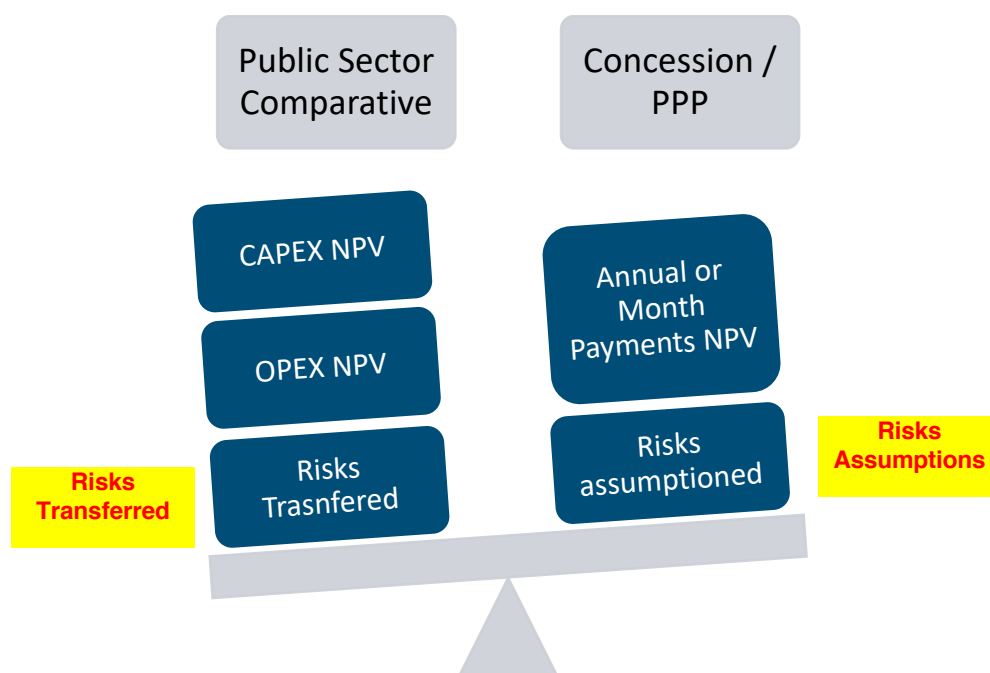


Figure 37: Comparison between Models

Source: Adapted from City of Rio de Janeiro

The value for money differs between models, as shown in the following figure.

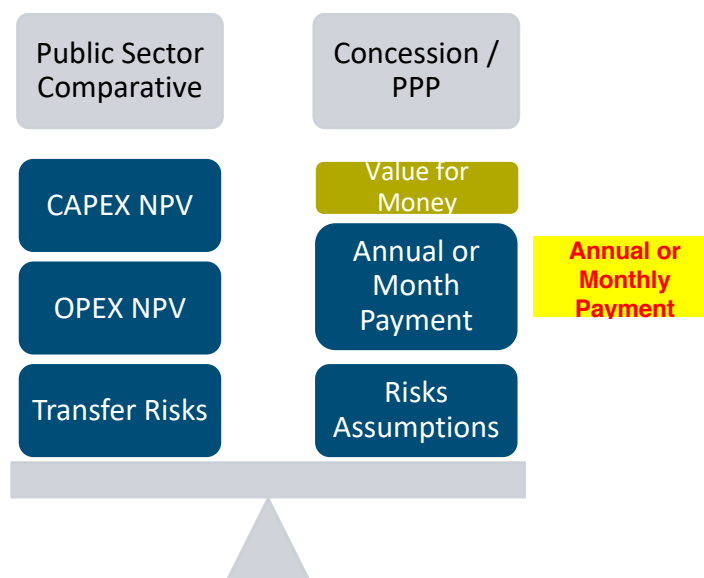


Figure 38: Amount per Money

Source: Adapted from City of Rio de Janeiro

8.15.1. PUBLIC COMPANY WITH PPP COMPARISON

The Public Reference Project - PRP - considers that any fleet purchases and all operational costs are the responsibility of the public operator. In this case, the operation will be less

Funding partners:

Implementing agencies:

efficient due to risks that are inherent to public companies, including being labor-intensive, showing lower productivity, subject to overcharges in their procurement, practicing low-quality maintenance, and having lower fleet availability. These risks can be quantified as follows:

- Risk of labor surcharge - According to analyses conducted by the Inter-American Development Bank - IDB^[1], labor costs in Latin America are approximately **4%** higher in public than private services.
- Purchasing cost risk - According to analyses conducted by the Interamerican Development Bank - IDB^[2], purchases in Latin America made by the public sector are about **17%** higher than the private sector.
- Risk of reserve fleet increase - Due to the inefficiencies expected in public management, maintenance may not be carried out properly, resulting in a greater need to use the reserve fleet. For this analysis, it is considered that the reserve fleet will be **50%** larger than for a private concession.

In the case of private operation, there is the cost of subsidies the public authority must contribute to cover the cost of the project, without regard to amounts received from taxes. Furthermore, a 5% surcharge was included, as the government needs to manage the concession contract.

The next table shows Net Present Values for the Public Reference Project (PRP) and the Public-Private Partnership (PPP) Project. NPV is USD 81.7 for PRP, and USD 73.6 million for PPP. This means the PPP alternative generates savings of USD 8.1 million for the company.

Table 31: Public Company x PPP

Comparative of the Public Sector/PPP	Net Present Value
(+) Public reference project (PRP)	81,734.89
(+) Base cost project reference	72,726.17
OPEX	33,684.28
CAPEX	39,086.82
Investments in net working capital	-44.93
(+) Cost of risk transferred	9,008.72
Risk of labor overprice	702.15
Risk of procurement overprice	6,644.76
Risk of reserve fleet increase	1,661.82
(-) PPP	73,599.77
(+) Public funds used for operator compensation	78,739.94
(-) Direct taxes	7,716
(-) Indirect taxes	1,361
(+) Cost of contract administration	3.937
Value for Money	8,135.13

Source: Logit

Funding partners:



Implementing agencies:



For the leasing alternative, it is necessary to consider that the costs a leasing contract will cover are fleet acquisition and maintenance.

The following table shows a comparison between the private operator and the fleet leasing model. The benefit to society, should a leasing system be adopted, is less USD 3.3 Million than with the PPP option. However, leasing is a better alternative from an economic point of view than a totally public operation.

Table 32: Comparison of Costs of PPP and Leasing

Comparison PPP/Leasing	Net Present Value (kUSD)
(+) Public reference project (PRP)	57,929.67
(+) Basic cost of reference project	49,516.42
OPEX	10,429.60
CAPEX	39,086.82
Investments of net working capital	-
(+) Cost of transferred risk	8.413
Labor overprice	107
Procurement overprice	6.645
Reserve fleet increase	1,662
(-) Leasing Project	54,591
(+) Public funds used for leasing compensation	54,591
Value for money	3,339.00

Source: Logit

8.16. FINANCIAL FEASIBILITY

The system is not financially sustainable at the rates simulated. The leasing purchase alternative has benefits, but it is more expensive than an PPP.

It will be necessary to seek new sources of financing the transport system to reduce the impact on Quito's budget. Close attention needs to be paid to the high financial impact of the metro operation.

[1] <https://flagships.iadb.org/es/DIA2018/Better> expending for better lives

[2] <https://flagships.iadb.org/es/DIA2018/Better> expending for better lives

Funding partners:



Implementing agencies:



9. PROCUREMENT

9.1. INTRODUCTION

The final part of the project is setting forth bidding terms on the supply of trolleys and buses for the trolleybus corridors (with Labrador-Carapungo Extension) and the Ecovía Corridor, respectively.

The metro starting operation, the need to find a metro operator, the need to adjust the levels of transportation fares, and the need for fleet replacement – since the existing trolleybuses have reached their life span – has complicated the decision making process, which was made even worse by the pandemic.

The terms were developed for the alternative of acquiring the fleet by leasing, with maintenance and operation by Quito's Metropolitan Public Transport Company (EPMTPQ), as per management decision communicated to Consultants by Quito's Mobility Secretariat.

The documents are independent from the demand and fare scenarios, and are valid for the procurement model approved by the administration.

9.1.1. BIDDING TERMS

The terms are divided into five components:

SPECIAL CONDITIONS FOR INTERNATIONAL BID PROCEDURES

Specific information and rules are established that govern the contracting procedure, including the forms and contracts. Quito's Metropolitan Public Transport Company will indicate the procedure's specific conditions, including details on the procedure and the contract to be signed. In consequence. It will make adjustments and/or changes as required to the particular conditions of this bid, and will make determinations and decide on the applicability of the components of the current procedure, replacing any text currently in brackets with the relevant content, and incorporating and replacing content at its discretion and as applicable.

GENERAL CONDITIONS OF PROCEDURE FOR GOVERNMENT PROCUREMENT UNDER AN INTERNATIONAL BIDDING SYSTEM

This contains information and participation rules that are common under the contracting purposes and, therefore, do not require adjustment and/or modification by the contracting parties. However, they were a substantial part of the conditions for participating in contracting procedures. Administrative resolutions and provisions issued by SERCOP during the procedure are hereinafter attached to the General Bid Conditions and are subject to mandatory compliance. The terms of reference and technical specifications are part of the general conditions.

INTERNATIONAL PUBLIC ASSETS BIDDING PROCEDURES FORMS

These are the documents that bidder must submit as minimum bid requirements.

PUBLIC ASSETS INTERNATIONAL BID CONTRACT – SPECIFIC CONDITIONS

Contractual conditions shall be agreed upon between Quito's Metropolitan Public Transport Company and the adjudicator.

Funding partners:

Implementing agencies:



PUBLIC ASSETS INTERNATIONAL BID CONTRACT – GENERAL CONDITIONS

Compiles general contractual conditions that are applicable and part of the National Public Procurement System rules, where applicable.

9.1.2. RECOMMENDATIONS ON USING THE BIDDING TERMS

The terms were prepared considering the demand estimates and the fare policy defined by Quito for starting Metro operation. They are detailed in the reports submitted that justify the number of buses to be purchased, in view of current uncertainties due to the City's current financial difficulties.

In view of the impossibility of defining financial resources to guarantee leasing contract payments, the documents are submitted only with data available at this time. But before that, some notices call for special attention.

The description of the system, the fares and the demand correspond to the scenario shown in the project's technical documents. This description must be updated when it is decided to go ahead with the fleet renewal through a leasing contract. The number of buses presented in this analysis could change, depending on the new scenarios.

The terms require compatibility and interoperability among battery charging equipment. However, no rules exist yet for the system and interoperability which have to be consistent with the type of standard that Ecuador/Quito want to promote in terms of charging infrastructure so that it can become a requirement in the terms.

One must remember that this is a first purchase, and interoperability is not a problem. However, if not specified correctly, AC buses may be supplied in a purchase, while DC buses are supplied in another. This has been described in reports of the present study, including cases reported from Santiago and Montevideo.

Other points need to be considered:

- Resolution 008-DIR-2017-ANT, "Regulation of Procedures and Requirements for Vehicle Registration", of March 18, 2017, needs to be amended before the call to bid.
- Before international bidding, the procedure must be followed to check on the domestic production [of similar equipment].

The following actions are required prior to bidding:

- Drafting of a multi-year budget document regarding funding to EPMTQP (Trust) to guarantee the leasing contract payments
- Approval of the Metropolitan Council budget
- Approval of the Public Transport Fare Policy
- Development of an integrated network operational model and a financial model, once the fare policy is approved
- Select properties to lend as areas for electric bus maintenance

Funding partners:



Implementing agencies:



9.2. MAIN POINTS OF THE TERMS OF REFERENCE

9.2.1. CONTRACTUAL PURPOSE

The purpose of the bidding is contracting, under the leasing modality, for the operation and maintenance of XX electric trolleys and XXX articulated electric buses, 18m-long, for operation in the Central Corridor and in Ecovía Corridor by the Quito's Metropolitan Public Transport Company (EPMTPQ), including full and complete maintenance of trolleys, (buses, batteries and equipment/charging systems and recharging, cleaning, sanitation, and all else necessary for the correct operation of buses), battery charging and recharging, and training of drivers and operational personnel on the operation of trolley buses.

The trolleybuses and electric buses of the operational fleet must be available all 365 days of the year in a location indicated for the beginning of operation, with battery charged fully and sufficiently for the stipulated autonomy. Force majeure cases are specified in the terms.

9.2.2. OBJECTIVES

- Replace buses that reach their service life
- Provide a better transport service to the population
- Contribute to the decarbonization of the City of Quito
- Improve availability and have access to new technologies

9.2.3. STANDARDS TO CONSIDER

- Regulation created by the "United Nations Economic Commission for Europe" (United Nations Regulations) through the Transport Division working group under the name "World Forum for Harmonization of Vehicle Regulations" for articulated electric buses.
- Organic Code of the Environment, Article 10, 225 (number 2), 233 and 239 for battery disposal
- UL 2580, UL 1642 or equivalent safety standards
- IEC 62660-2, SAE J2288 and UNECE R100 standards (second series)
- Local standards.

9.2.4. OPERATIONAL INFORMATION

The operational information has not yet been consolidated by the Mobility Secretariat. The Metro has run simulations with different fare scenarios and submits a proposal for reorganization of routes based on longitudinal corridors and transversal routes. The design criterion is to maximize metro demand. No financial and social assessment of the proposed changes has been submitted.

What can be seen in the proposed changes is the increase of transfers in the system. This number is not mentioned in the reports. If the idea is one payment for integration, the cost of travel can increase both in time and fare.

The operational data used in the reports is based on a route network that is reorganized only for services in the project's BRT corridors (Trolleybus and Ecovía) and the routes that feed these corridors. The result presented a need for 51 trolleys and 37 articulated electric buses. A possible reduction may result from applying scenarios which are currently being studied and seek to increase demand for the metro. A reduction in demand has been estimated for this reason, and the result was the purchase of 34 trolleys and 25 e-buses.

Funding partners:

Implementing agencies:

9.2.5. SCOPE

The scope section present the characteristics of the vehicles, manufacturing conditions (factory-new buses), manufacturer's technical warranty (the bus manufacturer's and supplier's warranties need to be stated), availability of the fleet (95% availability), range of maintenance (mechanical/electrical, cleaning, sanitation and battery recharging), redesign and refurbishment of bus depots, requirements for battery charging and recharging system, and requirements for the electrical power supply for the battery recharging system .

Scope also include quality tests bus performance tests:

- Bus evaluation: Autonomy, Recovery on flat surface (SAE 1491), Acceleration (SAE 1491) Start-up in a slope (SAE 1491), Maneuverability under a driving cycle set by SAE J1635, Breaking SAE 677
- Electric Tests: Charging time charging, and charging station tests
- Transparency and comparability of tests: The results of the tests must be issued by independent and well-known entities

Also part of the scope is the training of drivers and operations personnel to manage the logistics of electric bus operation.

9.3. MAJOR POINTS OF THE TECHNICAL SPECIFICATIONS

The technical specifications are based on the bidding document for the acquisition of electric buses and electric trolleys, with contributions made by consultants Helmer Acevedo and Pilar Henriquez.

Technical electrical specifications shall be those used in Ecuador and at Empresa Eléctrica Quito.

Technical specifications are detailed in report “2.3. Procurement Proposal”.

Funding partners:



Implementing agencies:



Table 33: Vehicle Features

Description	Requirements
Dimensions	
Outside length	18 m maximum 18.60 m
Outside width	Maximum 2.6 m
Height from street level to the highest point in bus	Maximum 3.5 m
Height from street level to bus floor	900 mm
Height from bus floor to ceiling at Passenger's standing point	Minimum 2.0 m
External turning radius	maximum 12.5 m
Accessibility	
Number of doors	3 at each side
Door clearance	Minimum width 1.2 m
Door height	Minimum 1.9 m
Capacity	
Total number of passengers	160
Minimum number of seats	45

The buses shall have enough power to go up 18% slopes.

Minimum operational autonomy for batteries is 230 kms for electric buses and 75 kms for trolley buses. Trolleybus autonomy is estimated so that bus can continue to operate while following detours, or for up to 30% of its route out of the catenary.

The autonomy for electric buses considers that these buses will operate all day long without interruptions.

Battery recharge: 11 pm to 4:30 am

Operating period: 5 am to 11 pm

9.4. MAIN CONTRACT CONDITIONS

Purpose: Supply of trolleybuses and articulated electric buses for a period of 15 years, including maintenance and training of drivers and operations team.

Contract term: 15 years

Vehicle life span: 15 years

Battery life span: 7.5 years minimum

Bus delivery deadline: maximum eight months after contract signing

Contract starting date: date when all buses start operating

End of contract: 15 full years from the starting date

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Implementing agencies:

Bus testing period: up to 15 days before they start operating

Complete installation of bus battery chargers: up to 15 days they start operating

Installation of the electric energy grid (EPMTQ has responsibility) - 60 days before the start of operations as defined in the contract

Payment method: quarterly payments, according to the actual availability of buses for operation.

Availability is measured as kilometers planned for operation minus kilometers not performed due to non availability of buses for the operation or due to bus defects occurring during operation. Kilometers not performed due to operational problems of the operating company or due to vehicle accidents are not considered.

Penalties related to availability:

- 95% - no penalties
- $95\% \geq 85\%$ - discount of kilometers not performed
- $85\% \geq 70\%$ - discount of kilometers not performed plus fine equivalent to the lost income for the number of passengers not transported
- $70\% \geq 50\%$ - discount of kilometers not performed plus fine equivalent to 1.5 times lost income for the number of passengers not transported
- 50% - discount of kilometers not performed plus fine equivalent to 3 times the lost income for the number of passengers not transported.

Justification for non availability: accidents, weather-related problems or other events preventing the circulation of buses, such as mass demonstrations.

Problems associated with battery charging logistics, charging equipment defects, and battery autonomy problems cannot be used as justification for non-availability.

Reasons for contract termination:

EPMTQ: less than 70% of availability for 3 consecutive months or for 12 nonconsecutive months during the contract period.

Leasing operator: more than six months of delay in invoice payment.

Penalty for contract termination:

EPMTQ - purchase of buses at the residual value, purchase of spare parts on the basis of prices defined in the contract, compensation for tools and facilities and a 10% penalty on the value of the contract not performed.

Leasing company: selling buses at their residual value, spare parts at price defined in the contract, assignment of tools and facilities without cost, and payment of a fine equivalent to 20% of the residual value of the buses.

Funding partners:



Implementing agencies:



9.5. IMPORTANT POINTS OF THE TERMS

Creation of a Trust Fund with a balance available for a minimum of six months of leasing and maintenance fees.

Creation of a Trust to manage revenues and payments

Creation of a Management Unit for the project

9.6. CONCLUSION

The terms are complete and serve the purpose of purchasing buses and trolleys that are state of the art in current technology. If the purchase is made after a period of more than six months, battery and charger specifications should be checked out and updated.

However, details should be further discussed by the Administration in view of recent developments in the decisions about the route system and fare policies.

Funding partners:



Implementing agencies:

10. GOOD GOVERNANCE

10.1. INTRODUCTION

Investments in infrastructure for urban mobility are particularly vulnerable to corrupt practices due to its size and complexity, the amount of investments, and the number of stakeholders involved. This happens in each public project phase (evaluation, planning, bidding, implementation, and contract management). Therefore, efforts to increase technical capabilities and raise awareness help familiarize public officials and suppliers with the most current and adequate integrity measures to prevent corruption.

On the other hand, training and raised awareness increase knowledge on specific integrity risks to infrastructure development, including knowing how to act in a particular situation and how to prevent and manage conflicts of interest, while strengthening the skills to identify the best advice and guidance and seek them when needed.

To support good governance and promote effective safeguards, effective political solutions (including measures to improve transparency of the procurement process and avoid conflicts of interest) should be recommended, as well as enabling detection measures over the project cycles, whenever these may be influenced by the project's stakeholders.

The Good Governance report was prepared based on technical articles and official documents, as they address aspects related to the definition, identification, valuation and management of risks through mapping tools for different types of risk, including management, operations, and corruption risks. The purpose of this task is to support and advise the city on good governance by focusing on risks in the context of each respective project. The report covers the following aspects:

- General definitions of good governance.
- Preliminary analysis of risk assessment tools the city can use to assess its own corruption risks.
- Description of a methodology to identify corruption risks and the actors involved in the various stages of the project cycles.
- Proposition of a plan to develop the city capabilities regarding the identification and administration of corruption risks.

10.2. DEFINITION OF GOVERNANCE

Governance means the process of making decisions and the process by which decisions are implemented (good governance) or not implemented (lack of good governance). Considering the preceding definition, a governance assessment should focus on: the processes and procedures in place within a company or institution; the formal and informal actors involved in making decisions and implementing decisions already made; the formal and informal structures that have been established to reach a decision and implement it.

The government is one of the actors in governance, that is, the formal governmental structures are the medium by which decisions are made and implemented. However, there may be informal decision-making structures or informal advisors that vary according to the level of government under discussion.

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Implementing agencies:



10.2.1. GOOD GOVERNANCE

Good governance is structured according to eight main attributes: Participation and Representation; Consensus Orientation, Accountability, Transparency, Responsiveness, Fairness and Inclusion, Effectiveness and Efficiency, Law Compliance. Good governance must be participatory and representative, consensus-oriented, responsible, transparent, receptive, effective and efficient, equitable and inclusive and, finally, deeply rooted in the rule of law. This ensures that corruption is minimized, that opinions of minorities are considered, and that the most vulnerable members of society are heard in the decision-making process. In addition, good governance must also be responsive to the present and future needs of society as a whole.

10.3. PRELIMINARY ANALYSIS OF TOOLS AVAILABLE TO THE CITY TO ASSESS ITS CORRUPTION RISKS

The Metropolitan District of Quito has available a broad legal and institutional framework to detect, prevent and intervene in situations where there is risk of corruption:

10.3.1. OPEN GOVERNMENT

Open Government is a worldwide initiative that seeks to improve government performance through fostering transparency in public administration management, the collaboration of citizens with inclusion criteria, the collective development of solutions to problems of public interest. It involves improving the provision of public services through the implementation of information management platforms and social interaction. The Metropolitan District of Quito (MDMQ) has decided to implement the Open Government idea by collecting its principles in one site (<http://gobiernoabierto.quito.gob.ec>). This portal is an initiative to promote transparency, access to information, citizen participation, and the administration's accountability.

The General Planning Secretariat, through the Metropolitan Office of Information Management, implements the Metropolitan Information System which is understood as a group of interrelated elements from institutions, technological media, and technical procedures for the purpose of managing information that is generated and processed by entities and/or municipal units and published in its website and information subsystem. It is based on three main policies that are the strategic pillars of an open government: transparency, participation and collaboration. The Secretariat is also in charge of coordinating information management and actions related to the functioning of all platforms and sites of open government.

The pillars of the Open Government in Quito are::

- **TRANSPARENCY:** to provide information of public interest on activities carried out by the government continuously, freely and free of charge, under open formats and in real time. The government makes available information on its decisions and actions, the management of assets and public resources under its control, and any results it has obtained in fulfilling the mandate it has been given. It must ensure that access to this information is simple, clear and in different formats so as to allow citizens to maintain continuous monitoring of government actions. To comply with these guidelines, different institutional tools are used:
 - **The Metropolitan Information System**, consisting of:
 - District Indicators System, available at <http://sid.quito.gob.ec/>

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Implementing agencies:

- Geoportal, available at <http://geoportal.quito.gob.ec/>
- Geographic metadata, available at <http://geo.quito.gob.ec/>
- Download information, at http://gobiernoabierto.quito.gob.ec/?page_id=1122
- Open data catalog, at http://gobiernoabierto.quito.gob.ec/?page_id=1620
- **Organic Law of Transparency and Access to Public Information (LOTAIP): Open Council, Open Budget, Annual Operational Plan, Management Reports, Open Planning.**
- **COLLABORATION:** Committing citizens, private companies and different associations to working together with public administration to achieve a common goal through co-creation and co-production. The aim is to always seek the general interest, encouraging the use of information and communication technologies that facilitate direct collaboration between citizens and actors. Quito counts on the following institutions and tools, for this purpose:
 - **The Metropolitan Commission to Fight Corruption (Quito Honesto)**
 - **Public transport data**
- **PARTICIPATION:** promoting the right of citizenship to actively participate in shaping public policies, and encouraging the Administration to benefit from the knowledge and experience of citizens. For this purpose, it drives actions and activities that increase protagonism and involvement of citizens in public affairs, while intensely committing the political forces to the citizens. Citizen participation received legal recognition in Quito after Metropolitan Ordinance No. 102 was approved, which promoted and regulated the Metropolitan System of Citizens Participation and Social Control, coordinated by the General Secretariat of Territorial Coordination and Citizen Participation. The following mechanisms have been expressly indicated by law:
 - **Advisory Council** (Metropolitan Ordinance no. 184, of September 29, 2017)
 - **Quito Decides** (<http://www.decide.quito.gob.ec>), which has the following tools: Citizens Ideas, Normative Collaboration, We Are Quito House, Participatory Budgets;
 - **Quito Participates**, with the following tools: Assemblies (in neighborhoods, districts, zones and the MDMQ assembly), Metropolitan Planning Council, Public Hearings, Pre Legislative and Environmental Consultation, and Popular Lobbying.

10.3.2. QUITO HONESTO

The general purpose of the Metropolitan Commission to Fight Corruption (CMLCC) - Quito Honest is to put in place the necessary measures to prevent, investigate, identify and individualize actions or omissions that imply corruption, as well as to promote the values and principles of transparency in the management of public affairs among all municipal facilities in the Metropolitan District of Quito, its companies and corporations. Its legal basis includes Metropolitan Ordinance n. 116, and the Organic Charter of Organizational Management by Processes of the CMLCC, of January 1, 2017, with indication of its attributes and responsibilities.

The Plenary of the Commission is made up of representatives from Quito's Metropolitan Mayor's Office Quito, universities, civil society, production chambers, and the construction

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chamber. The Commission operates with support and advisory units, and with specific directions for its mission by the Investigation Office and the Control and Prevention Office.

The Investigation Office's mission is to investigate cases of alleged corruption in the Metropolitan District of Quito, in metropolitan companies, corporations, and different facilities and agencies in which it has shares, assets, rights and interests. The Commission may receive, process and investigate reports of suspected acts of administrative or financial corruption, as well as find indication of criminal responsibility and alert all relevant authorities. Any municipal servant who uses his/her position can be denounced for seeking benefits not permitted under the law, or obtains an illicit advantage or benefit for said servant or related third parties. The complaints can be made in writing, by electronic mail (denuncias@quitohonesto.gob.ec), or by filling a form online. In all cases, the identity of the person reporting will be checked, and said person will commit to cooperate with the investigation, as necessary. However, Quito Honesto handles confidential complaints as such, provided claimant provides all necessary information and is willing to cooperate in the investigation. Total confidentiality will be maintained with respect to the whistleblower during the investigation process. Anonymous complaints are not accepted.

The Investigation Office also supports the development of Corruption Studies, which generates statistical data on corruption trends, based on investigations already performed. The purpose is to express in didactic form the acts that have been reported, the main typologies identified, as well to submit yearly reports and recommendations. From September 28, 2017 to September 28, 2018 (period covered by the last published Corruption Study), the Commission received 136 complaints, among which the most prevalent referred to abuse of power, non compliance with municipal regulations, traffic of influence, dereliction of public servant duties, and graft. Of the 40 complaints that qualified for an investigation during the reporting period of 2018, there was no concentration in specific institutions. The agencies involved in urban mobility policies in Quito (Metropolitan Traffic Agency, Metropolitan Transportation Agency, Quito's Metropolitan Public Transport Company, and the Mobility Secretariat) were each mentioned once in complaints received.

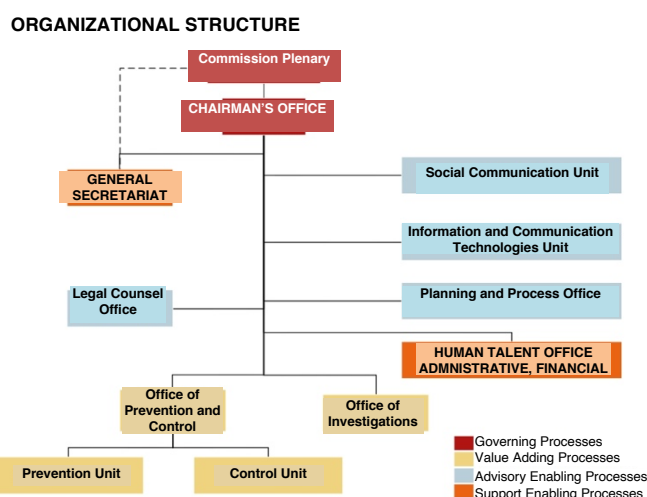


Figure 39: Organizational Structure of Quito Honesto

Source: Quito Honesto, 2020.

The Office of Prevention and Control of Quito Honesto has the duty of promoting and strengthening a culture of honesty, transparency, and control in adherence to the current legal norms, with the objective of preventing acts of corruption in city management. Specific

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projects of the Office include the Communication of the Code of Ethics of the Metropolitan District of Quito, and the analysis of municipal processes. It aims to identify their vulnerabilities to avoid situations that may give rise to possible acts of corruption, according to a methodology to develop a Vulnerability Map (http://quitohonesto.gob.ec/documents/MVULNERABILIDADESv_010.pdf).

To build the Vulnerability Map, the following phases are contemplated: (1) Data Collection, (2) Building a Vulnerability Map (Legal security, Procedures, Personnel, Computer Systems) and include preventive actions into the vulnerability map matrix. (3) Follow up activities. By June 2019, MDMQ's Metropolitan Information Office had developed a vulnerability map for the Technological Operations Management Macroprocess.

By the end of 2018, the Corruption Prevention Study was issued, which collects information on risk factors (weaknesses) found during an examination of public procurement processes and vulnerability maps for administrative procedures, and in the complaints investigated. The results of the study indicated vulnerabilities that have the potential to result in acts of corruption, and recommendations were made to address them.

10.4. METHODOLOGY FOR IDENTIFYING CORRUPTION RISKS AND ACTORS INVOLVED IN PROJECT CYCLE STAGES

The analytical approach to risk assessment may include analyses based on processes, actors, or in a combined form. The selection of the analytical approach to use must consider the specificities of the risk that the evaluation subject involves. When an analysis based on processes is selected, the focus of the review is on the set of successive phases of an occurrence or complex event that is susceptible to corruption, its procedures, controls, techniques, services, products, and development mechanisms. Therefore, it is appropriate to specify which stages of the processes – i.e., the subsets of operations something is submitted to for the purpose of developing or transforming it – are prone to corruption and how.

In this project for technical support to the technological transition of buses and to the extension of a trolley corridor, said analysis would seek to identify risks which are inherent to two macro processes: (1) development of civil engineering projects and implementation of construction work, and (2) specification of new vehicular technologies and implementation of its operational infrastructure. These macro processes can be evaluated in four specific phases: diagnostics, planning and budgeting, bidding, implementation and contract management.

When an analysis based on actors is selected, the focus of the exam is on the risks of corruption practices by individuals or groups of employees of institutions that take on a particular role in public processes. Any risk, in this case, has to do with making decisions tailored to certain interests, in order to inappropriately favor third parties in contracting processes, or favor oneself in the form of a bribe or embezzlement. However, in this technical support project, it is not possible to analyze the role of social actors and their risk of corruption but in their current and future development process and, therefore, both elements need to be analyzed jointly. Thus, the mixed analysis relates to the examination of the structures (legal, institutional, and functional), the organizational fields, and the main macro processes of the sectors, starting from their internal and external relationship with public, private and social agents, so that it becomes possible to determine the main interactions and possible scenarios suitable for corruption to appear.

Funding partners:

Implementing agencies:



10.4.1. MANAGING CORRUPTION RISKS IN QUITO

In the Metropolitan District of Quito, as shown in Section 11.3, the Open Government initiatives and those engaged in by the Metropolitan Commission to Fight Corruption - CMLCC (Quito Honesto) involve methodologies and processes that clearly show the stance and efforts made by the City on this topic. They are also integrated to national initiatives for transparency and prosecution (Official Public Procurement System, Organic Law of the National Public Procurement System, National Anti-Corruption Commission, General Attorney's Office, and Office of the General Comptroller). The existing methodologies implemented by the Metropolitan Commission to Fight Corruption and the Open Government unit offer sufficiently detailed material to accompany the different phases of the projects that are the object of this study for the transition of diesel autobuses to e-buses and extending the central trolleybus line.

The methodology to analyze municipal processes, carried out by the Office of Prevention and Control of Quito Honesto, could accomplish the objective of identifying vulnerabilities in municipal processes associated with this project of urban mobility, for the purpose of avoiding situations that could give rise to possible acts of corruption in the agencies directly involved: *Mobility Secretariat, Public Metropolitan Company for Mobility and Public Works, and Public Metropolitan Transport Company of Quito*.

The CMLCC can be invited to apply its methodology to the processes that make up each phase of the project discussed here.

The Good Governance Report identifies the processes that should be prioritized in this Methodology according to the extent to which its risks are within the sphere of influence of the project, and to the potential positive impact of mitigating these risks.

10.4.2. MAIN CORRUPTION RISKS AND POSSIBLE CONSEQUENCES OF THEIR MATERIALIZATION IN THIS PROJECT'S SPHERE OF INFLUENCE

10.4.2.1. ACTORS INVOLVED IN THE PROJECT

The two projects directly involve the following institutional actors: Mobility Secretariat, Quito's Metropolitan Public Company of Mobility and Public Works (EPMMOP) Quito's Metropolitan Public Transport Company (EPMTPQ). In addition to them, there are other social actors involved in the project of replacing diesel autobuses with e-buses: **(1) Potential service providers and materials suppliers:** Vehicle suppliers (purchase of new trolleys and e-buses), Providers of operational infrastructure, Providers of engineering projects (Labrador - Carapungo extension and support for new technology vehicles), and construction companies; **(2) Users of the transport system:** New users of the trolleybus central line (Labrador - Carapungo extension), Users of the BRT Ecovia, where the transition of autobuses to e-buses will take place; **(3) Mechanisms of citizen participation and Metropolitan Council:** Citizen's meetings and councils.

10.4.2.2. MAIN RISKS OF CORRUPTION

The vulnerabilities to corruption were presented for each one of the project cycles (diagnostics, planning, bidding, implementation, and contract management), so that the map of vulnerabilities (according to methodology from the Office of Prevention and Social Control of Quito Honesto) can be focused on the specificities of its implementation. A matrix of risks of corruption highlights the main interactions and possible scenarios the favor the occurrence of corruption in the project processes by phase and by actors and processes, including the negative impacts and the possible positive impacts of mitigating these risks.

Funding partners:

Implementing agencies:

Table 34: Example of a Guide Matrix - Corruption Risks by Phase.

Phase	Process	Actors	Risk in the sphere of influence	Negative impact of these corruption risks	Potential positive impact
Diagnostics	Handling of privileged information	SM; EPMMOP; EPMTPO	Inappropriate transfer of privileged information to certain companies about upcoming contracts	Advantages for potential suppliers in the bidding process; complaints in the press	Ensuring equality of suppliers in the bidding process; ensuring the good reputation of public bodies.
Planning and budgeting	Assessment of needs	SM; EPMMOP; EPMTPO; potential suppliers; other social actors	Influence by external actors on employee decisions; informal agreement on contracts; inclusion of additional services to the purpose of the contract which not all bidders are able to provide	Demand for goods and services that do not respond to a real need	Proper use of public resources
Bidding	Selection of the procurement procedure	SM; EPMMOP; EPMTPO	Selection of inadequate procedures that limit competition; abuse of non-competitive procedures on the basis of legal exceptions (division of contracts, abuse of extreme urgency, unsupported changes)	Competition limitation	Ensuring broad participation and bidding competition
Implementation and management of contracts	Supervision	SM; EPMMOP; EPMTPO; Contracted suppliers	Absence or deficient justification for contractual changes; subcontractors not elected in a transparent manner	Receiving deficient services or of lower quality than those offered by the winning bidder	Compliance with contractual clauses

Source: Logit

10.5. PLAN TO DEVELOP CAPABILITIES TO IDENTIFY AND MANAGE CORRUPTION RISKS

In addition to the matrix proposed to qualify the methodology of vulnerability mapping used by the Quito Honesto's Office of Prevention and Control, a plan is recommended for the development of capabilities to identify and manage corruption risk, which focus public officials and the agencies involved in this project. The strategy proposed to develop capabilities to identify and manage corruption risks have two lines of action: (1) organizing specific training to create and/or strengthen personal skills to fight corruption, including measures that support the professionalization and integrity of public servants; (2) qualifying existing integrity and transparency initiatives to increase their efficiency, as there are already significantly developed institutions in this area, such as Quito Honesto and Open Government actions.

10.5.1. SPECIFIC TRAINING TO CREATE PERSONAL SKILLS

CFF has developed a systematic methodology (C40 Cities Finance Facility's Capacity Development Framework, 2017) of capability assessment. It reviews and compares existing to basically required capabilities in the context of project preparation to detect skill set gaps and input them into the skills development plan. The capability assessment methodology includes several consultation methods (self-assessments and external assessments) to complement and validate results with respect to skill set gaps. These include: (1) a SWOT analysis; (2) interviews with representatives of the interdepartmental PIU (Project Implementation Unit) under the city administration; (3) a brainstorming workshop to discuss possible interventions to address the skills set gaps identified in the SWOT analysis, (4) external evaluation, with feedback from international technical experts assigned to the project.

The results from all previous methods are summarized and interpreted. They are also classified according to the three levels of capability development (individual, organizational and inter-organizational) and the areas needed for project development. A draft capability development plan is developed which may combine short-term and medium-term actions with

Funding partners:

Implementing agencies:

quick-impact actions; these should be interrelated and aligned with the schedule and technical activities of the project work plan.

10.5.2. QUALIFICATION OF EXISTING INTEGRITY AND TRANSPARENCY INITIATIVES FROM QUITO HONESTO AND OPEN GOVERNMENT

Based on a preliminary analysis, the following tools are available to the city to assess and mitigate corruption risks, which may qualify under this project's scope: (1) Enforcing the Organic Law on Transparency and Access to Public Information (LOTAIP), (2) Promoting better communication with society about the actions carried out by Quito Honesto (3) Increasing the participation of municipal agencies in investigation processes carried out by Quito Honesto (4) Disseminating the Code of Ethics, (5) Developing a study of corruption prevention for the entire transportation sector. Additional recommendations include: (1) Applying ISO 37001 (anti-bribery actions) (2) Basic technical training for employees at control agencies (3) Attention to contractors and vendors, (4) Including Quito Honesto from the start in the bidding commission, (5) include a representative from the Metropolitan Council in the project .

11. GENDER AND LEAVE NO ONE BEHIND

11.1. INTRODUCTION

Urban transport is often seen as neutral when it comes to gender and social aspects: a system of roads and buses that benefits everyone equally. However, women, men and vulnerable groups have different preconditions, needs and restrictions when using transportation. The travel pattern of women differs from men's due to their different social roles. In addition, there are other dimensions to identity that affect equal access in the transport sector, such as age, disability, discrimination based on ethnic origin, among others, which can influence each other as intersecting dimensions of inequality. Different circumstances should be considered in the design of subprojects to ensure they meet the needs of all local citizens. In line with a growing awareness of the need to incorporate gender and social equality, this has become an important component to improve urban transport.

The methodology proposed for Gender Analyses and Leave No One Behind (LNOB) is based on the following documents: Approaches for Gender Responsive Urban Mobility, published as part of Sustainable Urban Transport Project (SUTP); Guide for Preparation of Gender Analysis, published by GIZ; and Mainstreaming Gender in Green Climate Fund Projects, published by The Green Climate Fund (GCF).

11.2. REVIEW OF GENDER, DISABILITY AND LNOB DIMENSIONS IN ECUADOR AND QUITO

To create a clear understanding of the social, economic, physical, and political dimensions underlining inequalities exacerbated by climate change, we reviewed the socioeconomic and disability statistics, basic rules and regulations, and other relevant information to the current context of social exclusion and inequality in Ecuador and Quito, in particular. Following are the main observations made, including how there is an intersection between inequalities related to gender, age and disability:

- In Ecuador, despite the population being fairly equally divided by gender, on average men get more income for their work than women.

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- Ecuador's age profile shows a predominance of the population of children, teenagers and youths over the older adult population.
- In Quito, the BRT corridors are located in areas where a large portion of its population is concentrated.
- In Quito, people with disabilities experience lower income levels.
- Accessibility standards set forth by technical regulations require the public transport system to provide for all types of disabilities, but physical, hearing, and visual disabilities have the greatest special needs.
-

11.3. GENDER AND “LEAVE NO ONE BEHIND” DIMENSIONS IN QUITO'S URBAN MOBILITY

Understanding how gender and LNOB components may affect urban mobility in Quito, being aware of the special needs of each study group, and knowing how these inequalities may be superimposed is essential in promoting the development of inclusive transport projects in the city. Starting with a literature review, trip patterns were studied, including number of trips per person, percentage who did not travel on the survey date, mobility aspects according to mode and time, and finally money spent on travelling under full or reduced fares. Also an analysis was conducted of traffic accidents in the city and their relationship with the BRT corridors and feeder routes. Following are the most relevant findings:

- Immobility rates are higher for women, the elderly and people with disabilities, which makes it more difficult for these groups to move around the city.
- The average trip number per working day is higher for men than for women, contrary to what is observed in the literature, but the difference is due to higher use of private vehicles by men.
- The use of public transport and active modes is greater among women than men.
- The youngest segments of the population, including students, have more trips under active mobility (up to 14 years) and public transport (15 to 24 years), while adults use more private transport.
- Those over 60 years of age rank second in the use of active modes and also private transport.
- "Domestic employees" use public transport more frequently; they also show higher use of active modes.
- Domestic employees show mobility in different periods of the day and show travelling activity all day long. This group, comprised mostly of women, needs specific policies that consider a wider range of fare integration.
- There is a high incidence of crashes and collisions with pedestrians.
- The highest incidence of crashes are along the BRT corridors and feeding routes, which shows the importance of ensuring road safety in projects.
- Considering the different spheres of inequality, there is a predominance and more relevance of public transport and active modes to the most vulnerable segments of the population, who therefore deserve greater attention in the development of policies and projects in the city.
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11.4. MAPPING THOSE WHO ARE POSSIBLY FALLING BEHIND

After reviewing the information collected, it was compared to current programs and initiatives in the city to understand its level of responsiveness to inequality issues, as well the level of

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participation of women and disabled persons at different decision-making processes on mobility. Figure xx shows current programs and initiatives in Quito, and the issues they cover.

The diagnostic of Quito's experience showed that the city has approached the issue on different levels. With regard to gender, the city has proved to be quite advanced in terms of incorporating gender perspective into the city's public transport system, especially by adopting the internationally recognized program "Turn Down Harassment". However, with respect to accessibility by people with disabilities, the city still needs to improve on aspects of transport infrastructure, in order to include this population segment in a more comprehensive and systematic way. The importance of focusing on aspects of road safety is also emphasized, including building and expanding pedestrian protection (especially the most vulnerable pedestrian) in their access to the public transport system.



Figure 40: Programs and initiatives identified in Quito.

In addition, we list important findings that help describe who is potentially falling behind in Quito in terms of urban mobility:

- There is a negative perception about air quality in the city; improving air quality is one of the main citizen demands to the local government.
- Although transport coverage is medium to high, the service and quality need improvement, as it is directly related to air quality and social inclusion.
- Most cases of sexual violence still take place in urban public transport (regular service), followed by trolleybus and Ecovía, which together account for 48% of all occurrences.
- Several initiatives have been identified on making transport safe and free of sexual harassment of women and girls. The existing programs require strong coordination among several entities. These programs have had international technical and financial support, as well as citizen participation and support.
- However, a perception of insecurity has been detected, mainly boarding and alighting from vehicles, inside the vehicles, and in the vicinity of stations and terminals, showing that more action is required to improve overall safety.
- The most vulnerable groups (women, children, the disabled, students and seniors) need to have priority attention as they face higher obstacles in transportation.
- Continued efforts are required to promote gender, generation and territory equity, including higher participation and representation in mobility decision making.

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11.5. RECOMMENDATIONS FOR A PROJECT DESIGN WITH A VIEW TO INCLUSION AND EQUALITY

To address gender differences and LNOB and face the main challenges identified, some recommendations are made considering the city's current level of development and the suggested references. The recommendations are divided into seven main components: Accessibility, Infrastructure, Service, Women and Children's Safety, Women Participation in the Mobility Sector, Knowledge Management, and Other. It is important to emphasize that the recommendations made apply both to adapting existing stations and terminals and to the design and construction of the Labrador-Carapungo extension.

11.5.1. ACCESSIBILITY

Recommendations on accessibility are based on the "Third Observation Phase" on accessibility and services for people with disabilities, developed by the National Council for the Disability Equality (CONADIS). The use of these guidelines has to be complemented by raising awareness and training all individuals involved in the processes of planning, designing, implementing and operating the project. These individuals must know and apply INEN's technical regulations on accessibility to physical means. It is important that the process includes planning that considers gradual actions to eliminate architectural and geometric barriers, in order to generate inclusive spaces for all citizens.

11.5.1.1. MAIN ACCESS TO TERMINALS AND CONTROL MECHANISM

On the main access and control mechanisms, the following recommendations are made:

- The main access to terminals must be completely free of barriers, gaps, street vendors, advertising, or any other element that constitutes an obstacle to the free circulation of users who enter or leave the facility.
- Width and height clearances for human passage must be respected, especially in order to ensure the entrance of wheel chairs, baby carriages, obese persons, and people with reduced mobility. Visually, it should be easily located from a distance through floor texturing, signage and indicator borders through clear glass panels.
- The main access floor must be firm and be in good working condition; the presence of pedestrian ramps and crossings complement the chain of accessibility.
- In case control mechanisms prevent the passage of wheelchairs or baby strollers due to insufficient width, the assistance of security personnel is required or creating alternative accesses for these persons.

11.5.1.2. TICKET BOOTHS

Recommendations on ticket booths include:

- Ticket booths should have a universal design with sufficient height or low counter to allow access by any person. Lower height allows wheelchair users and children. This facility must also have information in different formats on fares and other aspects of importance to the user. Lettering, labels and printed materials must comply with relevant standards to increase accessibility and legibility to as many individuals as possible.
- Special, preferential fares for people with disabilities must be available and used only for the right persons, who must produce evidencing documents. Ticket booth workers must be trained on how to serve appropriately persons with disability and reduced mobility.

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11.5.1.3. SANITARY FACILITIES AND RESTROOMS

Facilities and toilet room characteristics:

- Spaces must be designed, built and run according to universal accessibility criteria and design-for-all principles, allowing their access and use under safe and equal conditions by all persons.
- One must have at least one adapted bathroom separate from the sanitary facilities in terminals. The bathrooms should be separated for women and men, and the bathrooms for women should have greater capacity.

11.5.1.4. RESERVED PARKING SPACES

Reserved parking spaces must consider:

- Parking spaces should not be designed near bus circulation lanes or in front of pedestrian crosswalks.
- Reserved parking spaces can be in parking lots for employees, provided they comply with minimum requirements, location and distribution recommended by standards in force on accessibility to physical spaces.

11.5.1.5. PLATFORMS

Platforms are structures usually used for boarding and disembarking land transport passengers. They must meet the following requirements:

- They should guide people with disabilities and mitigate risks through signage and floor texturing (preventive tactile foot bands). Pedestrians must be able to easily move between platforms and, if necessary, pedestrian ramps or mechanical devices will be incorporated to overcome level differences or help in pedestrian crossings.
- They should have minimum dimensions for safe unidirectional or bidirectional circulation of users. The interior of stops is complemented with mechanisms and accessories to alert and inform users.

11.5.1.6. PASSENGERS BOARDING AND ALIGHTING

A major problem for users with or without disabilities is stepping out of bus into the platform or entering the bus from the platform. The Technical Standard NTE INEN 2292 - "Accessibility by persons to the physical means of transportation" has the following requirements:

- "The embarkation and disembarkation zones between the vehicle and the platform must be at the same level ± 20 mm; if the gap is bigger, it must be overcome by means of ramps, platforms, support edges or other devices that ensure user accessibility".
- "Access doors must have a minimum width of 1800 mm and a minimum height of 2100 mm".

11.5.1.7. WHEELCHAIR SPOTS AND RESERVED SEATING IN TRANSPORT UNITS

To increase accessibility, buses must have:

- Places for wheelchair users, with appropriate accessories, safety devices, and signage.
- Seats reserved for people with disabilities, seniors, adults carrying children, and pregnant women; these seats shall comply with applicable regulations regarding their number, size, color and other requirements.

11.5.1.8. COMMUNICATION MEDIA IN TRANSPORT UNITS

Communication media inside transport units should comply with the following requirements, at a minimum:

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- Information about itinerary, next stop announcements, giving seats to certain groups, occurrences or incidents along the itinerary, among others. Main beneficiaries are people with sight and/or hearing disabilities, out of towners, and foreign visitors.
- Some types of communication media are LED display panels, flat display panels, door closing announcements.

11.5.1.9. INFORMATION, URBAN ELEMENTS, AND FURNITURE

Stations in corridors must comply with minimum requirements related to facilitated access, free mobility, general information, and the use of safe conditions for all persons, regardless of their condition or disability.

- Access from the street must be connected to the stop with a pedestrian cross and a traffic light, including pedestrian traffic lights.
- The gap between the road and the station platform can be overcome with access systems such as ramps with slopes that comply with accessibility standards in appropriate environments, non-slip material or finish, textured floor (foot touch band), signage (horizontal, vertical and sound), and handrails at proper height.
- Furniture inside the stations to be in good condition, and its use must not represent a risk to the users; garbage cans, telephones and newsstands cannot be a barrier to pedestrian movement.
- Information must be clear and comply with signage standards, properly located, identifiable, legible, and easy to understand. The information must also be complemented in the different formats to make it more accessible to all persons, preferably through haptic plans or embossed. It must be free of scratches, broken or detached parts. Constant maintenance is required.

11.5.2. INFRASTRUCTURE

Recommendations for the surrounding infrastructure should ensure secure, free and convenient access to stops and terminals for pedestrians and bike users.

- Provide pedestrian infrastructure that includes wide, level, unencumbered pathways, favorable traffic lights, safe crossings, bollards to prevent cars going into the sidewalks, tree coverage, seats and benches without barriers.
- Sidewalks with proper signage and markings, and improved surfaces.
- Measures to calm traffic, such as elevated pedestrian crossings, quiet traffic areas and complete streets design. Self-executable solutions based on low cost designs, using physical design to require compliance by controller.
- Inclusion of gender-sensitive design in bidding documents.
- Stops and terminals well illuminated and without stairs.
- Elimination of dark entries in stops and terminals; good walking areas, good lighting and clear lines of vision.
- Visual information on corridor stops and routes.
- Space for parked baby strollers and storage for shopping bags.
- Wider crosswalks.
- Existence of public toilets along main roads, especially near stations and terminals. Design of new social areas and public spaces adapted to women's needs.
- Integrated bicycle path with space for bicycle parking near residential buildings, public transport stops, schools, workplaces, and infrastructure facilities, encouraging intermodality.

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11.5.3. SERVICE

The main recommendations on providing transportation services in the BRT corridors and feeding routes in a gender-sensitive and inclusive way are:

- Promoting discipline behavior among bus drivers, fare collectors and security personnel .
- Increase the number of public transport inspectors on the streets.
- Schedules and frequencies adequate for off peak periods.
- Night time buses allowing passengers to alight out of the authorized stops.
- Dedicated taxi service available for women at night.
- New mobility services, like shared travel plans for women.
- Implement user feedback and complaint mechanisms.
- Promote fare integration with ticket issuance systems for multiple short trips, with time-based fares.
- Offer lower fares for off-peak hours and group travel fares.
- Permanently monitor and control SITQ, so that the service currently provided by operators continues to improve.

11.5.4. SAFETY OF WOMEN AND CHILDREN

Even though the Quito Metropolitan Government has shown significant advance in actions against sexual harassment in the public transportation system with programs like “Stop Harassment”, additional recommendations are made to ensure the women and children’s safety:

- Continuous training and coordination of the police regarding women safety needs. Continuous training of public transport personnel regarding their behavior towards women.
- Presence of trained personnel at stops and terminals.
- Disclosures and publicity about sexual harassment using the public transport infrastructure.
- Conduct research and studies regarding women’s safety in transportation.
- Plans and services to provide support to violence survivors in stations and terminals.
- Include communities in the implementation, monitoring and evaluation of transport initiatives to address violence against women and girls.
- Encourage community members to report cases of violence witnessed in public spaces and transportation systems.
- Continuous improvement of the legal framework, ensuring that all forms of violence are always recognized in law, both in federal and local instances
- Make gender violence a component in all mobility projects.

11.5.5. WOMEN’S PARTICIPATION IN THE MOBILITY SECTOR

On women’s rights and women’s participation in SITQ, Plural Consultants (2019) proposed the development of an “Inclusive Employment Generation Plan for Women in SITQ’s executive, strategic, administrative and operational areas,” which encourages women’s participation in different sectors of the city. The Employment Plan must include at least the topics presented on the chart in Figure 2:

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Figure 41: Possible Scope of the Inclusive Jobs Plan for Women in SITQ

Source: Plural Consultoría, 2019.

In addition, recommendations are made to address the lack of representation of the female population in transportation planning and implementation, which could be included in the Inclusive Jobs Plan for Women in SITQ:

- Promotion of gender-sensitive hiring practices, dissemination of information on opportunities, flexible work, better work conditions, and vocational training for women.
- Promotion of equal pay for men and women hired in jobs created in planning, design, implementation, and project monitoring.
- Inclusion gender-related objectives in bidding documents for transport projects, including bidding documents prepared to implement these projects.
- Set goals for women participation in all training provided by transportation projects.
- Public participation that systematically includes women during project consultations.
- Access by women to property and compensation in future resettling situations.

11.5.6. KNOWLEDGE MANAGEMENT

In terms of knowledge management, it is important to generate bases of statistical data based on gender, age and other social and economic information, which can be used to plan transport projects and monitor the results, including issues of equality and inclusion.

Although the analysis considered data by gender and age, the information provided could be complemented with:

- User satisfaction surveys broken down by gender, age and disability.
- Collection of economic data broken down by differences in income by gender, age, and disability.
- Collection of information about work hours (official and daily activities) by gender, age, and disability.
- Inclusion of equality analysis and inclusion in the process of planning future transport projects.
- Investment in social inclusion and gender research in city transport.
- Implementation of accessibility and security audits on public transport.
- Sensitization of the executing agency, the contractor and the operator with respect to the incorporation of gender perspective and social inclusion.

11.5.7. OTHER

Some additional recommendations to address the issue of gender and social inclusion through transportation are:

- Integrate transport policies with social policies.
- Planning the type of land use that promotes a combination of resident activities, jobs and services together with transport availability and creating active and safer spaces.

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- Development of commercial districts that are associations between business owners in a particular area to make collective contributions toward maintenance and promotion of inclusion and safety.

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12. Climate Proofing

Climate change represents one of the greatest environmental challenges today, and the increase in gas concentration from human activities has already caused changes in temperature, rainfall and occurrence of extreme events.

Climate change can already be felt in many places, and especially affects the most vulnerable populations in developing countries, who suffer negative impacts such as water scarcity, rising sea levels, flooding, extreme rainfall and storms.

The purpose of Climate Proofing is to indicate the main environmental conditions subprojects have to fulfill to be considered under a sustainable project logic. It supports identifying climate change impacts, so that development measures are more efficient, especially when working with more distant planning horizons. The application of climate proofing at the local scale is a means of incorporating the issue of climate change in the planning agenda, where it can be integrated with strategic environmental assessments and investments.

12.1. ANALYSIS OF THE PROJECT CONTEXT

The city of Quito is the political and administrative capital of Ecuador, and is located in the Province of Pichincha, in the northern region of the country. The Metropolitan District de Quito (DMQ) is the largest canton in the country, with a total area of 423,074 ha, surrounded by mountains, at an altitude between 500 and 4,780 meters above sea level in the western Andes.

The climate and meteorological conditions of the region are strongly influenced by its geographical location and type of terrain, which has a diversity of valleys and mountains. These characteristics, together with great atmospheric systems (air masses) control the distribution of rainfall, evaporation, temperature, air humidity and wind regime.

Its wide variation in altitude corresponds to an equatorial temperate zone, 75% relative humidity and an average temperature of 14.78°C, with rainfall for most of the year. (Environmental Atlas, 2016). Due to its location and geographical configuration, the MDQ presents a wide range of climatic diversity and great landscape diversity, with 17 different types of ecosystems.

According to the latest Population and Housing Census (CPV), the DMQ population in 2010 was 2,239,191 inhabitants, of which 2.3% lived in urban parishes (city districts) and 27.7 % in rural parishes. In 2020, DMQ's population was estimated at 2.7 million inhabitants and, according to population projections made for the study *Vision of Quito 2040 and its New City Model* (IMPU, 2018), by 2040 the Metropolitan District of Quito will reach 3.4 million inhabitants.

The urban area of Quito has undergone a process of great change, with the expansion of the limits of occupation beyond the boundaries of urban parishes, and also exerting demographic pressure on rural parishes and on ecological protection zones.

12.2. CLIMATE RISK ANALYSIS

Infrastructure projects must be resilient to impacts related to climate change, and resilience conditions must be considered throughout the project cycle, addressing current and future change scenarios. Direct and indirect climate impacts must be evaluated and managed

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through a climate risk assessment and a set of mitigation measures appropriate to local environmental management structures.

12.2.1. CLIMATE SENSITIVITY OF SUBPROJECTS

Climate sensitivity refers to the susceptibility of a sensitive receiver and the environmental context to interference from the impact. In other words, it is the degree of interference that an impact can cause, combined with the importance of this impact in the context in which it is inserted. Thus, sensitivity is related to the relevance of environmental loss resulting from the impact. This loss can be high, medium or low, to the extent that it has greater or lesser influence on the overall environmental quality.

The analysis has considered two groups of sensitive receptors: population and infrastructure. The population receptors considered were **users of the corridors**, the **surrounding population**, and **vulnerable groups**. Infrastructure receptors considered were the **transport systems** (buses in corridors and in the feeder system), the **road system**, and the buildings (terminals, stations and stops).

12.2.2. ANALYSIS OF RISKS EXPOSURE

For the analysis of risk exposure, climate scenarios were considered for temperature and precipitation (intense drought and rain), from data projected and found in available studies, as well as relevant extreme events observed in DMQ, such as land slides, floods, and heat waves. The potential impact of natural climate phenomena and extreme events described were identified and measured for each one of the sensitive receptors, as shown in the table below where the impacts are identified by threat and by sensitive receptor.

Table 35: Identified impacts

Threats	Receptors		Identified impacts
Land slides	Population	Transport users	Increased accident rate
			Increase in vector-borne diseases
			Economic losses (time and access)
		Surrounding population	Increase in vector-borne diseases
			Economic losses (property damage)
		Vulnerable surrounding population	Increase in vector-borne diseases
			Economic losses (property damage)
	Infrastructure	Transport infrastructure	Operational losses due to road disruption
		Road infrastructure	Damage to road infrastructure

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Threats	Receptors		Identified impacts
		Building infrastructure	Structural damage to building elements
Floods	Population	Transport users	Increase in vector-borne diseases
			Economic losses (time and access)
		Surrounding population	Increase in vector-borne diseases
			Economic losses (property damage)
		Vulnerable surrounding population	Increase in vector-borne diseases
			Economic losses (property damage)
	Infrastructure	Transport infrastructure	Operational losses due to road disruption
		Road infrastructure	Damage to road infrastructure
		Building infrastructure	Structural damage to building elements
Heat waves	Population	Transport users	Increased mortality and morbidity.
			Increase in vector-borne diseases
		Surrounding population	Increased mortality and morbidity.
			Increase in vector-borne diseases
		Vulnerable surrounding population	Increased mortality and morbidity.
			Increase in vector-borne diseases
	Infrastructure	Transport infrastructure	Air conditioning overload
		Road infrastructure	Damage to road infrastructure (heat resistance)
		Building infrastructure	Air conditioning overload

Source: Logit

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12.2.3. VULNERABILITY ANALYSIS

Vulnerability is the degree of susceptibility that a sensitive receptor shows while facing the adverse effects of climate change and, in particular, climate variability and extreme phenomena. This results from joint consideration of sensitivity and adaptability.

Prior definition of impacts associated with each threat allows the establishment of vulnerability indicators, which are represented in spatial and georeferenced elements, to allow the spatialization of the risk analysis.

12.2.4. RISK EVALUATION

The notion of risk is associated with the possibility of an event occurring and, in the case of environmental risk, it refers to the proximity, imminence or contiguity of a possible damage. For the purpose of this analysis, the existence of a climate risk considers the vulnerability of the sensitive receptor and its exposure under the considered threat.

The analysis of exposure to each of the threats is based on geoprocessing tools, which allow superimposing different, existing data sets – in this case, the density of extreme events grouped by parish, within the limits of a 1-km area of influence – that define such exposure.

Based on these elements, the risk associated with each combination of threat and sensitive receptor is categorized, resulting in a set of 36 maps organized by threat, corridor and sensitive receptor, which are detailed in **Report T.2.4 - Climate Proofing**.

The mains findings are presented in the table below :

Table 36: Risk assessment

Threat:	Land slides	Sensitive Receptor	User
Findings			
For the 'corridor user' sensitive receptor, very high- or high-risk situations are observed in the central sections of both corridors. This situation is justified not only by the density of occurrence of land slide events in these areas, but also because these are the most loaded sections of the system. The southern and northern extremities of the corridors present the lowest risks, and the approaches to the central areas present medium risk.			
Threat:	Land slides	Sensitive Receptor	Surrounding population
Findings			
For the Trolleybus Corridor, the risk of land slides on the surrounding population is classified as very high only in the Centro Histórico parish, one of the densest in the area, in Manuela Saenz Zonal Administration. But the parish of Chimbacalle, in Eloy Alfaro, also an area of high population density, is classified as high risk. In the other parishes, distributed by all Zonal Administrations, there's a predominance of very low and low risk. These classifications are attributed to 16 and 9 parishes, respectively. The medium risk classification, in turn, is given only to 5 parishes, 4 of which are in Eloy Alfaro.			

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For the Ecovía Corridor, the Centro Histórico is also the only parish that shows very high risk. In turn, high risk is observed in the parishes of Chimbacalle, La Argelia and La Ferroviaria, all in Eloy Alfaro. In the other parishes, distributed through all the Zonal Administrations, very low and low risk predominate. These classifications are attributed to 16 and 8 parishes, respectively. The medium risk classification, in turn, is given to only 4 parishes, 3 of which are in Eloy Alfaro and one in Manuela Saenz (Itchimbía)

Threat:	Land slides	Sensitive Receptor	Vulnerable population
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Findings

In the surrounding area of the Trolleybus Corridor, notice there are no areas classified as very high risk for this sensitive receptor, which is explained by the distribution of this segment of the population in the territory. In the northern portion of the area of influence, very low risk predominates, with the exception of the parish of Carcelén, in La Delicia, classified as low risk, and the Comité del Pueblo, in Eugenio Espejo, classified as medium risk. For the parishes near the center and south of the corridor, the parishes of Centro Histórico (Manuela Saenz), La Ferroviaria (Eloy Alfaro) and Quitumbe (Quitumbe) are classified as high risk. The parishes of San Juan (Manuela Saenz), Chimbacalle and La Argelia (Eloy Alfaro) and La Ecuatoriana (Quitumbe) show medium risk to the vulnerable population and the others show low risk.

In the Ecovía Corridor, the situation is different, either because of the distribution of this segment of the population in the territory, or because of the distribution of threat events. Thus, the parishes of La Ferroviaria and La Argelia, in Eloy Alfaro and Quitumbe. The Quitumbe area presents a very high risk for this sensitive receptor. Already the parishes Itchimbía and Centro Histórico, in Manuela Saenz, and Turubamba and Guamaní, in Quitumbe, show a high risk indicator. In Eloy Alfaro, the parishes of Solanda and San Bartolo show very low risk, and Chimbacalle and La Magdalena, medium risk. Finally, it should be noted that the three parishes where the risk is very low are Jipijapa, Marechal Sucre and Belisario Quevedo, in Eugenio Espejo.

Threat:	Land slides	Sensitive Receptor	Transport
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Findings

In the case of transportation, the highest risks are in the parishes close to the center, which is justified by the concentration of land slide in these areas. The risk to buses in the northern area is low or very low and in the central region is high or very high, especially for the ones that circulate in the Centro Histórico parish.

Threat:	Land slides	Sensitive Receptor	Road system
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Findings			
As for the road system, the highest risks are also in the parishes close to the center, in Manuela Saenz and Eloy Alfaro, which is justified by the concentration of land slide events in these areas.			
Threat:	Land slides	Sensitive Receptor	Buildings
Findings			
As previously shown, the sensitive receptor 'building infrastructure' considers as an indicator of vulnerability the density of the buildings according to their typology. Thus, the parishes with the greatest vulnerability are those with the most robust types of infrastructure, which explains the distribution of risks for corridors.			
For the Trolleybus Corridor, very high risk is observed in the Centro Histórico parish. It is also very high risk for the Ecovía Corridor, which is explained by the existence in the area of two large integration structures: the Transfer Terminal Marín and the Terminal "Playon de la Marín". In the Ecovía Corridor, also classified as high risk are the areas in the parishes of Itchimbía (Manuela Saenz) and, to the south, Quitumbe, where the integration station of the same name is located.			
For the Trolleybus Corridor, low-risk areas predominate in the north and south, except for the Quitumbe Terminal vicinity, and medium-risk in the central portion, with the exception of the Centro Histórico. For the Ecovía Corridor, there are medium risk regions to the north and in the central area, except for the areas already mentioned: high risk in La Argelia (Eloy Alfaro) and low risk in the others.			
Threat:	Floods	Sensitive Receptor	User
Findings			
For the sensitive receptor 'corridor user', very high, high or medium risk situations are observed in the central sections of both corridors. Just like for the risk of land slides for this receiver, this situation is justified both by the density of occurrence of flood events in these areas, as well as due to the bus load in these sections. It should be noted that, in this case, only the southern extremities of the corridors have the lowest risks.			
Threat:	Floods	Sensitive Receptor	Surrounding population
Findings			
For the Trolleybus Corridor, the risk associated with floods for the surrounding population is classified as very high in the Centro Histórico parish (Manuela Saenz) and in Solanda (Eloy Alfaro). The parishes that present high risk are Kennedy and Belisario Quevedo, in			

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Eugenio Espejo and Chimbacalle and San Bartolo, in Eloy Alfaro. The parishes to the north, Comité del Pueblo and Concepción, in Eugenio Espejo, and Ponceano, in La Delicia, present medium risks, and the others, low and very low risks.

For the Ecovía Corridor, the Centro Histórico is the only parish that presents a very high risk, but high risk is also observed in the parishes of San Bartolo and Solanda, both in Eloy Alfaro. The medium risk is present in the parishes of Itchimbía (Manuela Saenz) and Chimbacalle, La Ferroviaria and La Argelia in Eloy Alfaro; the others present low or very low risk.

Threat:	Floods	Sensitive Receptor	Vulnerable population
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Findings

There are no areas classified as very high risk, which is explained by the distribution of this segment of the population in the territory and the distribution of extreme events recorded. In both cases, in the northern portion, low-risk situations predominate, with high-risk situations being observed for the parishes of the central area, Centro Histórico, Itchimbía and San Juan, in the Manuela Saenz Zonal Administration, and Solanda, in Eloy Alfaro, also in the two corridors. Already in Quitumbe and in the other parishes of Eloy Alfaro, the classification of medium risk predominates.

Threat:	Floods	Sensitive Receptor	Transport
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Findings

In the case of transportation, the highest risks occur throughout the area of influence, which is justified by the distribution of flood events in these areas and by the vulnerability attributed to the receptor.

Threat:	Floods	Sensitive Receptor	Road system
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Findings

In the case of the road system, the highest risks are occurring in the most central portions, which is justified by the distribution of flood events in these areas and by the vulnerability attributed to the receptor.

Threat:	Floods	Sensitive Receptor	Buildings
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Findings

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In the case of this sensitive receptor, the very high risk is observed in the parishes of the Centro Histórico and Itchimbia, in Manuel Saenz, which is explained by the existence in the area of two large integration structures: the Marín Transfer Terminal and the Terminal “Playon de la Marín”. Jipijapa parish also presents a very high risk, due to the concentration of events and the existence of the north station “La Y”. The parishes that present high risk predominate in the northern portions of the corridors, in Eugenio Espejo, except for the parish of Quitumbe, which is considered high risk for the surroundings of the Trolleybus Corridor.

Threat:	Heat waves	Sensitive Receptor	User
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Findings

Due to their threat status, the risk assessment of heat waves results in the classification of medium to very high risk, with no situations of low or very low risk for the users of the system. Risk variation, in this case, occurs as a function of system loading, which is the vulnerability indicator assigned to this receptor.

Threat:	Heat waves	Sensitive Receptor	Surrounding population
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Findings

For both corridors, the risk associated with heat waves varies from medium to very high, with no situations in which risks are considered low or very low. Thus, the risk variation occurs as a function of the population density in the corridor’s environment, that is, the vulnerability indicator assigned to this receptor.

The highest risks are the central parishes and, in the case of the Trolleybus corridor, also in the parishes of the northern portion. The other areas present a medium risk associated with heat waves.

Threat:	Heat waves	Sensitive Receptor	Vulnerable population
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Findings

For both corridors, the risk associated with heat waves from medium to high, and variation in risk occurs depending on the vulnerability of sensitive receptor, in this case, the proportion of population living in social vulnerability. Thus, as can be seen, the highest risks are in the southernmost parishes, both for the Trolleybus corridor and for the Ecovía corridor.

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Threat:	Heat waves	Sensitive Receptor	Transport
Findings			
In the case of transport, the situations presented consider the risk classification associated with heat waves as very high for the buses in the Trolleybus and Ecovía Corridors and high risk for the other buses (feeding and conventional lines).			
Threat:	Heat waves	Sensitive Receptor	Road system
Findings			
For the road infrastructure, very high risk is considered for the infrastructures of Trolleybus and Ecovía corridors, high risk for the roads where there is bus circulation (feeding or conventional) and medium for the other roads, which are those potentially used for access to transportation.			
Threat:	Heat waves	Sensitive Receptor	Buildings
Findings			
In the case of buildings, the risks are associated with the density of structures by type in each parish. Thus, a very high risk is observed in the parishes where the integration structures remain.			

Source: Logit

12.3. ENVIRONMENTAL POLLUTION ANALYSIS

The evaluation of environmental pollution is one of the most relevant aspects to confirm the sustainability of a project. Specifically, in the case of bus systems, the pollution aspect must be analyzed both for its potential to reduce Greenhouse Gas emissions (air pollution), and for its potential to reduce noise (noise pollution).

Environmental pollution has negative consequences on the quality of life of the inhabitants of the affected urban centers and can produce or aggravate episodes of respiratory and cardiovascular diseases and reduce life expectancy. Health effects occur both from short-term exposures, with high concentrations, and long-term, with low exposures.

12.3.1. GREENHOUSE GASES

The World Health Organization (WHO) recognizes air pollution as an important determinant of health, especially in developing countries, and the Global Reporting initiative on Greenhouse Gas (GHG) emissions directly quotes these emissions as the main cause of climate change.

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According to the emissions inventory prepared for the Metropolitan District of Quito (2011), vehicular traffic is responsible for 95% of the emissions of carbon monoxide into the atmosphere and, together with industry and thermoelectric plants, it is one of the main emitters of particulate matter.

Infrastructure projects must help reduce GHG emissions, aligned with both national and international policies and objectives. The two subprojects, whose main objective is to change the diesel fleet to e-buses, are part of the national energy efficiency policy, including a set of measures aimed at mitigating climate change by limiting greenhouse gas emissions and air pollution.

Based on the fleet renewal scenarios, compared to a trend scenario (no change), the emission reduction potential for the subprojects was estimated within the horizon years of project implementation. The main findings are presented in the table below.

Table 37: Emission reduction potential for fleet renewal scenarios

Corridor	Year	Reduction potential	
		Scenario 1	Scenario 2
Trolleybus	2022	No reduction potential	1.60%
	2024	22.50%	24.50%
	2026	23.30%	25%
	2031	36.60%	56.6%,
	2033	Total reduction	Total reduction
Ecovia	2022	17.90%	32.20%
	2026	21.10%	35.20%
	2031	68.30%	72.60%
	2033	Total reduction	Total reduction

Source: Logit

Even though the Ecovía Corridor has a greater potential for reducing emissions, it is important to note that the Trolleybus Corridor has, at its baseline, a lower potential for emissions, since it already has electric traction vehicles in its fleet

Finally, it should be noted that, in the trend scenarios, which do not contemplate the substitution of technology, the potential for emission increase is substantial, which is contrary to the project's sustainability principles. Thus, in terms of the potential to reduce emissions, the subprojects are aligned with the sustainable development objectives, established in the agreements to combat climate change. They also reach the goals of the Quito Climate Change Action Plan, of April 2019, which provides for emission neutrality by 2050.

12.3.2. NOISE

The traffic of motor vehicles is one of the actions derived from human activities that generate noise and, when they occur for prolonged periods and simultaneously with a series of other activities, such as industrial or commercial activities, can cause damage to people's health.

The Environmental Noise Monitoring Network of the Ministry of the Environment set three fixed ambient noise monitoring stations at the Centro Histórico, Jipijapa, Carapungo stations, operating continuously 24 hours a day, every day of the year. Of these stations, only one is

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within the corridor's area of influence; it is also located about 300 meters from the Trolleybus Corridor and more than 650 meters from the Ecovía Corridor.

12.3.3. MITIGATION MEASURES

In addition to technological changes introduced by the subprojects themselves, which constitute a step towards changing the emission patterns of urban transport, different measures must be planned to achieve the objectives of urban resilience and reduction of climate change. Thus, in addition to technology, the measures may have an economic, financial, regulatory, urban design, or communication/educational nature.

More specifically, to mitigate environmental risks associated with the subprojects, the proposed measures are:

- 1) Air quality management: seeking to keep emissions at a level acceptable to maximum emission standards and, in the long term, reaching zero emissions from transportation.
- 2) Risk management, considering the following actions:
 - a. Contingencies due to the occurrence of extreme events.
 - b. Land use management, seeking to:
 - i. prevent irregular occupation of slopes to avoid land slides, and
 - ii. improve the quality of urban drainage and create permeable spaces along the corridors to contain floods.
- 3) Management of transport demand, with the aim of changing the modal matrix and promoting the use of public transport and/or non-motorized transport, thus reducing the emissions responsible for the global temperature change;
- 4) Educational campaigns for the population and workers of the public transport system, designed to promote public transport, efficient driving, and reduce accidents.

To mitigate the environmental pollution associated with the subprojects, the proposed measures are:

- Control and monitor air pollution in key points of the corridors, considering the existing stations in the area of influence.
- Control and monitor noise pollution in key points of the corridors, which may be close to areas of human concentration, such as the integration terminals, which will receive not only e-buses, but also the conventional fleet
- Monitor the health of workers involved in the operation of the corridors, including not only drivers, but also terminal operators.

12.4. CLIMATE PROTECTION OPTIONS

Infrastructure projects shall prevent, evaluate, mitigate, and manage their impact on human health and the environment. Management plans and monitoring mechanisms that comply with international best practices and regulatory requirements must be provided throughout the project life cycle.

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These projects must also comply with national regulations to ensure that environmental and social management policies and plans are applicable throughout their life cycle. Thus, the proposed measures and plans must be integrated to national policy instruments in force and international regulations.

The tables below show climate protection options based on the measures aimed at reducing environmental risks and air and noise pollution, proposed in the preceding sections.

Table 38: Risk management plan

Plan	Risk management plan
Objective	Show measures to prevent and reduce environmental risks and measures to take in the event of an accident or unexpected situation that may cause significant environmental impact.
Justification	The organization of responses to extreme events is of fundamental importance for minimizing impacts to sensitive receptors, especially users of the corridors and the transport infrastructure; this has to be consistent with risk management plans for the city of Quito and the Historical Heritage.
Content	The prevention and reduction of risks is performed through overseeing compliance with land ordinance measures, i.e., local legislation and strategic urban development plans.
Subprograms	Land use management subprogram Contingency subprogram

Source: Logit

Table 39: Demand management plan

Plan	Demand management plan
Objective	Maximize the efficiency of the urban transport system by discouraging the unnecessary use of private vehicles and promote more effective, healthier, and more environmentally friendly modes of transportation (public and non-motorized transportation options).
Justification	The need to change people's travel behavior, seeking to improve the quality of urban mobility in its different modalities, and thus, improving environmental quality.
Content	Among the actions to consider are: Actions to improve the quality of infrastructure, promoting travel on foot and bicycle (for example, the requalification of the public promenade and the implementation or expansion of bicycle paths);

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Plan	Demand management plan
	<p>Actions to stimulate intermodal integration (for example, the implementation or expansion of bicycle parking areas and / or vehicle parking at strategic points of the transport network);</p> <p>Actions to incentivize the use of public transportation (for example, improve integration infrastructure, vehicle quality and variable fares);</p> <p>Ensure the public transport network is fully integrated to high- and medium-capacity modes fed by lower-capacity systems, thus adequately ensuring physical, operational and fare integration under good comfort conditions in all modes;</p> <p>Improve pedestrian accessibility around stations and terminals.</p> <p>Ensure universal, safe, and comfortable accessibility in all stations and terminals, with the right size for the demand.</p> <p>Develop infrastructure projects for urban mobility vehicles, ensuring their insertion into the day-to-day life of the city as an efficient means of transportation;</p>

Source: Logit

Table 40: Air quality monitoring plan

Plan	Air quality monitoring plan
Objective	Quantify concentration of pollutants emitted by public transport that are found in the environment and the degree of exposure of the different receptors in regions that are conducive to the highest concentration of pollutants, based on the maximum and minimum concentrations defined by national standards.
Justification	The monitoring of emissions and air quality is an indispensable tool for the development of policies and the definition of priorities for management actions. It is the basis for the application of other environmental management instruments, since it allows evaluating whether they are meeting current air quality standards, in addition to allowing the identification and contribution of new sources of pollution and threats to ecosystems, mapping possible sources of damage to public health and the environment, and allowing emergency measures to be taken in critical episodes
Content	<p>The plan to monitor emissions and air quality related to the subprojects must contain:</p> <p>Indication of contaminants to monitor</p> <p>Location of monitoring points</p>

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Implementing agencies:



Plan	Air quality monitoring plan
	<p>Methods and equipment necessary to monitor air quality</p> <p>Indication of sample frequency</p> <p>Operational information related to the public transport system (characteristics of the projected fleet, passenger demand, operational speed, energy consumption parameters per kilometer, modal distribution patterns.</p> <p>Public transport fleet data and technology.</p>
Subprogram	Worker's health subprogram

Source: Logit

Table 41: Noise pollution monitoring plan

Plan	Noise pollution monitoring plan
Objective	The implementation of a noise pollution monitoring plan aims to prevent and control noise-related health conditions, especially in the vicinity of sensitive receptors, so that the levels observed in the phase prior to the implementation of the new system are not exceeded.
Justification	The implementation of electric bus systems has great potential to minimize the noise from vehicle traffic and, to ensure that these improvements are carried out, it is necessary to implement a noise pollution monitoring plan
Content	<p>The plan must contain:</p> <p>Identification of the main critical receptors</p> <p>Setting up monitoring points along public transport corridors</p> <p>Measurement of noise and vibration levels to define the baseline and the objectives to be achieved, in accordance with national standards;</p> <p>Definition of monitoring frequency and submitting environmental noise reports;</p> <p>Definition of a periodic vehicle maintenance program focused on noise emission;</p> <p>Definition of communication channels to receive complaints and feedback from users and residents of the areas near the corridors.</p>
Subprogram	Worker's health subprogram

Source: Logit

Funding partners:



Implementing agencies:



Table 7 : Social communication plan

Plan	Social communication plan
Objective	The objective of the plan is to always disclose the characteristics of the new system clearly and precisely, including its implementation phases and the respective control, mitigation and monitoring measures. It must also ensure the effective participation of the community, through interaction between the different stakeholders and serve as an instrument to minimize any conflicting situations.
Justification	The implementation of a communication plan is necessary for social interaction and participation through a communication channel aimed at listening, recording, forwarding, and mediating the fulfillment of requests, contributing in a way to prevent and minimize impacts, as well as to reduce any drawbacks caused by the new configuration of the transport system.
Content	<p>The execution of the Social Communication Plan must be based on the following activities / actions:</p> <ul style="list-style-type: none"> Identification and characterization of user profiles; Development of an executive schedule for Social Communication; Production of graphic materials; Dissemination of basic information about the system; Continuous interaction with the population, including information on fleet changes, works and possible changes in the operating pattern; Disclosure of the communication channel to receive requests, complaints and suggestions, and monitoring / mediating calls; Disclosure of institutional and governmental contacts. Evaluation and permanent adjustment of communication strategies / actions.

Source: Logit

Table 42: Environmental education plan

Plan	Social communication plan
Objective	Raise user population's awareness about the importance of environmental conservation / preservation, and promote citizen rights through their participation in matters related to sustainable environmental management and issues affecting their region.
Justification	The environmental education plan is justified by the need to involve users and workers in the context of environmental conservation.

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Implementing agencies:



Plan	Social communication plan
Content	<p>The execution of the Social Communication and Environmental Education Plan should be based on the following activities / actions:</p> <ul style="list-style-type: none"> Identification and characterization of the target audiences; Development of an executive schedule for Environmental Education; Production of print materials; Dissemination of basic information about the system; Evaluation and permanent adjustment of communication strategies / actions. Development of instrumentation workshops on Environmental Education targeting students and the surrounding population, with differentiated approaches and workshops on Safety, Environment and Health for company workers and contractors, where the target audience is always the protagonist of the activities carried out. Development of instrumentation workshops on Environmental Education targeting corridor employees, with an emphasis on driver training.

Source: Logit

12.5. CONCLUSIONS

With the noted increase in extreme weather events, cities must be prepared to implement plans and projects aimed at adapting to climate change, seeking to minimize the associated impacts and risks, and achieve the economy's decarbonization. Each sector will face different challenges while trying to contribute to achieving this objective. More specifically in the area of transportation, efforts should be much greater, given this sector's large share in total pollutant emission.

The objective of the Climate Proofing study was to point out the main environmental conditions so that the subprojects can be inserted within a sustainable project logic. Thus, the proposed measures, although already in line with local planning instruments, are actions to be carried specifically in the field of corridor management.

Ecuador and Quito have available a large amount of data and documents of great relevance in the context of urban and environmental planning. For the purpose of this analysis, the information obtained allows us to draw a broad outline of environmental issues related to the subprojects and achieve the general objectives of climate proofing.

Funding partners:



Implementing agencies:



13. CONCLUSION AND RECOMMENDATIONS

13.1. CONCLUSIONS

The City of Quito faces a complex situation with the metro starting operation, and the need to reorganize transport's surface network and the integrated system fare policy.

The lack of activity integration among agencies that would lead to a single line of action has made decision-making even more difficult.

If each level of government and agencies are left to solve their issues by themselves, this can only lead to exacerbating future problems. What is called for is for the City Administration make a decision that encompasses all areas and agencies.

The pressure towards a solution that increases demand for the will cause imbalances in services and financially for the entire system, which will possibly inconvenience passengers and make it difficult to set up a PPP due to increasing mistrust in government by the private investors.

The pandemic and the resulting impact on the municipal finances has prevented the municipality from considering the financing of bus acquisition of buses, as it no longer meets its debt criteria. In addition to the difficulty of promoting a PPP, the city administration has decided that Quito's Metropolitan Public Transport Company (EPMTPQ) will adopt the model of acquisition by leasing.

Due to the lack of definition of a network and a fare scenario, the reports reflect the results of the demand modeling under the scenario discussed at the beginning of the project.

The City of Quito, through EPMTPQ, has indicated it does not expect to be able to acquire a new fleet before 2022, due to the city's financial difficulty and the uncertainty of demand for next year.

All analyses indicate that the system will not be financially sustainable with a 35-cent fare. The scenarios point to a breakpoint fare of nearly 50 cents. Setting a higher fare for the metro while reducing the supply of parallel systems can have other negative impacts, such as the uncontrolled operation of illegal vehicles. As this decision is political, the amount of subsidies required to keep the system operating within the desired parameters must be identified for each scenario.

However, the baseline bidding conditions are complete and may be used by EPMTPQ for the acquisition of the number of buses that is decided at the time.

The bidding will require a system operation plan and justification for the demand and fleet.

The financial analysis model was delivered to the Quito Administration and particularly to EPMTPQ, including a training program for its future use.

All documentation has been delivered with the required explanations so that the entire process can be replicated in the future.

In due time, the City will have the necessary decisions to develop an operational plan for the system and decide on the acquisition of electric buses.

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13.2. RECOMMENDATIONS

- Perform an analysis of alternatives for fare policy and reorganization of the surface network, including determination of social impact (travel times and cost) and financial impact (technical fare and system's financial balance).
- Make projections of the financial situation of the City and appropriate actions to handle any issues;
- Decide on the fare policy and metro operation as soon as possible.
- Maintain a conversation with C40 and GIZ regarding future cooperation.
- Maintain a conversation with the energy company so it can become more integrated into the electromobility policy and be an investor for the purchase of batteries and use of the battery's second useful life span as a backup in peak periods.
- Conduct training at the Mobility Secretariat and EPMT PQ so they can carry out their own analyses of the demand and the financial and social impact of change alternatives in the service network.
- Develop a long-term transport policy that includes determining the technical fare as a basis for setting up the fare and operator compensation.
- Implement the management agency (Single Transportation Authority) and ensure this agency is able to monitor the operation and the fare collection system.

Funding partners:



Implementing agencies:

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Federal Ministry
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and Development



**CHILDREN'S
INVESTMENT FUND
FOUNDATION**



UK Government



USAID
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Implementing agencies:
