EletroMobilidade
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ELECTRIC BUS FINANCING PROJECT

IN BELO HORIZONTE

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SUMMARY

LIST OF ACRONYMS

AC	Alternating Current
ANEEL	Brazilian Electricity Regulatory Agency
ANP	National Agency of Petroleum
ANTP	National Association of Public Transport
BDMG	Development Bank of Minas Gerais
BH	Belo Horizonte
BHTRANS	Belo Horizonte Municipal Transport and Transit Company
BNDES	National Bank for Economic and Social Development
BNEF	Bloomberg New Energy Finance
BRT	Bus Rapid Transit
BYD	Electric vehicle manufacturer
CAF	*Corporación Andina de Fomento*
CAPAG	Capacity to Pay municipalities
CEF	*Caixa Econômica Federal*
CEMIG-SIM	Electric Utility Provider
CETESB	Environmental Technology and Sanitation Company
COFIEX	External Financing Commission
DC	Direct current
eCaRR	Electric vehicle with regular fast charging
ENEL	Multinational that operates in the field of electricity and gas generation and distribution
FINAME	Machinery and Equipment Financing Line
GHG	Greenhouse gases
GEIPOT	Transport policy integration executive group
IBGE	Brazilian Institute of Geography and Statistics
ICMS	Tax on Circulation of Goods and Services
HDI-M	Municipal Human Development Index

OPI	Organizational Performance Index
IPCA	Broad National Consumer Price Index
IPK	Index of Passengers per Kilometer
ITDP	Institute for Transportation and Development Policy
LOM	Municipal Organic Law
MDR	Ministry of Regional Development
MOVE	Rapid Transit Bus (BRT) system operating in Belo Horizonte
PBH Ativos	A privately held corporation that has as shareholders the municipality of Belo Horizonte, PRODABEL and BHTRANS
GDP	Gross Domestic Product
PlanMobBH	Mobility Plan of Belo Horizonte
PMA	Average Annual Route
PREEGE	Greenhouse Gas Reduction Plan of Belo Horizonte
Proconve	Car exhaust testing program
PRODABEL	IT and Information Company of the Municipality of Belo Horizonte
RMBH	Metropolitan Region of Belo Horizonte
RTS	Transport Networks and Services
SAIN	Secretariat of International Economic Affairs
SITBus	Intelligent Transport System of the Municipality of Belo Horizonte
SOFR	Secured Overnight Financing Rate
SPE	Special-Purpose Entity
TLP	Long-Term Rate
TUSD	Use of distribution system tariff
USEPA	United State Environmental Protection Agency
WRI	World Resources Institute
ZEBRA	Zero Emission Bus Rapid-Deployment Accelerator

INTRODUCTION

This report is part of **Product 6.1 – Financing project for electric buses in City 1 and 2, in Portuguese and English**, produced under the contract of consulting services for analysis, structuring, and implementation of studies and projects of electric buses in Brazil, part of the Transition to Electromobility in Brazilian Cities Project.

This version refers to the financing project for electric buses acquisition developed for the **Municipality of Belo Horizonte**. The development of this work, which occurred interactively between the team of consultants and the city teams through several technical discussions, is reported in this document composed of 6 chapters, described below.

Chapter 1 – Context presents the contextualization of the reality of the municipality, the initial premises for the preparation of the Financing Project, an analysis of the current operating contracts, and discusses the critical points to be considered for the pilot project, such as the electricity tariff structure and asset disposal mechanisms – buses and batteries.

Then, **Chapter 2 – Business model alternatives** brings a conceptual discussion of business model possibilities considered for the financing pilot project, contextualizing the issues and central elements to enable large-scale implementation of electric buses in the municipality.

Chapter 3 –Pilot Project Design in the Municipality brings the discussion on the four central aspects of the financing pilot project (operational aspects, legal aspects, economic and financial aspects, and social aspects). This chapter considers the specificities of the municipal reality, the guidelines on possible contractual solutions, and the development of the economic-financial evaluation model.

Chapter 4 – Asset financing explores options and alternatives related to funding sources for public transport, emphasizing the possibilities for the defined business model.

Chapter 5 – Recommendations for implementation and monitoring guides the objectives of the public administration for the construction of short, medium, and long-term goals for the electromobility of public transport in the municipality and recommends instruments for monitoring indicators and training of drivers and maintenance staff.

And finally, **Chapter 6 – Financing Pilot Project** addresses the financing strategy for the solution chosen by the stakeholders consulted. Thus, this chapter presents the implementation steps, from the consolidation of public definitions to the request for funding. It also brings issues around the financial balance of the proposal.

1.

CONTEXT

This chapter contextualizes the municipality's reality based on findings made throughout the development of the study. Initially, it introduces a brief characterization of the city regarding its demographics, urban mobility system - with a focus on public transport - and its advances regarding the transition to electromobility until the beginning of the project.

Through these aspects, this chapter presents the initial premises for elaborating the Financing Project, defined together with the municipality team, such as the quantity and size of vehicles to be replaced, lines in which they should operate (spatial coverage), and types of technologies, among others.

This chapter also explores contracts for the operation of public transport services currently in force in the municipality to provide an understanding of the existing legal framework, which can directly influence the implementation of financing pilot projects.

Finally, the chapter also supports the municipality in understanding the critical points to be considered for the pilot project, such as the electricity tariff structure and asset disposal mechanisms – buses and batteries.

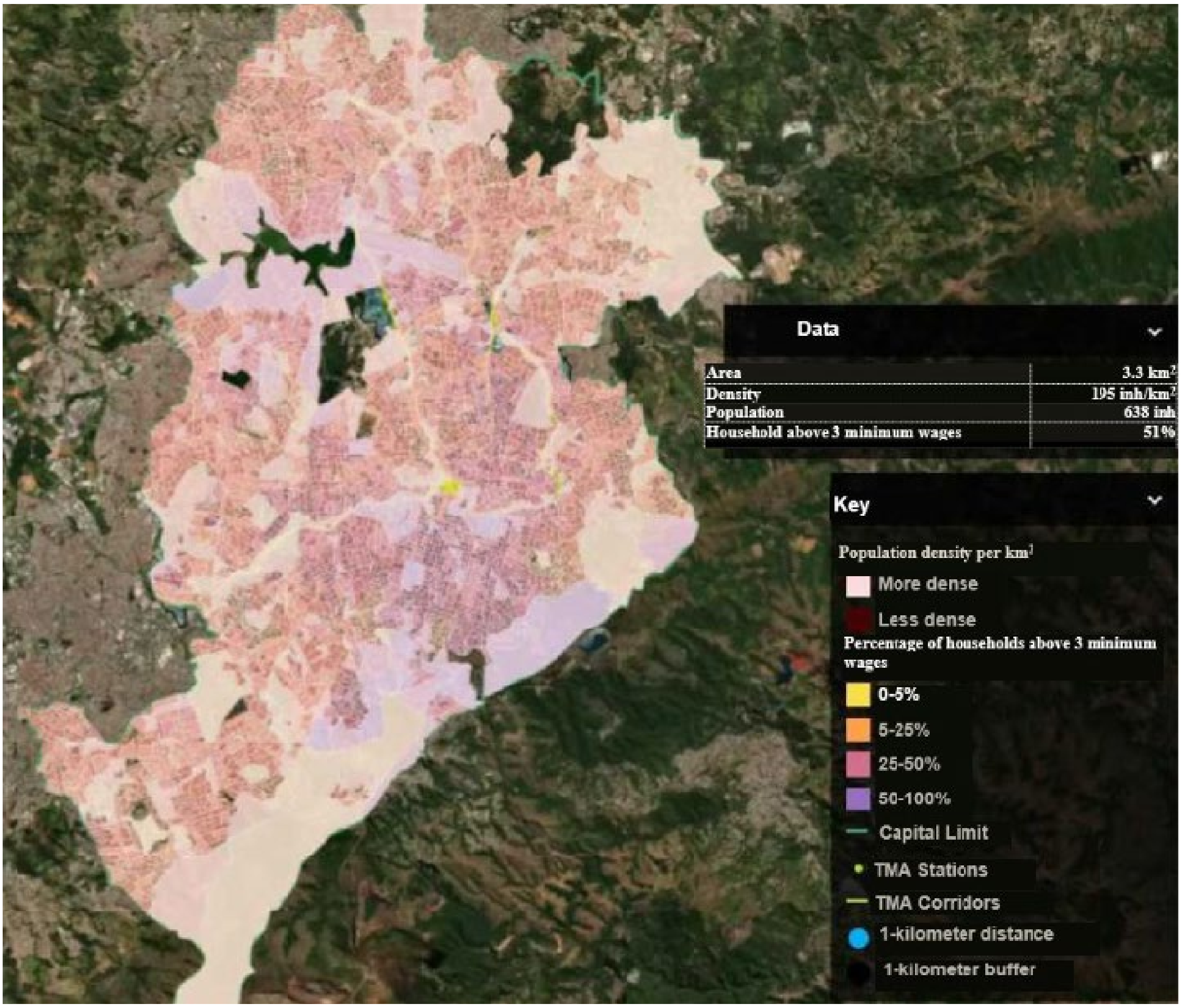
1.1 GENERAL CHARACTERISTICS AND URBAN MOBILITY

Belo Horizonte is the 6th most populous city in Brazil (with an estimated population of 2,530,701[1] people) and has a population density of about 7,167.00 inhabitants/km^2, being the 11th with the highest population density in the country.

1 Brazilian Institute of Geography and Statistics – IBGE. Available at: https://cidades.ibge.gov.br/brasil/mg/belo-horizonte/panorama

According to the *MobiliDADOS* platform, the capital of Minas Gerais has 40% of households with income below one minimum wage per capita, 52% of the population is Black, and women represent 53% of the population. Considering only the municipality of Belo Horizonte, only 17% of the population is near medium and high-capacity transport. When the evaluation considers the income range, this number is even lower: 12% for the population with income of up to half a minimum wage, see Figure 1 below.

Figure 1 – People Near Transport [2] by income bracket



Source: MobiliDADOS.

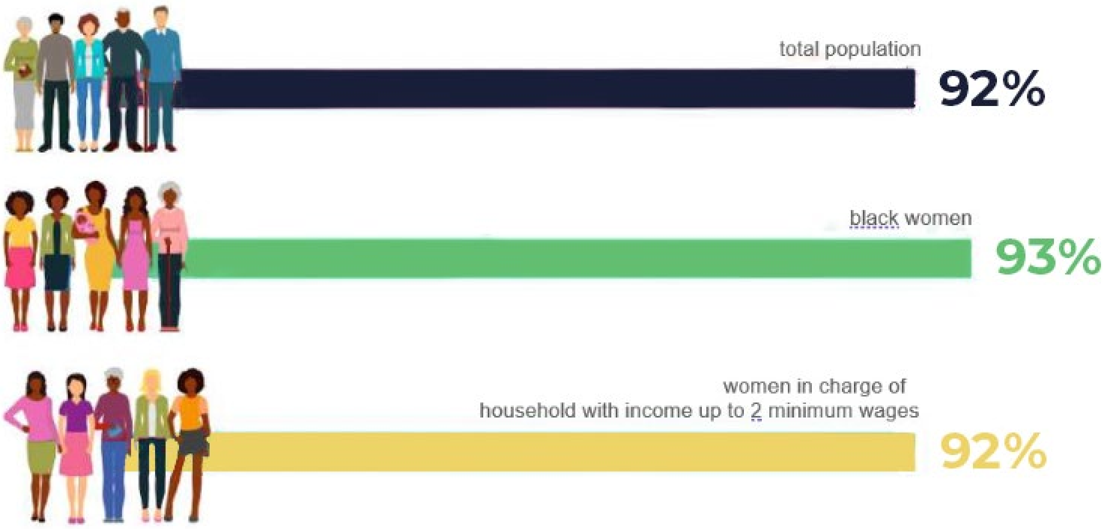
2 Do inglês People Near Transport, PNT.

According to a study[3] conducted in 2020 by ITDP Brazil in partnership with NossaBH, transportation in Belo Horizonte is distant from people, expensive, unsafe, and unequal. It was found that, when considering the Metropolitan Region of Belo Horizonte (RMBH), access to public transport is low, with about 92% of the population far from medium and high-capacity transport, such as BRT and Subway.

Thus, the average time for commuting from home to work is around 36 minutes, and about 14% of people take more than 1 hour for these commutes. The average daily public transport stay is relatively high, about 59 minutes.

The same study also highlights the issues of income, gender, and race in the RMBH. For example, 93% of black women and 92% of women responsible for household (with an income of up to 2 minimum wages) are also distant from the medium and high-capacity transport network, as highlighted in Figure 2 below.

Figure 2 – Percentage of people distant from medium and high-capacity transport by gender, race, and income

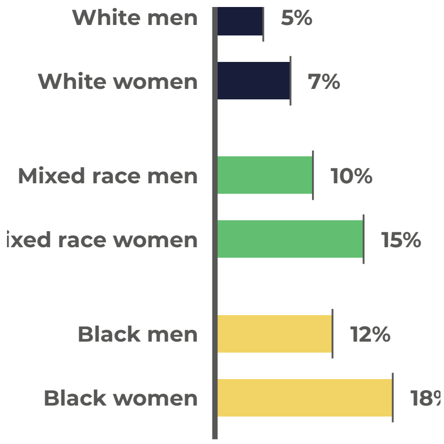


Source: ITDP Brasil and NossaBH, 2020.

In addition, the cost of public transport in RMBH is very high due to a tariff considered one of the most expensive in the country. Spending on two daily bus travels compromises 22% of the minimum wage.The study above cross-referenced the variables of gender and color/race and reported that it is clear that black people in Belo Horizonte, especially black women, have the highest expenses with public transport, considering their average income, as shown in Figure 3.

3 O Belorizontino e o transporte na cidade. ITDP Brasil. October, 2020.

Figure 3 – Impact of the tariff on the average income in Belo Horizonte by gender and color/race



Source: Programa 24 propostas para 2024, NossaBH, 2020.

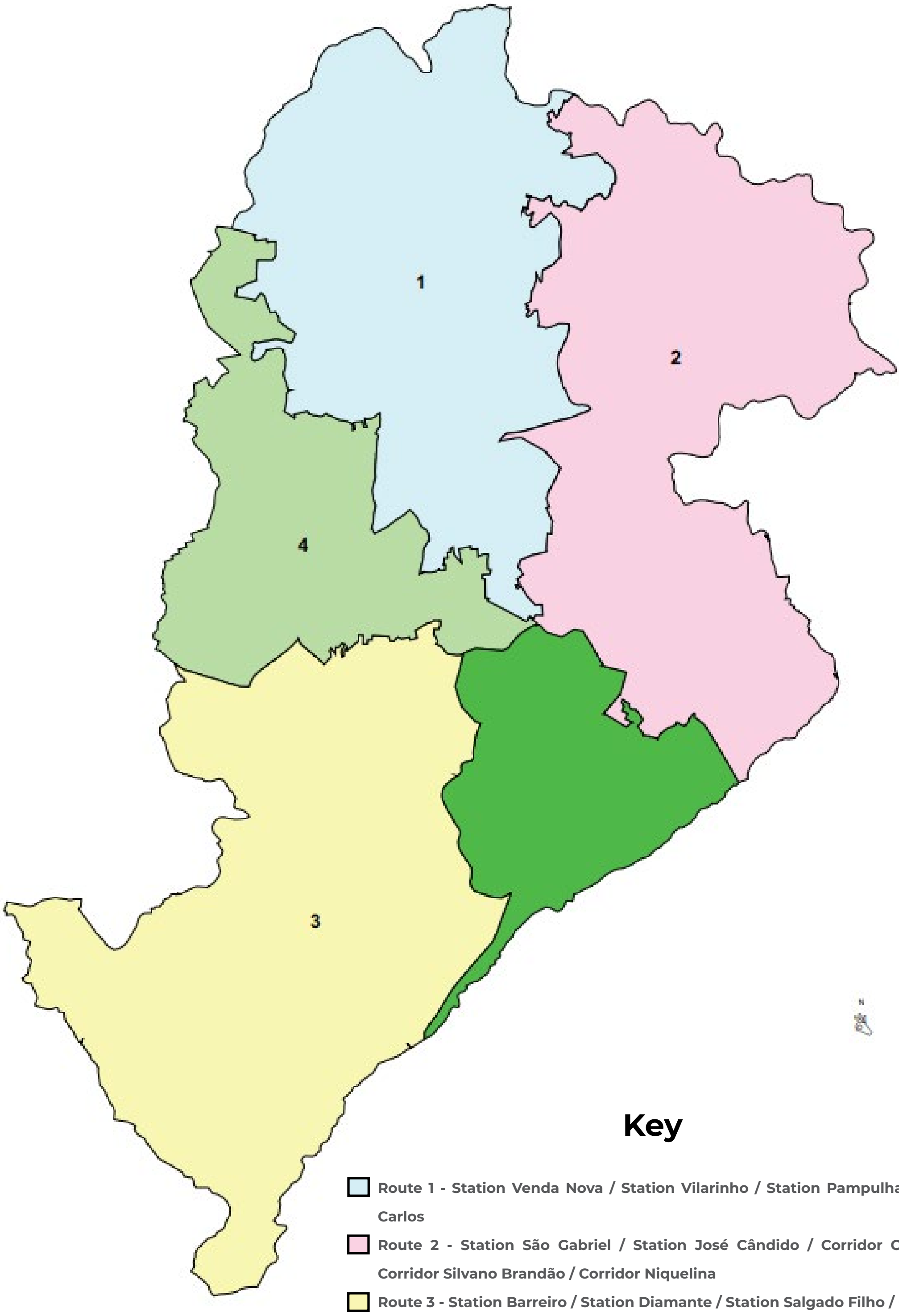
In Belo Horizonte, urban public transport services by taxi, vans, mini-busses, public bicycles, and municipal buses are under the management of the city through the public company BHTRANS. The intercity buses are under the Government of the State of Minas Gerais's responsibility, while the subway is under the responsibility of the Federal Government. According to 2018 data, the bus fleet transported about 137 million passengers annually through almost 20 km of dedicated BRT lanes (bus corridors) and about 42 km of exclusive lanes, and the fleet was composed of 2,629 conventional buses and 192 articulated buses.

The city's public transport system by bus operation is divided into four operational basins under different concessionaires, known as the Transport and Service Networks ("RTS"). In 2008 were signed the four concession contracts currently in force:

- RTS 1 - Venda Nova / Pampulha: operated by the Pampulha Consortium, composed of 12 companies;
- RTS 2 - North / Northeast / East: operated by BH Leste, composed of 9 companies;
- RTS 3 - Barreiro / Oeste: operated by Consortium Dez, composed of 9 companies;
- RTS 4 – Northwest and the common area of operation (south-central region): operated by the Dom Pedro II Consortium, composed of 9 companies.

Figure 4 presents the spatialization of RTS in the city of Belo Horizonte, but it is essential to highlight that the services operated by each consortium, despite belonging to a specific RTS, are not limited to them, often exceeding their limits.

Figure 4 – Transport and Service Networks (“RTS”) in Belo Horizonte



Key

- Route 1 - Station Venda Nova / Station Vilarinho / Station Pampulha / Corridor Antônio Carlos
- Route 2 - Station São Gabriel / Station José Cândido / Corridor Cristiano Machado / Corridor Silvano Brandão / Corridor Niquelina
- Route 3 - Station Barreiro / Station Diamante / Station Salgado Filho / Corridor Amazonas
- Route 4 - Station Alípio de Melo / Station Carlos Luz / Corridor Pedro II
- Center-South Region

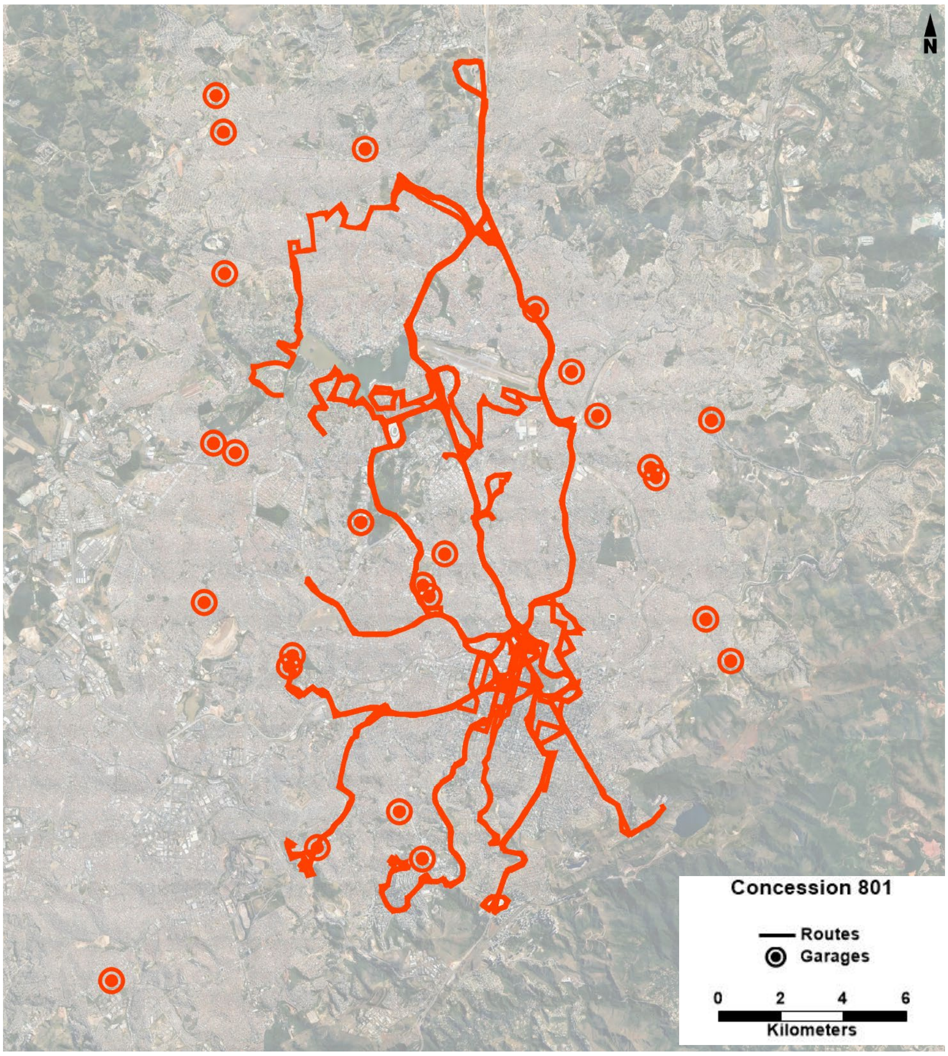
Source: Description of transport and service networks and relevant information on the current transport system of the municipality (BHTRANS).

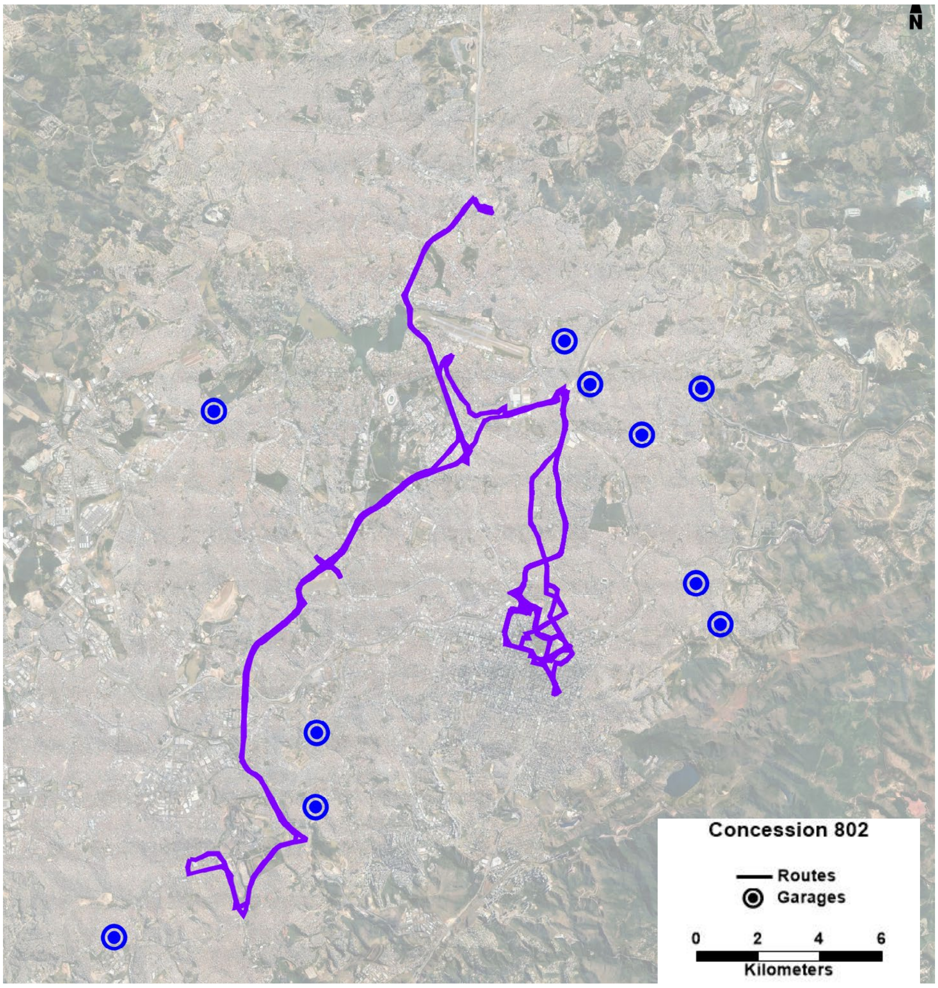
The MOVE system is the Bus Rapid Transit (BRT) system that operates in Belo Horizonte and some of its neighboring municipalities, such as Ribeirão das Neves, Santa Luzia, and Vespasiano. MOVE was inaugurated in 2014 and is part of the city's municipal transport system managed by BHTRANS and the inter-municipal system managed by the State Department of Infrastructure and Mobility (SEINFRA) and is operated by the concessionaires of this network.

In the case of the 4 consortiums that operate the municipal transport system by bus in Belo Horizonte, only 2 use MOVE services: Pampulha Consortium (code 801) and the CONSORTIUM BH Leste (code 802).

Figure 5 shows the MOVE services operated by each concessionaire and the locations of the respective garages, as reported by BHTRANS.

Figure 5 – MOVE services operated by the Pampulha (left) and BH Leste (right) Consortiums





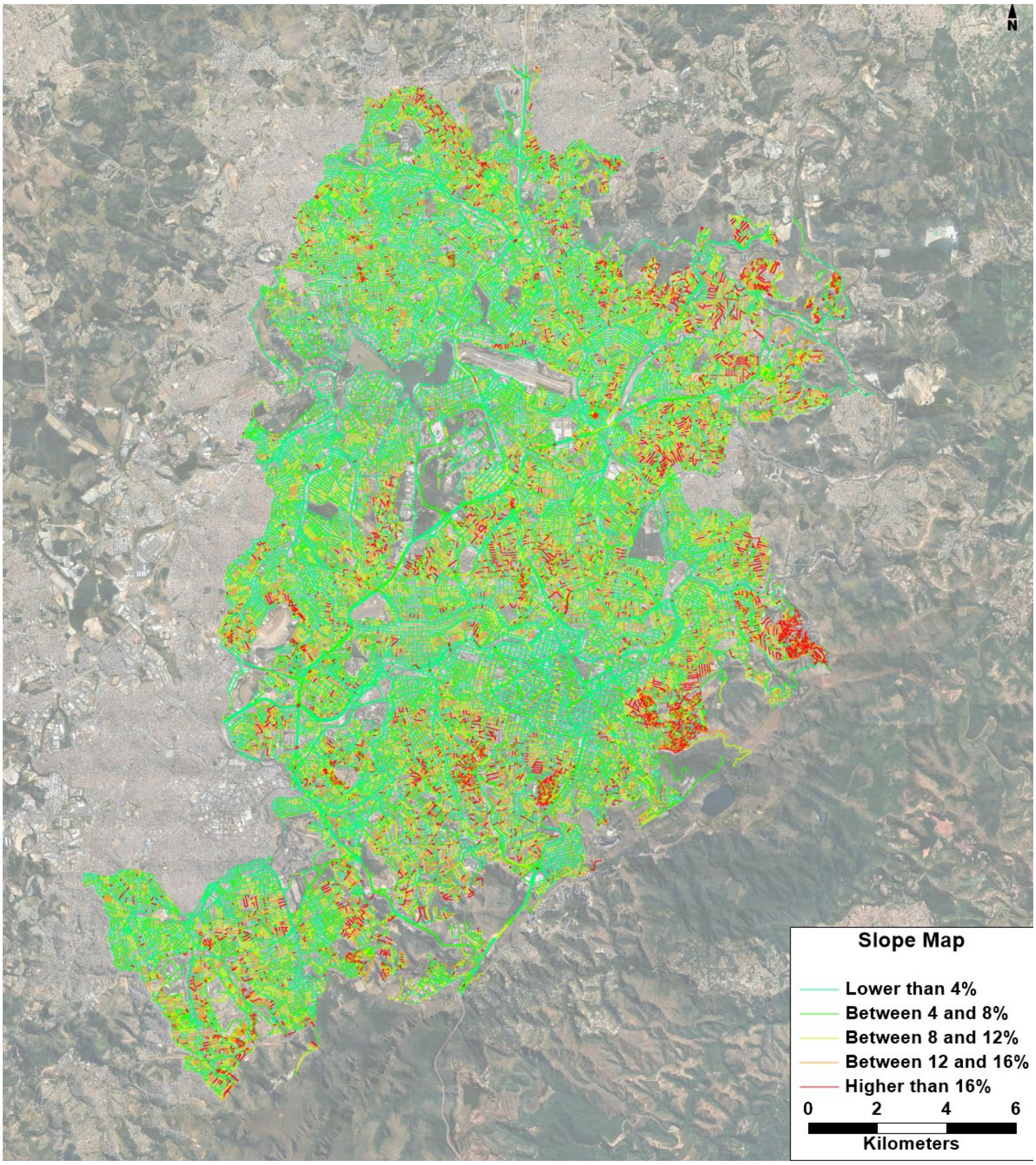
Source: BHTRANS, year 2021.

It is also worth highlighting the issue of slope on the roads of Belo Horizonte since the issue is historically discussed in depth in the city and represents one of the points of attention considered by BHTRANS to define the distribution of public transport lines and avoid operational problems. Unfortunately, according to the City Hall, the city's topography is sometimes still used to justify the lack of accessibility for people with reduced mobility and cyclists, an argument that does not sustain itself.

In this sense, the Institute of Geosciences of UFMG (ICG/UFMG), in partnership with ITDP and BHTRANS, surveyed the slope of the municipality, which resulted in the Map of Declivities of Belo Horizonte. The study aims to collaborate in helping the mobility projects that depend on identifying the flattest paths.

This study revealed that the city has an average slope of 8.28%. The Central and Pampulha areas have the smoothest slopes, while the East region has the highest average slopes. The results also show that some roads have slopes from 40 to over 72%, as shown in the map below.

Figure 6 – Belo Horizonte slope map



Source: Belo Horizonte slope map, 2020. Belo Horizonte City Hall.

1.2 HISTORY OF ADVANCES WITH ELECTROMOBILITY

Belo Horizonte does not have electric buses in its fleet but has participated in pilot tests and projects. The city might also receive possible support from WRI, which has prepared a pre-viability study supported by the World Bank.

In 2019, the city participated in a project on electromobility. The project involved developing three adapted electric minibusses, a fast charging station, and an experimental line in operation. The project also studied the impact of the implementation of the eCaRR[4] system on public transport in Belo Horizonte - MG, on the BRT corridors.

In 2021, the city conducted a major test with electric vehicles on some public transport lines. The tests brought great learning to the teams involved and were a starting point for developing the financing pilot project.

According to the reports of the tests provided by BHTRANS in this study, the project aimed to evaluate the operational suitability of an electric bus, considering different weather conditions, topography, and vehicle capacity. In addition, the recorded test results aimed to support the transport management agency's decision-making and evaluation of services provided.On November 12 and December 7, 2021, four public transport bus lines operated with the 100% electric vehicle in conjunction with a diesel vehicle. The operational test involved joint monitoring of a reference vehicle powered by diesel, made available by VIAÇÃO TORRES, with characteristics similar to the electric vehicle provided by the company BYD, such as the ability to transport passengers seated and standing, the length of the vehicle, type of suspension and air conditioning system.

An intercurrence was observed during the electric vehicle test period: the vehicle could not overcome an inclination of approximately 25%. In addition, the vehicle operated on line 5503A at peak hours with passengers on board, which also influenced the climb limitation due to the increase in the vehicle's weight component in the rolling resistance on a very steep slope.

BHTRANS reported that the electric vehicle testing period took place satisfactorily and without other significant complications than the one mentioned above. The estimated period of operation was shorter than planned. However, during the traveling period of the vehicle, it was possible to observe its operation in several operating conditions, including steep slopes and varied climatic conditions, such as periods of rain and variations of up to 20°C at maximum and minimum temperatures.

4 Electric vehicle with regular fast charging.

The reported project was divided into two phases, with the first carried out in 2021 with a bus provided by BYD in the form of a lending contract for operational tests. In the second phase, the tests would be expanded with the forecast of using 25 buses of different sizes. Both phases aimed to meet one of the fundamental goals of the mobility plan (PlanMob) of the city of Belo Horizonte: to reduce GHG emissions.

PlanMobBH-2030 was divided into eight axes. The Sustainable City axe contains indicators, targets, and actions, and it aims at promoting a change in the energy matrix of the transport system operated by vehicles with low environmental impact. Some of the goals set by 2030 are:

- 100% of non-fossil fuel vehicles in the fleet contracted by the municipality; and
- 40% renewal of the bus fleet by hybrid or non-oil-powered vehicles.

Three permanent actions compose the plan to achieve these goals:

- Prospect and promote the gradual replacement of the public transport fleet by vehicles with lower GHG emission potential;
- Stimulate the monitoring of emissions from the circulating fleet of diesel-powered vehicles; and
- Monitor environmental policy and ensure its articulation with mobility actions.

Thus, the project represents a strategic initiative and one of the fundamental steps of innovation in mobility, being a critical action in coping with the climate emergency and in the search for improvement of air quality, reduction of noise pollution, and reduction of GHG emissions, and especially in contributing to the quality progress of public transport.

Source: BHTRANS.

The second phase will be considered in this study's pilot project under development. As described in the following item, 25 electric buses of different sizes, conventional or articulated, are being considered for the financing pilot project, as previously planned.

1.3 INITIAL ASSUMPTIONS

As part of the actions carried out within the scope of this study, two technical meetings were held with the BHTRANS team responsible for the topic, in addition to the project kick-off meeting, where assumptions and starting points were discussed for the development of the financing pilot project. They also brought up the number of types of electric vehicles to include in the Municipality's operation, the type of technology, and the system cut that could receive these vehicles.

Regarding the fleet, **25 different types of electric vehicles** were selected, **20 conventional and 5 articulated vehicles were selected**. This fleet should operate in the MOVE system to take advantage of segregated infrastructure bus corridors to maximize operational gains and minimize possible losses or problems.

This decision is in line with the experience of testing an electric vehicle that occurred at the end of 2021, when the vehicle had problems overcoming the slope of the path of one of the chosen lines, forcing it to seek a new route and generating inconvenience to passengers on board. Thus, BRT corridors present a more favorable environment because their paths do not show too steep slopes as in some streets where the lines that also operate outside the corridors pass.

Therefore, the recommendation is that electric vehicles could be considered initially, under the financing pilot project, for **operation only on the trunk lines of the MOVE system**. In addition, it was considered that the trunk lines -present the highest levels of demand, enabling new electric vehicles to be experienced by more users.

For the charging infrastructure, the municipality had opted, in the previous test conducted in 2021, for the **traditional plug-in** and night charging in garages. However, in the current pilot project, two scenarios were also evaluated with traditional plug-in: i) slow charging in garages and ii) slow charging in garages and occasional charging in the terminals to increase the daily autonomy of vehicles.

The daily autonomy of vehicles is a concern since, in the previous test, low autonomy was observed compared to other experiences of other cities. Thus, it is essential to search for options that can increase the use of electric vehicles since the greater the use, the greater the operational gains and socioeconomic indicators.

The MOVE system's trunk lines were evaluated from this defined scenario cut to identify vehicles that could be replaced during the pilot project implementation. This report presents the complete analysis in item 3.1 - Definition of operational scenarios.

In discussion with the team, it was decided not to define specific vehicles to be replaced within the structuring of the financing project. This limitation would restrict the project to one or some operators of the responsible consortiums for MOVE's operation. Thus, the team recommended maintaining and furthering the analysis but only for supporting the results' discussions and evaluation.

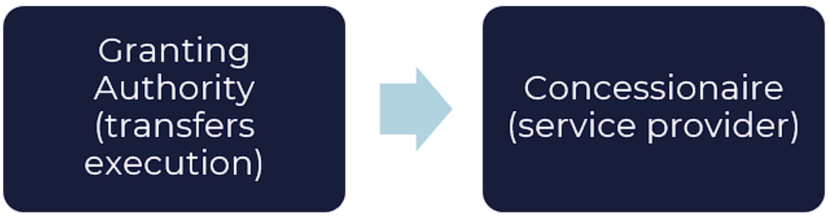
1.4 CURRENT REGULATORY ENVIRONMENT

This item presents an evaluation of the contracts for the operation of public transport services currently in force in the municipality to provide an understanding of the existing legal framework, which can directly influence the implementation of financing pilot projects.

1.4.1 National perspective

The Federal Constitution, in Article 175, establishes that public service is provided directly or through delegation. The constitutional provision was regulated by Federal Law n° 8987/1995, for the concession and permission regime, and Federal Law No. 11,079/2004, for private-public partnerships. In the concession contract, the Grantor shall be the federal entity constitutionally competent to provide this specific service and may delegate its execution to a private entity. In turn, the Concessionaire will be the legal entity of private law, constituted by private individuals who will relate to the user through public service provision. This means the direct legal relationship is between the Granting Authority and the Concessionaire. The grantor delegates the provision of the public service.

Figure 7 – Legal relationship between Grantor and Concessionaire



Source: Own elaboration.

Specifically, regarding public transport, Federal Law No. 12,587/2012 defined rules for urban mobility and instituted the remuneration rate as a form of payment for this service. However, considering that the contracts concluded by the city were the result of bidding procedures before 2012 and concluded based on Federal Laws No. 14,133/2021 (bidding) and No. 8987/1995 (concession), some notes on the contract defined in those laws are made on a preliminary basis.

Article 23 of the Concession Law establishes the essential clauses of the contract, and among them, the following stand out:

- The object, area, and term of the concession;
- The mode, form, and conditions of service provision;
- The criteria, indicators, formulas, and parameters defining service quality;
- The price of the service and the criteria and procedures for readjusting and revising tariffs;
- The rights, guarantees, and obligations of the granting authority and the concessionaire, including those related to foreseeable needs for future alteration, expansion, and modernization of the service, improvement, and expansion of equipment and facilities;
- User's rights and duties to obtain and use the service ;
- Inspection methods for installations, equipment, execution of the service methods and practices, as well as the indication of the competent agency to exercise it;
- The contractual and administrative penalties to which the concessionaire is subjected and application method.

Administrative contracts have as characteristic the so-called exorbitant clauses that, due to the protection of the public interest, allow: unilateral alterations of the implementing clauses, provided the economic and financial balance of the Contract is ensured (art. 9º§4); unilateral termination of the contract before the end of the established term; inspection and supervision of the contract execution; the direct application of contractual and administrative sanctions. These prerogatives aim to ensure that the public service is provided in line with the needs of the citizen.

Contracts must provide tariff review mechanisms to ensure economic-financial balance (art. 9º, § 2º), and if the government unilaterally changes the execution of the contract, it must guarantee the initial economic-financial balance simultaneously to such alteration (art. 9º, § 4º).

With the termination of the contract, two simultaneous situations arise: a) the rights and privileges transferred to the concessionaire and the reversible assets return to the granting authority, that is, goods described in the contract that automatically pass to the property of the granting authority with the termination of the concession; b) the service will be immediately taken over by the granting authority, carrying out the necessary surveys, assessments, and settlements (Art. 35, §1 and 2º).

1.4.2 Concession contracts

The City of Belo Horizonte has the competence to plan, organize, direct, coordinate, execute, delegate, and control the provision of public services related to collective and individual passenger transport, traffic, transit, and municipal road system, as established by the Organic Law of Municipality (Article 193).

According to Municipal Law No. 9491/2008, the Executive Power is authorized to grant the collective passenger transport service, and BHTRANS was assigned to regulate and supervise the services granted. This assignment was outlined through Municipal Law No. 5953/1991.

On March 27, 2009, the City Hall published Bid No. 131/2008 for the concession of public transport service by bus, based on Federal Laws No. 8987/1995 and No. 14,133/20, in the Organic Law of the Municipality and Municipal Law No. 9494/2008. As a result, public transport by bus in Belo Horizonte was divided into four operational basins served by different concessionaires, known as Transport and Service Networks (RTS). Finally, on July 25, 2008, the four concession contracts were signed:

- RTS 1: operated by the Pampulha Consortium, composed of 12 companies [1];
- RTS 2: operated by BH Leste, composed of 9 companies [2];
- RTS 3: operated by Consortium Dez, composed of 9 companies [3];
- RTS 4: operated by the Dom Pedro II Consortium, composed of 9 companies [4].

The purpose of the Concession Agreement is the delegation of the management of transport services which corresponds to the transport of users, installation, conservation, and maintenance of the garages, and installation, maintenance, development, updating, and operation of the SITBus. The validity term of the contracts in question is twenty years from the beginning of the service provision, which took place on November 15, 2008, with the rule of not extending the adjustment (clause 6.1). However, the contract allows changing the concession term, subject to the contract review (items 19.13 c/c 30.2). In turn, the review (clause 19) may be implemented by the mechanisms established in item 19.13 and, among them, the possibility of changing the concession term.

The concessionaire's remuneration derives from the tariff paid by the passenger, under the current tariff policy (item 11.1), with other sources of income allowed – alternative, complementary, and ancillary inherent to the services and arising from associated projects (item 12.1).

The contract provides tariff readjustment by applying the formula from the contractual instrument (clause 11) to correct the tariff value according to the variation in the costs of the services. The approval of the adjustment is published in the Official Gazette until December 26 of each year. In addition, every four years, the Grantor carries out a tariff review to transfer the productivity gains aimed by the Concessionaire to the tariff value (clause 22).

The assets linked to the Concession were regulated by Annex III of the Notice and in the Commercial Proposal presented by the concessionaire during the bidding process. Accordingly, they must follow the regulation issued by BHTRANS (clause 7ª), and such assets cannot be reversed. Also, compensation for adding or replacing these assets is not applicable (item

7.7.1).The Reversible Assets are regulated in item 7.6 and must be in a condition of use for at least 24 months (item 7.6.1), and, as a rule, there is no compensation for the reversal (item 7.6.2).

The parameters for the provision of services are set out in Annexes III and VIII of the Public Tender Notice and in the Services Regulation. Annex III deals with the minimum requirements for the provision of services. At the same time, Annex VIII specifically addresses the SITBus (Intelligent Transport System of the Municipality of Belo Horizonte), detailing all the functionalities and equipment that must be present in the system.

Regarding the operation, the evaluation is made by the Organizational Performance Index ("OPI")[5]. The Agreement and Regulation did not establish the composition of the OPI and left it to BHTRANS to define it. Its establishment took place through the act of the Belo Horizonte Municipal Transport and Transit Company ("BHTRANS") - Ordinance No. 052/2021.

The OPI[6] consists of a set of operational indexes to evaluate the adequacy and satisfaction of the services offered to users based on the performance of the main travel attributes, that is, the performance of the service provided, and is calculated by the following indexes:

- Schedule Compliance Index: assesses the percentage of travels by the hourly schedule;
- Travel Punctuality Index: evaluates the percentage of travels that started respecting the hourly schedule, with a tolerance of up to 10 minutes or half a headway (the lowest value between the two is considered);
- Travel Comfort Index: assesses the percentage of sub-timeslots that have a bus capacity higher than the one established (considering the maximum occupancy rate);
- Mechanical Reliability Index: ratio between the number of travels interrupted due to mechanical failures and the productive mileage of the system;
- Travel Safety Index: ratio between the number of travels with occurrences of unsafe events (travel accidents, robberies, depredation, etc.) and the total number of travels carried out;
- Regulatory Infractions Index: lists the number of points related to the infractions committed (from the service regulations) and the productive mileage of the system;
- User Complaints Index: evaluates the number of complaints by the total number of passengers using electronic ticketing.

5 With regard to these indices and as pointed out by Kittelson & Associates Inc et al.., (2003), it makes sense to use various performance measures to reduce the excess of reported information, so that it is possible to provide an overview of the performance of the service, but has the power to mask some changes in the system.

6 Memória Descritiva do Índice de Desempenho Operacional – IDO.

The OPI arises from these indexes' results, then is converted to a variable scale: "A" for excellence level and "E" for unacceptable.

Nevertheless, the indexes that make up the OPI of Belo Horizonte have their own goals, allowing the individual assessment of each analyzed aspect. Although each index has permissible limits, no penalties are associated when not complying with them. However, if a concessionaire obtains an E-level OPI for six consecutive months, it is subject to contractual termination – expiry (item 27.6.1). On the other hand, the concessionaire that presents the best OPI in 12 months can explore new lines created by the public authorities within the common area of operation (item 14.1.3).

On a more general note, the concession of the Belo Horizonte system does not provide for a measure that allows assessing the customer's perception of the system, except for the complaint channels. There is no satisfaction survey, which is an important element in measuring the system's quality and identifying points that can be improved. In this sense, Marçal Justen Filho (2003) [5] states that:

> *"One can only obtain the full and satisfactory operationalization of the concession by recognizing that the community and the service users are not third parties to the legal relationship. The concept that the concession represents a trilateral legal relationship is adopted, in which one of the poles is occupied by institutions representing the community."*

As for the fleet, the contract provides for replacement after the end of the vehicle's useful life, which is 10 to 12 years on average. Articulated and bi-articulated vehicles may have up to 12 years of use. Light vehicles will have a maximum useful life of 7 years, and the other vehicles will have a useful life of 10 years.

To replace the vehicle, the Concessionaire should consult BHTRANS for evaluation and must align with regulatory standards and legislation applicable to the species. (clause 2.4.2 of Annex III).

The implementation and maintenance of access points (bus stops, stations, and terminals) are not under concession responsibility, so there are no specifications regarding these aspects.

The conclusion of contracts, governed by the rules of private law, between the concessionaire and third parties is allowed. However, no legal relationship is established between the third parties and the Grantor. The concessionaires may hire third parties to develop activities inherent, ancillary, or complementary to the service and for implementing associated projects (item 14.8). It is important to note that this is not about contracting third parties to provide the public service granted.

The Contract allows the sub-concession of the contract (clause 29) if there is express authorization by the Grantor and a competitive bidding process always precedes this grant. On the other hand, the transfer of concession or corporate control of the concessionaire without the prior consent of the grantor will result in the expiry of the concession (item 28.1).

In addition, the BHTRANS can require the installation of ramps at the doors of buses to ensure universal accessibility and the use of less polluting energy sources. Still, there is no specification of deadlines, percentage of the fleet that must meet these criteria or other details on these items. This means that BHTRANS has the possibility, at any time, to require adaptations, updating, and use of new technologies and fuels for environmental improvement.

Until April 2022, there are seven contractual addenda:

- 1st Addendum for advance payment by the Concessionaire;
- 2nd Addendum to change the settlement agent nomenclature; indexes for calculating tariff readjustment; advertising rules; insurance contracting; the possibility of using arbitration; unforeseeable circumstances or force majeure;
- 3rd Addendum to change the index for calculating the tariff readjustment;
- 4th Addendum to add a clause on collective bargaining or collective labor agreement; clause on IRR arising from the review processes and to amend the clause on the reduction coefficient;
- 5th Addendum allowing the use of vehicles from another RTS for greater efficiency in the provision of services offered; inclusion of concessionaire responsibilities; tariff determination for quadrennial review; change of indices for tariff readjustment calculation6th Addendum to adjust the value for contractual review; alteration of indexes to calculate the tariff readjustment; tariff change in the case of collective bargaining or collective labor agreement
- 7th Addendum allows the Grantor to bid to third parties specialized services for tourist assistance characterized for using vehicles other than those currently specified for the collective and conventional public transport by bus, without giving the concessionaire the right to readjust the economic-financial balance of the contract.

Finally, it is worth mentioning that the Public Ministry of Minas Gerais is questioning the public transport concession contracts in Belo Horizonte[7]. Table 1 below presents a summary table of the evaluated documents.

7 The main objective of the lawsuit is the judicial declaration of nullity of Public Tender 131/2008 (bidding process for the concession of the municipal collective transport service by buses) and all public transport concession contracts and amendments arising from it due to evidence of collusion between bidding participants and lack of competition. On the subsidiary/secondary basis, it seeks a judicial declaration of expiry of the concession due to breach of contract. The lawsuit was filed in September 2021, under no. 514049650.2021.8.13.0024. In April 2022 took place the last progress of the process, which awaits the judge's order to proceed with the subpoenas. Currently, in August 2022, it is pending and without a sentence.

Table 1 – Summary table of contracts and addenda - Belo Horizonte

CONTRACTS				
Contract	RTS N° 1	RTS N° 2	RTS N° 3	RTS N° 4
Date of signature	07/25/2008	07/25/2008	07/25/2008	07/25/2008
Operation Area	Venda Nova/ Pampulha	Norte/Nordeste/Leste	Barreiro/Oeste	Noroeste and common area of operation
Private Partner	Consortium DEZ	BH LESTE	Consortium DEZ	Consortium DOM PEDRO II
Modality	Concession	Concession	Concession	Concession
Grant Amount (in billions of R$)	4,33	4,81	4,33	2,84
Number of lines served	81 lines + tourist service lines	89 lines	92 lines	60 lines
Period of validity	20 years			
Contractual extension forecast	No prediction			
Remuneration policy	Tariff collection according to current policy			
Tariff readjustment	Annually (December)			
Tariff review	Every 4 years, to pass productivity gains on to the tariff values. Eventual imbalances of the economic-financial equation of the contract may be considered.			
Sub-concession	It shall be accepted if preceded by a competitive bidding process			
Concession transfer/corporate control	Admitted			
With Addendum	Yes			
New technologies foreseen	Yes (Annex III, item 2.4.6 fls. 9)			
Considers environmental compensation	No			
Provides training actions	No			
Provides for social inclusion and gender actions	No			
CONTRACTUAL ADDENDUM 1				
Contractual Addendum date	07/25/2008			
Contractual Addendum Object	Advance payment by the concessionaire			

CONTRACTS	
CONTRACTUAL ADDENDUM 2	
Contractual Addendum date	12/17/2008
Contractual Addendum Object	Addendum: in the nomenclature of settlement agent; indexes for calculating tariff readjustment; advertising rules; insurance contracting; possibility of using arbitration unforeseeable circumstances or force majeure
CONTRACTUAL ADDENDUM 3	
Contractual Addendum date	12/14/2010
Contractual Addendum Object	Addendum: of the index for tariff readjustment calculation
CONTRACTUAL ADDENDUM 4	
Contractual Addendum date	12/19/2014
Contractual Addendum Object	A clause on: collective bargaining or collective labor agreement; clause on IRR from the review processes. There is a change in the clause on the reduction coefficient;
CONTRACTUAL ADDENDUM 5	
Contractual Addendum date	12/19/2014
Contractual Addendum Object	Addendum of the clause allowing the use of vehicles from another RTS for greater efficiency in the provision of services offered; inclusion of concessionaire responsibilities; rate determination for quadrennial review; change of indices for tariff readjustment calculation
CONTRACTUAL ADDENDUM 6	
Contractual Addendum date	12/16/2015
Contractual Addendum Object	Addendum to adjust the value for contractual review; alteration of indexes to calculate the tariff readjustment; tariff change in the case of collective bargaining or collective labor agreement
CONTRACTUAL ADDENDUM 7	
Contractual Addendum date	10/07/2016
Contractual Addendum Object	Addendum to give the Grantor the possibility of bidding to third parties specialized services for tourist assistance characterized for using vehicles other than those currently specified for the collective and conventional public transport by bus, without giving the concessionaire the right to readjust the economic-financial balance of the contract.

Source: Own elaboration

1.5 GUIDELINES FOR THE PILOT PROJECT

Section 3.2 of this Report presents a detailed analysis of the premises and methodology used for the financial modeling of the Electromobility Transition Pilot Project. Such assumptions result from a combination of market constraints over which the agent responsible for the operation of electric vehicles will not interfere, such as the diesel price, with a set of variables on which the operator agent will be able to intercede. For example, the way electricity is contracted, the bases for acquiring vehicles and others, and the financing method.

In this context, the following section presents a brief evaluation of the electricity tariff structure, while section 1.5.2 deals with the mechanisms for eliminating buses and batteries at the end of their useful life.

1.5.1 Electricity tariff structure

The large-scale operation of electric vehicles, covering a significant percentage of the fleet in operation in the municipality, will have as a by-product a significant demand for energy for the movement of this fleet. This volume of energy demand enables the entity responsible for the operation of electric vehicles to qualify as a "free consumer" or "special consumer." Under the regulating terms of the National Electric Energy Agency, a Free Consumer has contracted a demand with a distributor exceeding 1000 KW. This consumer can purchase any type of energy: conventional or incentivized, special or not. As of January 2023, consumers with a load equal to or greater than 500kW and any voltage level may be qualified as free consumers.

A special consumer is a unit, or a set of consumer units established in contiguous areas or registered under the same CNPJ, whose demand contracted with the distributor is equal to or greater than 500 KW and less than 1500 KW. This type of consumer can contract the following energies:

- special incentivized energy (there is a transfer of discount on TUSD) and
- special conventional energy (there is no transfer of discount on TUSD).

This volume of contracted energy demand is much higher than the expected consumption with vehicles linked to the Pilot Project, covering the load of 20 articulated vehicles and 5 Padron-type vehicles. The pilot project considers the energy cost for "Captive Consumers," those who purchase energy from the Regulated Commercialization Environment.

In the case of Belo Horizonte, the responsible distributor is CEMIG-SIM, whose values are reproduced below.

Table 2 – Group A CEMIG-SIM tariff (before taxes) for medium and high voltage

BLUE TARIFF						
A1 - 230KV OR MORE	**DEMAND R$/KW**	**GREEN FLAG - CONSUMPTION R$/KWH**	**YELLOW FLAG - CONSUMPTION R$/KWH**	**RED FLAG 1 - CONSUMPTION R$/KWH**	**RED FLAG 2 - CONSUMPTION R$/KWH**	**WATER SCARCITY FLAG - CONSUMPTION R$/KWH**
Peak Demand	0,00					
Off-peak Demand	0,00					
Surcharge Demand Off-peak	0,00					
Surcharge Demand Off-peak	0,00					
Peak Cons. - Dry period		0	0	0	0	0
Peak Cons.-Humid period		0	0	0	0	0
Off-Peak Cons. - Dry period		0	0	0	0	0
Off-Peak Cons. - Humid period		0	0	0	0	0
A2 - 88 KV TO 138KV	**DEMAND R$/KW**	**GREEN FLAG - CONSUMPTION R$/KWH**	**YELLOW FLAG - CONSUMPTION R$/KWH**	**RED FLAG 1 - CONSUMPTION R$/KWH**	**RED FLAG 2 - CONSUMPTION R$/KWH**	**WATER SCARCITY FLAG - CONSUMPTION R$/KWH**
Peak Demand	13,98					
Off-peak Demand	6,07					
Surcharge Demand Peak	27,96					
Surcharge Demand Off-peak	12,14					
Peak Cons.		0,469820	0,488560	0,509530	0,56476	0,61182
Off-peak Cons.		0,320800	0,339540	0,360510	0,41572	0,4628
A3 - 69 KV	**DEMAND R$/KW**	**GREEN FLAG - CONSUMPTION R$/KWH**	**YELLOW FLAG - CONSUMPTION R$/KWH**	**RED FLAG 1 - CONSUMPTION R$/KWH**	**RED FLAG 2 - CONSUMPTION R$/KWH**	**WATER SCARCITY FLAG - CONSUMPTION R$/KWH**
Peak Demand	21,54					
Off-peak Demand	7,94					
Surcharge Demand Peak	43,08					
Surcharge Demand Off-peak	15,88					
Peak Cons.		0,47948	0,49822	0,519190	0,5744	0,62148
Off-peak Cons.		0,330460	0,3492	0,370170	0,425380	0,47246

A3A - 30 KV TO 44 KV	DEMAND R$/KW	GREEN FLAG - CONSUMPTION R$/KWH	YELLOW FLAG - CONSUMPTION R$/KWH	RED FLAG 1 - CONSUMPTION R$/KWH	RED FLAG 2 - CONSUMPTION R$/KWH	WATER SCARCITY FLAG - CONSUMPTION R$/KWH
Peak Demand	44,9					
Off-peak Demand	14,86					
Surcharge Demand Peak	89,8					
Surcharge Demand Off-peak	29,72					
Peak Cons.		0,49566	0,5144	0,53537	0,590580	0,63766
Off-peak Cons.		0,34664	0,36538	0,38635	0,441560	0,48664

A4 - 2,3 KV TO 25 KV	DEMAND R$/KW	GREEN FLAG - CONSUMPTION R$/KWH	YELLOW FLAG - CONSUMPTION R$/KWH	RED FLAG 1 - CONSUMPTION R$/KWH	RED FLAG 2 - CONSUMPTION R$/KWH	WATER SCARCITY FLAG - CONSUMPTION R$/KWH
Peak Demand	44,90					
Off-peak Demand	14,86					
Surcharge Demand Peak	89,8					
Surcharge Demand Off-peak	29,72					
Peak Cons.		0,495660	0,5144	0,53537	0,590580	0,63766
Off-peak Cons.		0,346640	0,36538	0,38635	0,441560	0,48864

AS - SUBTERRANEAN	DEMAND R$/KW	GREEN FLAG - CONSUMPTION R$/KWH	YELLOW FLAG - CONSUMPTION R$/KWH	RED FLAG 1 - CONSUMPTION R$/KWH	RED FLAG 2 - CONSUMPTION R$/KWH	WATER SCARCITY FLAG - CONSUMPTION R$/KWH
Peak Demand	71					
Off-peak Demand	15,47					
Surcharge Demand Peak	142					
Surcharge Demand Off-peak	30,94					
Peak Consume		0,531000	0,549740	0,570710	0,625920	0.673
Off-peak Consume		0,381980	0,400720	0,421690	0,476900	0,52398

GREEN TARIFF						
A3A - 30 KV TO 44 KV	**DEMAND R$/KW**	**GREEN FLAG - CONSUMPTION R$/KWH**	**YELLOW FLAG - CONSUMPTION R$/KWH**	**RED FLAG 1 - CONSUMPTION R$/KWH**	**RED FLAG 2 - CONSUMPTION R$/KWH**	**WATER SCARCITY FLAG - CONSUMPTION R$/KWH**
Demand	14,86					
Surcharge Demand Off-peak	29,72					
Peak Cons.		1,58306	1,601800	1,62277	1,67798	1,72506
Off-peak Cons.		0,34664	0,365380	0,38635	0,44156	0,48864
A4 - 2,3 KV TO 25 KV	**DEMAND R$/KW**	**GREEN FLAG - CONSUMPTION R$/KWH**	**YELLOW FLAG - CONSUMPTION R$/KWH**	**RED FLAG 1 - CONSUMPTION R$/KWH**	**RED FLAG 2 - CONSUMPTION R$/KWH**	**WATER SCARCITY FLAG - CONSUMPTION R$/KWH**
Demand	14,86					
Surcharge Demand Off-peak	29,72					
Peak Cons.		1,58306	1,601800	1,62277	1,67798	1,70506
Off-peak Cons.		0,346640	0,36538	0,386350	0,441560	0,48864
AS SUBTERRANEAN	**DEMAND R$/KW**	**GREEN FLAG - CONSUMPTION R$/KWH**	**YELLOW FLAG - CONSUMPTION R$/KWH**	**RED FLAG 1 - CONSUMPTION R$/KWH**	**RED FLAG 2 - CONSUMPTION R$/KWH**	**WATER SCARCITY FLAG - CONSUMPTION R$/KWH**
Demand	15,47					
Surcharge Demand Off-peak	30,94					
Peak Consume		2,25074	2,26948	2,29045	2,34566	2,39274
Off-peak Consume		0,38198	0,40072	0,42169	0,4769	0,52398

Source: CEMIG-SIM, 2022

The distribution of the energy parameters used by CEMIG-SIM led to the adoption of the following parameters to calculate the costs of supplying this input within the scope of the Pilot Project

- Acquisition in A4 - 2,3 KV TO 25 KV,
- 30% of the energy in Green Flag, 30% in yellow flag, and 40% in red flag.
- Taxes on energy purchases:
    - PIS / Pasep: 0,77%
    - Cofins: 3,56%
    - ICMS (MG): 30,00%
- Expenditure on demand with expenditure on energy consumption: 7,0%

Based on these parameters, the company responsible for operating the vehicles must decide on the charging model, as explained in the following chapters. If charging is restricted to night, 100% of the demand will be contracted in the off-peak period. In the opportunity charging model, it is considered that about 15% of the total charge will be carried out during peak tariffs, while the most significant part, 85%, would remain carried out off-peak.

Considering all these elements, the value for energy with the opportunity charging is R$ 0.623903 per kw/h. On the other hand, if the operation is restricted to night charging, acquiring the full energy at the off-peak tariff, the tariff value will be R$ 0.588189 per kw/h.

1.5.2 Bus and battery disposal mechanisms

Electric bus technology is relatively new, and there are few real examples of electric fleets reaching the end of their useful life. However, unlike conventional buses, electric buses have fewer moving parts in the engine, so they are expected to demand less maintenance while offering a longer useful life (Mahmoud et al., 2016 [6]). Thus, battery degradation is likely to be the first factor to be considered for replacement. For this reason, it is suggested to align battery disposal plans with the expiration of the battery warranties, according to the "How to Enable Electric Bus Adoption in Cities Worldwide" manual prepared by WRI in 2019 [7].

Still, in the technical and operational planning of the project to implement electric buses in the fleet of the public transport system of a municipality, it is necessary to address issues regarding the destination of vehicles and batteries after the end of their useful lives. The establishment of disposal mechanisms during the initial stage of the project tends to reduce uncertainties and favor the project's economic viability, according to the Electromobility Guide (MDR) [8]. The "How to Enable Electric Bus Adoption in Cities Worldwide" manual presents four options, as the battery warranty expires and/or the battery becomes too degraded for bus operation:

- **Replace the battery and continue to operate the bus with the same operator for additional years.** This scenario is more likely since the bus usually has a longer useful life than the battery.

- **Replace the battery and sell the bus to third parties.** The bus operator might not want to bear the cost of a new battery unless the total cost of resale compensates for installing a new battery.

- **Sell or dispose of the bus and keep the battery through recycling or second-life use.** This scenario is most likely to happen when the market for used batteries destined for recycling or other uses is mature, and the bus chassis is old.

- **Sell or dispose of both the bus and battery.** This scenario is most likely to happen when the residual values of batteries and buses are unclear or too low, and the battery replacement cost is higher than the value received if everything was sold.

It is known that it is difficult to predict the cost and availability of vehicle batteries. However, costs are decreasing rapidly and are expected to continue to decrease over the next decade (BNEF, 2018 [9]). Although estimates of future costs vary due to uncertainties, most forecasts illustrate the same overall trend, as estimated by Bloomberg New Energy Finance: the cost of batteries should continue to halve, reaching $70/kWh by 2030, according to the WRI manual, 2019. In addition, many studies focus on recycling and the second-life use of batteries.

"Second life" refers to the transition from using batteries in vehicles to application in stationary energy storage and peak demand management. The degradation of batteries in vehicles results in a reduction in operating autonomy, which makes their use inappropriate over time. Thus, batteries can still support grid and facilities services (Stringer and Ma, 2018 [10]).

It is indicated that the decision on the final disposal of batteries and vehicles at the end of their useful life depends on criteria, such as projections of battery costs, the market value of batteries after the end of their useful life, and projections of the costs of electric buses. For example, if the cost of battery replacement drops and the residual value of electric buses and used batteries increases to a certain point, replacing bus batteries may be a more appropriate option than acquiring new buses. On the contrary, if the capacity of electric buses in the future increases significantly compared to costs, purchasing new buses and disposal of old ones may be a better solution for operators.

It is estimated that these factors are difficult to predict, so the agency should adopt a set of criteria for selecting any of these options. These conditions should be assessed regularly to assist in timely decision-making. Considering the current advances in battery technology improvement and cost reduction, the pilot project trend should be battery replacement and continuation of the operation of electric vehicles.

After the end of their useful life, batteries still retain about 80% of their storage capacity, as previously presented, so they can be reused for peak energy displacement (in which energy consumption tends to be more expensive) and energy storage. The displacement of the peak energy consists of charging the batteries during the idle moment of the power grid, and during peak hours, the batteries can be used to reinforce the supply of electric vehicles. The benefits of this practice include cost reduction, emission reduction, and integration with renewable energy sources (Walker et al., 2015 [11]).

The cost of reusing a battery pack into storage energy elements is more cost-effective than purchasing new batteries (MDR, 2022). However, it is worth noting that it is necessary to evaluate the economic impacts of this reuse, given the trend of reduction of batteries, to guarantee the project's economic viability.

Energy storage consists of supporting the implementation of smart grids, i.e., electrical energy distribution and transmission systems through digital resources, operating more efficiently through greater control of energy flow. For the implementation of this smart grid, it is necessary to have an energy storage system that can be done through second-life batteries. Although there are uncertainties and the model is still under development, there are initiatives to use second-hand batteries as energy storage in China and the United States.

An alternative or a subsequent way to use second-life batteries deals with recycling critical materials for the production of batteries. The development of this practice would result in a lower demand for raw materials (which represent about 60% of the battery cost), a drop in emissions, and a decrease in impacts resulting from mining and refinement (MDR, 2022). However, Brazil's batteries' disposal and recycling policies and regulations were developed before the electric vehicle market, not contemplating lithium-ion batteries.

Thus, it is imperative to develop a construction and regulation that directs the proper handling of batteries in electric buses to reduce uncertainties and foster the recycling industry. Meanwhile, using second-life batteries as storage and peak energy displacement should gain relevance (MDR, 2022).

Currently, transport operators in large cities, which usually have higher requirements in terms of fleet age, tend to resell buses, still in good condition, to companies in smaller cities or for other private purposes, such as company employees' transport. Therefore, there is a chain of reuse of conventional buses over their useful life, which makes this market more consolidated and reliable for asset owners.

That said, it is essential to continuously promote the adoption of technology throughout the country, based on the good experiences obtained by the cities that have already implemented the electrification of the fleet, to consolidate the electric bus market, allowing better use of the vehicle throughout its useful life.

2.

BUSINESS MODEL ALTERNATIVES

This chapter presents the possible business models evaluated with the Agents responsible for planning and managing public transport for implementing the Electromobility Transition Pilot Project in public transport by bus. A Transition Pilot Project should not be understood as an end but rather as part of a broader process that seeks to develop the foundations to support the transition on a broader scale.

Throughout the debates, the municipality has as its goal the electrification of 40% to 50% of its fleet by 2030. With such an ambitious goal, it becomes crucial to understand what the first steps should be and how these steps will determine the subsequent dynamics of a broader transition. This chapter seeks to contextualize the issues and central elements to enable, as soon as possible, the large-scale implementation of electric buses in Brazilian cities.

Initially, the chapter introduces the theoretical bases for constructing a business model, including financial instruments and instruments of legal nature, with different alternatives for allocating responsibilities, risks, and rights to public and private parties developing this transition project. It also presents the barriers and opportunities found in the technical discussions and identified during training, considering all business models for electric buses.

According to constitutional principles (Article 37, CF), the responsible for urban public transport is the municipal public authority, which may adopt as a form of execution of the service the direct operation or delegation to a private entity, according to Article 175 of the Federal Constitution. Federal Laws 14.133/2021 - Law on Bids and Administrative Contracts, and 8987/95 - common concession, regulated this constitutional provision, subsequently expanded by Federal Law 11.079/04, which deals with the contracting models and execution of public services under the aegis of public-private partnerships.

The most usual form of public transport delegation is the Common Concession, best discussed below, is anchored in Federal Law 8987/1995. In this model, the Government is responsible for planning the operation, and its execution is delegated to the private sector. The allocation of financial risks is shared, and a significant part of the management and operation risks of the system goes to the operators.

It is essential to highlight that the contractual form developed is a direct result of the business model understood as the one creating the best conditions for developing services in a balanced way. The business model seeks to create positive incentives for improving services in favor of the user, in favor of the system's economic-financial balance, and, in a broader way, for the society, to encourage the reduction of the emission of polluting gases from the vehicle operation. When implementing an electric bus fleet, among several challenges intrinsic to the activity, the need for alignment between all stakeholders (governments, operators, funders, manufacturers, and technology suppliers) stands out for an efficient transition.

Public transport concession contracts generally establish, as a municipality attribution, the supervision and management of services, and, as a role of private initiative, the programming and operation. Depending on the principles in the regulatory standards, contracts may include very restrictive clauses that discourage investment in more daring or high-risk innovation projects.

In cases of greater rigidity, the low flexibility and lack of synergy between the parties reduce the opportunities for risk sharing and innovations that optimize and modernize the service. This constitutes one of the main obstacles to introducing electric buses as technological innovation. Therefore, the risks of this investment are still high, despite the undeniable benefits and externalities (which should be treated as intangible assets of the business model).

The following tables present the most popular modalities of contracting public services for projects. These forms can adapt to the business modeling of electric buses. Table 3 shows the modalities for planned projects "from scratch" (greenfield systems), while Table 4 presents the possibilities for projects already implemented and that can undergo modifications over time (brownfield systems).

Table 3 – Modalities for contracting unimplemented public services (greenfield systems)

Modality	Features	National and international examples	Regulatory standards
Availability contract	The private investor builds the system and transfers the transaction to the granting power. Public agents may delegate the operation to specialized agents or take over the process through a public company. Part of the revenue from the service administration remunerates the private investor. The remuneration is for the asset rental to the public authority during the contract period or for payments linked to ownership transfer if this occurs immediately after completing the works.	In Brazil, the main availability contracts are present in the sanitation sector. The São Paulo State Basic Sanitation Company (Sabesp), responsible for water supply and sewage treatment in the state, has made numerous bids for the construction and maintenance of water and sewage treatment plants. In the transport sector, the most common experiences are international; for example, in England, with airports and basic infrastructure for public transport systems.	The supply contract's technical framework considers the requirements for providing services. The technical framework may be objective, precisely defining what should be done; when the contracted party proposes the best technical solution for the infrastructure to be implemented.
Common or sponsored grant with asset reversal	Classic concession model in the area of rail transport. The concessionaire receives a basic project and is in charge of the system's implementation, operation, and maintenance for a defined period. The ownership of the operating assets is the granting power, but the concessionaire retains possession of them and can depreciate the investments made according to the temporal distribution of demand. At the end of the concession period, the concessionaire reverts the assets to the granting power without charge.	National Examples: - Line 4 of the São Paulo Subway; - Line 6 of the São Paulo Subway; - Lines 5 and 17 of the São Paulo Subway; - Lines 1 and 2 of the Salvador Subway.	The standardization of projects emphasizes the quality of the service offered to the user and the quality of the assets to be implemented. As assets return to the government at the end of the contract, there is stricter compliance with the quality standards in the deployment and maintenance conditions.

Modality	Features	National and international examples	Regulatory standards
Common concession or traditional transport permit	Standard in motorized municipal urban transport projects throughout Brazil. The concessionaire makes the investments, operates the services under the contractual standard, and maintains ownership of the assets indefinitely, including at the end of the contract. No reversal of assets in favor of the granting power at the contractual termination, so no concession applies.	Municipal public transportation systems in São Paulo, Rio de Janeiro, Brasília, Campinas, and several other Brazilian municipalities. This model is used in metropolitan regions in São Paulo, Recife, Fortaleza, and other parts of the country.	Different normative models. The most common provides for a higher level of planning and programming by the granting power, directly affecting the responsibility matrix of the parties. Generally, standardization focuses on service quality, observing indicators such as maximum occupancy and interval between departures at or outside peak hours, among others. The standardization regarding the quality of investments is reflected in the type of vehicle used, at the maximum age, and in related themes

Source: Own elaboration.

Table 4 – Modalities of contracting public services already implemented (brownfield)

Modality	Features	National and international examples	Regulatory standards
Concession of operation of public assets	Concession model usually applied to newly built projects, in which the granting power develops the infrastructure and hires the operation. It differs from outsourcing due to the risk of demand assumed by the private stakeholder, in addition to other risks of an operational nature.	Common in road concessions implemented by the government, transferring the operation to the private sector. In the transport sector, it is common in urban terminals delegation to the private sector but still experimental in projects involving the movement of passengers.	Technical milestone for the operation. New investments during the concession are negotiable but are generally the responsibility of the granting power.
Concession for the renewal and operation of public assets	A model widely used to improve existing systems in which the public assets used in the provision of services are in a state of degradation. The concessionaire assumes the operation and is responsible for continuous improvements throughout the operating period.	- Supervias in Rio de Janeiro - CPTM Lines 8 and 9 in São Paulo	Strict regulation of the standard of services, but any technical framework follows the possibilities of improvements and investments verified throughout the concession. New investments during the concession are negotiable and usually involve the grantor. It requires a robust regulatory agency.

Source: Own elaboration.

As one can observe, there is a strong correlation between the business model intended to be developed for implementing electromobility and the contractual structure that will govern the relationship between the municipality and private agents. Different legal arrangements can be used in single contracting and segregated contracting.

The choice of the type of public procurement may depend on the business models designed and best suited for each case. However, it is essential to highlight that, for the structuring of common concession contracts and public-private partnerships, the adequate allocation of risks, performance indicators, the payment system (rates or government contribution), penalties, the risk matrix, and the economic-financial balance system are central points of the contract. They define the set of incentives for the action of each party in the contractual relationship. Table 5 presents the possible concession types for electromobility projects.

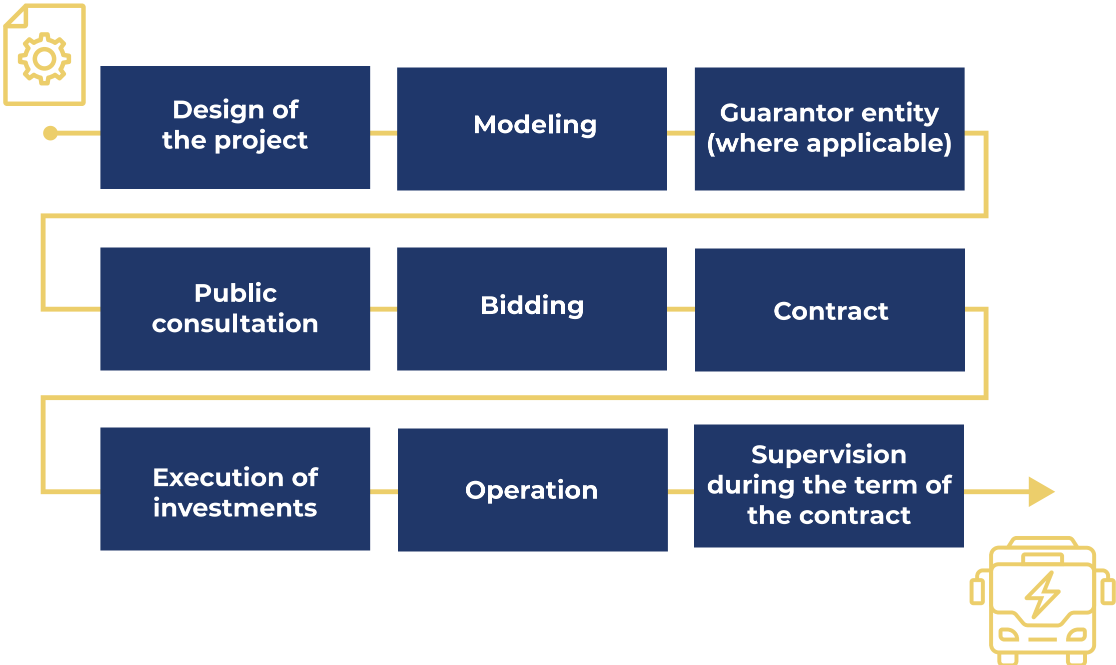
Table 5 – Possible concession types for electromobility projects

Type of concession	Common	Sponsored	Administrative
Concept	It is the delegation of public services, public works, and public service permits, whose remuneration comes from the tariff collected.	It is the delegation of public services or public works from the Federal Law n. ° 8,987/95, in cases where it involves, in addition to the tariff charged, monetary compensation from the public partner to the private partner.	Service contract in which the public administration is a direct or indirect user, even if it involves the execution of work or the supply of goods.
Remuneration	By collected tariff.	Payment by the public administration + tariff paid by the user	Contribution from the public administration.
End-user relationship	The private partner is directly related to the end user and charges the rate.	The private partner is directly related to the end user and charges the rate.	The private partner has no direct relationship with the end user, which is the public administration.
Goals	Defined in the contract.		
Regulation and supervision	Defined in the contract and may include mechanisms of performance indicators.		

Source: Own elaboration.

The steps for contracting one of the modalities and delegating services follow the synthetic path illustrated in Figure 8.

Figure 8 – Public service delegation process



Source: Own elaboration.

To formulate and evaluate the most appropriate business model for public transport projects (involving fully or partially electric bus components), the city may consider the alternatives described in the following items.

2.1 PUBLIC OPERATION

The first alternative is the constitution of a public company dedicated to implementing and operating an electric fleet system. The public company would also articulate the organizations responsible for the operation and implementation of associated infrastructures.

This alternative has already been adopted in São Paulo, but not for electric buses. Just by example, Companhia do Metropolitano de São Paulo and CPTM were founded to implement, operate and maintain the são Paulo subway system. The bus system of São Paulo was, in the past, operated by a public company, the Companhia Municipal de Transportes Coletivos (CMTC). In Rio de Janeiro, Flumitrens was created to explore the rail transport system, while Metrô Rio explored lines 1 and 2 of the subway system.

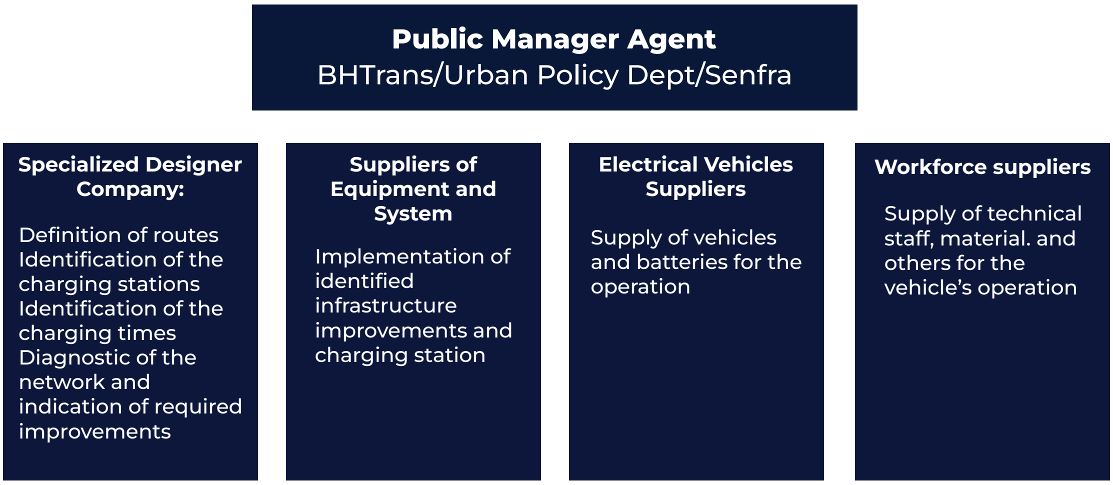
Subsequently, a relevant part of these systems was delegated to the private sector. In São Paulo, lines 4, 5, 6, 17, and 18 of the São Paulo Metro were the object of delegation, in addition to lines 8 and 9 of the CPTM. In Rio de Janeiro, Flumitrens' operation was delegated to the current Supervia, as well as Metrô Rio, which is also managed by a private concessionaire. São Paulo's tire transport system was delegated to the private sector in the early 1990s.

Regarding the adoption of electric buses, the only relevant example is the experimental operation of internal passenger circulation at the Campus of the State University of Campinas, UNICAMP. On this Campus, the University City Hall, through several agreements signed with suppliers and research institutes, made it possible to replace combustion vehicles with electric vehicles, collecting relevant information and pointing out possible improvements in these systems. However, there are no large-scale operations of this kind.

2.1.1 Model operationalization

The operationalization of this model is summarized in the following schematic figure.

Figure 9: Operationalization of the public operation model



Source: Own elaboration

The implementation of this model begins by identifying the agent responsible for project development and the proper attribution of responsibilities. It could be BHTRANS or one of the State Secretariats with operational and technical training focused on managing and implementing projects and enterprises of public services and urban infrastructure. The choice of this model does not imply the project management agent needs to hire its workforce, but it does suggest the subcontracting of specialized companies responsible for the attributions of:

- Design the entire system properly, including vehicle typologies, charging points, electrical charge to be supported, and network adjustments, among others.
- Suppliers of equipment, systems, and civil constructions, responsible for implementing charging systems.
- Suppliers of electric vehicles, according to the selected technology.

- Companies supplying labor aimed at the handling and maintenance of vehicles.

The Public Administrator becomes, in this model, an integrator agent of technologies to the identified needs of the pilot project. The integrator's role implies relevant responsibilities and knowledge absorption by the public sphere.

2.1.2 Legal aspects

In this alternative, there is no delegation, which means that the Municipality will implement and operate the public transport service. Thus, the public entity will be responsible for planning, financing, acquiring, operating, and maintaining the system.

This context implies the need for the immediate and future availability of resources, bidding for the acquisition of goods and services, and availability or hiring of personnel for the management of the system operation, all carried out under the aegis of Federal Law 14.133/2021.

Specifically on electrification and considering that public service delegates already operate the service, the Government (Grantor) will define the routes and identify the points and times of charging. The grantor will also be responsible for evaluating and diagnosing the network and acquiring and operating the assets, including the bus, battery, and charging.

This results in real difficulties of operational overlap, that is, risks in the management of the operation of electric buses concomitant with the existing operation and insufficient technical personnel specialized for the operational management of assets.

The administrative activity intertwined with the Legal Regime of Public Law imposes a long, complex, and bureaucratic path of management of personnel, goods, and services concomitantly with an existing operation that requires a budget to support all expenses.

2.1.3 Barriers and opportunities

During the discussions with the city teams that took place in technical meetings and training carried out during this project, some reflections on the barriers and opportunities of the model in question stood out. These reflections are essential for evaluating the Public Operation model regarding the reality of the municipality and its applicability. Therefore, they are presented in this item and the following table.

As opportunities or strengths of the model, the possibility of the Local Government financing the project considering the number of vehicles of the Pilot Project stood out, in addition to the fact that the current contract is already a reason for deadlock, discussion, and obstacles. It was also emphasized that the model brings greater control to the government in implementing the transition policy for Electromobility, which could bring greater alignment with the municipality's objectives and ensure better service performance, as well as a more accessible tariff policy.

Regarding the barriers to implementing the models, it was identified that the Local Government of Belo Horizonte does not have enough structure and human resources to implement the infrastructure and still manage the system's operation and all its components involved. In addition, it is challenging to take responsibility for the ownership of the vehicles since, after the use of the vehicle during their useful life for the city, there should still be a policy for eliminating or reusing the buses.

The main obstacle will undoubtedly be the existing grant for the current Concessionaires to operate the main corridors of MOVE. For the government to take electric vehicles to the highest density corridors, it would be necessary to overpower a new operator, public, to existing operators. This movement would generate enormous institutional instability, putting at risk the continuity of concession contracts and the very existence of public transport in the municipality.

Some other barriers to the business model are identified: the rigidity of the legislation; excessive bureaucracy; the difficulty in acquiring and negotiating the price of buses and parts; the associated legal risks assumed by the government, and the difficulty in maintaining the assets and operation at the highest levels necessary.

Table 6 – Barriers and opportunities of the public operation model

Barriers	Opportunities
• Operational overlap with concessionaires in the key corridors of the Public Transport System of Belo Horizonte. • The government currently does not have an administrative structure and human resources for all the responsibilities involved; • The possession of vehicles by the government involves responsibilities that cannot be assumed today; • The process of acquiring both vehicles and parts for maintenance would be more bureaucratic and complex; • The rigidity of current legislation and excessive bureaucracy in the processes can make the model inefficient; • The model can bring legal risks that the government does not currently assume; • Destination of vehicles and components (batteries) at the end of their useful life; • Difficulty in maintaining the goods and the level of service of the operation within required standards for the operation of a public transport system	• A reduced number of vehicles planned for the pilot project would allow for public funding; • The current model of concession contracts is the subject of discussions and obstacles; • The model allows greater control by the government; • The government would have greater control over the levels and standards of the service provided; • It would enable the implementation of a more accessible tariff policy; • It would allow greater alignment of the service provided with the sustainable objectives of the municipality.

Source: Own elaboration based on discussions.

2.2 FULL INCORPORATION OF ELECTROMOBILITY INTO EXISTING CONCESSION CONTRACTS

This alternative is the most common in public transport service contracts. The addendum of Concession Contracts for these functions corresponds to the most common model in Brazil, such as for the municipalities of Bauru, Santos, Maringá, and the Federal District.

It is guided by the full delegation of the acquisition of vehicles, systems, operation, and maintenance of these vehicles to the private initiative. The full delegation implies that all pre-operational activities of the electric fleet, from the preparation of executive projects (through obtaining resources, means of implementation, and integration of investments) to the beginning of the effective operation and commercial operation of services, would go to the private sector without any activities delegated to cities (except those exclusively linked to regulatory aspects).

Once the acquisition or leasing of electric buses and their components is complete, systems integration and operation preparation, the operator becomes fully responsible for managing and commercially exploiting the system — including the maintenance and conservation of assets and the provision of services related to urban mobility, among other responsibilities.

One of the main risks of this phase is associated with investment costs, demand, operation, and macroeconomic fluctuations, fully or partially attributed to the private sector. In the current scenario, characterized by the financial fragility of the operating companies due to the COVID-19 pandemic, the risk of a credit crunch necessary for acquiring fleet and charging equipment adds to the most common risks in this type of operation.

The risk of default should be absorbed by the financial agents who finance these investments resulting not from the change of vehicular technology but from the drastic reduction in demand for public transport that has been observed throughout the pandemic period and remains today. The transition to electromobility is impossible without the investors willing to make resources available to operators. The list of risks allocated to the private sector excludes those mandatorily attributed to the grantor, such as the risk of variations in the economic-financial balance of the concession resulting from force majeure situations. At the end of the concession, all assets are held by the private sector, except those mandatorily reverted to the granting authority.

Adopting this alternative allows the city to enjoy the social and environmental benefits arising from the implementation of electromobility without having to disburse excessive resources to do so.

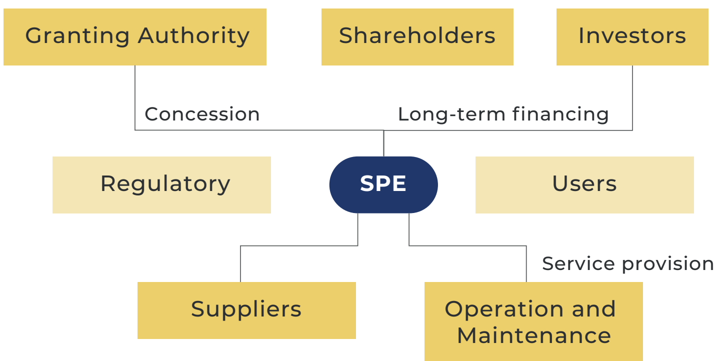
For the private sector, the necessary consideration for the assumption of responsibilities is the need to adequately remunerate the capital used in this enterprise. Without adequate remuneration for the capital employed, there is no incentive (or reason) for the investment to occur. This is particularly important in the case of electric buses, given their high initial investment cost and planning and operation complexity.

The following diagram points out the positioning of the main agents involved in structuring the project in a global concession model. The operators organize in the form of a Specific Purpose Company, entities specially constituted by the Shareholders for executing the Concession Contract by a direct delegation of the grantor.

As responsible for the services' execution, it is up to the SPE's to contract funding for the acquisition of electric vehicles and charging equipment (Providers), as well as the execution of the provision of services (Operation in favor of users) and maintenance of assets in perfect conditions, under the terms put in the Concession Contract (Maintenance). The Regulatory Agent regulates both the quality of the Operation and maintenance, formally designated for this, in this case, BHTrans.

Thus, in a global concession, there is a concentration of activities for the SPE, responsible for all stages of the production process of generating services, from planning activities, financing, acquisition, and maintenance of assets, and use of these assets for the provision of services to the end user.

Figure 10 – Model of implementation and operation of electric buses under total private responsibility in a single contract



Source: Own elaboration. Note: LP – Long Term.

In electromobility projects that adopt this condition, the activities of acquisition, implementation, integration of systems, operation, and maintenance are directly performed by the contracted company. Some examples are present in the Federal District (DF), Santos (SP), Bauru (SP), Maringá (PR), and Campinas (SP).

The contracts signed in these cities mention investments in acquiring electric vehicles and charging systems in the original financial equation. Based on the model, subsequent investments and operating costs depend on the recovery of the financial balance. It is worth noting that, in all these cases, electromobility is in the experimental phase. Therefore, these systems' acquisition, operating, and maintenance costs will go to the private sector by reviewing the initial economic-financial balance.

2.2.1 Operational aspects

The operationalization of this business model depends on a negotiation between the Granting Authority and the private concessionaires. This negotiation process should necessarily involve:

- The deadlines for the implementation and operation of the fleet of electric vehicles desired by the Municipality;
- The lines on which the new vehicles purchased will be used;
- The operational programming of these vehicles, including the number of travels, operational mileage, dead mileage, and the need for additional reserve vehicles on account of recharging;
- The revision of the economic and financial equation of contracts, including:
    - The increase in investments in electric vehicles and the suppression of diesel vehicles that are no longer purchased;
    - The increase in investments in systems, reforms of civil constructions and projects;
    - The increase in variable costs with electric vehicles, including current energy prices, maintenance productivity parameters, lubricants, and others,
    - The reduction of variable costs with combustion vehicles, considering the replacement of the mileage traveled by combustion vehicles with electric ones.
    - The residual value, under market conditions, of vehicles and systems.
- The way of recompressing the contractual economic-financial balance, such as the granting of possible increases in the need for remuneration by the local government, the extension of contractual deadlines, and the reduction or exemption of other contractual charges.

Once all the issues have been established, the Concessionaire company fully assumes the attribution of execution, and the Government is responsible for regulating and monitoring the contractual execution.

2.2.2 Legal aspects

Under Law No. 8.987/1995, common concession delegates the public service execution to a private agent at his own risk and within a specified period. The duration is established following the appropriate time for amortization, depreciation, and investment return.

In this case, the implementation and operation of electric buses are under full private responsibility in a single contract. The private company becomes entirely responsible for acquiring and maintaining the asset, managing the system, and providing the service.

Concerning the acquisition of vehicles and batteries, the main acquisition models are the purchase of the bus or leasing:

I. Purchase with equity, where the total amount is paid in advance, either by the government or a private company responsible for supplying the vehicles assuming the operational and technology risks;

II. Purchase with financing, where the part is paid in advance and part via a loan, either by the government or a private company responsible for supplying the vehicles, assuming the operational and technology risks. In this case, due to credit risk, there is a risk of increasing the cost of the loan;

III. Full leasing, with payment by use of the bus for a certain period.

IV. Partial leasing, where specific components are paid for a specified period.

In this model, the Concessionaire decides between purchasing a battery bus or only the bus and renting the battery or leasing both the bus and battery. In addition, it considers and assumes the battery recharging infrastructure, and nothing reverts to the Government.

This decision reflects on an existing concession contract, with the insertion of new obligations to the Concessionaire, which impacts the contract's time and financial aspects.

The contractual addendum is the legal way to resolve this situation in existing contracts. Thus, it must be clear about time and cost to enable the measurement of the addendum's term and its economic reflexes.

2.2.3 Barriers and opportunities

During the discussions with the city's teams about the global concession model, the first opportunity identified was similar to that of the Public Operation model, that is, the possibility for the local government to finance the project considering the number of vehicles in the pilot project. It also highlighted the possibility of taking advantage of the existing structure and experience of current operators (garages and operation structure, for example) and greater ease in the adequacy of legal risks since it is a model already implemented and known by the city.

Two points were highlighted as barriers to this model understood as challenging to transpose. The first barrier is the situation of administrative litigation between the Granting Power and Concessionaires Companies, a dispute that resulted in a Parliamentary Committee of Inquiry established in the City Council of Belo Horizonte. On the other hand, there are allegations of contractual non-compliance, and it is implausible that concessionaires agree to negotiate the realization of relevant investments without solving the other issuers.

The second theme was the veto presented in the City Council so that the Municipality could subsidize public transport operations. This barrier has already been resolved through Bill (PL) 336/2022, providing for the subsidy of R$ 243.4 million for the public transport of Belo Horizonte, approved by the City Council in July 2022. Without this recent alternative, it would be left to the Municipality to raise users' tariffs, taxing them with an added value that can cause social impacts and on the balance of the system itself.

It was also highlighted that the current operators might face difficulties in acquiring the electric fleet, with high CAPEX costs, without a counterpart on the part of the government, considering the current critical financial situation aggravated by the macroeconomic context and the pandemic scenario of COVID-19.

In addition, there is a high degree of uncertainty on the part of current operators regarding Electromobility because it is a new technology with a higher initial cost than the current one and with few large-scale Brazilian applications.

Table 7 – Barriers and opportunities of the global concession model

Negative Points, Challenges, and Barriers	Positive points and Opportunities
• The current concession contracts are currently grounds for questioning, discussion, and obstacles; • The current context of the pandemic has led to a financial crisis in the transport system; • Current operators' difficulty in making investments in new vehicles and infrastructure; • The high costs of vehicles make the model unattractive to private investors; • The theme of Electromobility is seen with many uncertainties by the operators.	• Reduction of costs for the government for the implementation of the pilot project; • The current operators already have the administrative structure and human resources necessary for the implementation of the pilot project; • Easier to adjust for legal risks; • The current operators already have experience in the operation of a transport system; • The operators' current technological park could be used to implement the project.

Source: Own elaboration based on discussions.

2.3 PUBLIC ACQUISITION OF VEHICLES AND PRIVATE OPERATION

In this model, the city can enable the adoption of electric buses through conventional bidding for the acquisition of vehicles and implementation of recharging systems, governed by the terms of Federal Law No. 8.666/1993 (current Law 14.133/2021), with the subsequent lease of vehicles to the concessionaires of the Public Transport System.

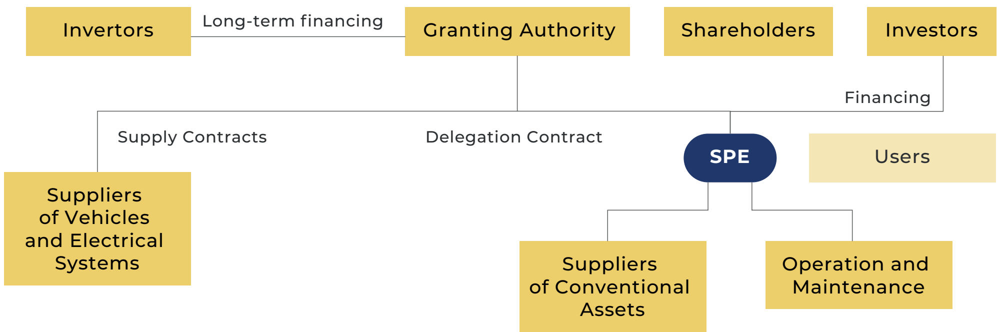
The alternative of public purchase followed by the leasing of assets relieves the Concessionaire companies not only in investments in electric vehicles, which would be a relevant barrier to the implementation of the enterprise but also in making investments in the renewal of combustion vehicles to be replaced. Thus, this model is temporary relief in the need for cash or the provision of guarantees to companies' funders, replacing the purchase of fleet with rental directly from the Government.

This model, simple from a financial point of view, needs attention to its technical part so that the conditions of use and maintenance of vehicles leased to concessionaires are well defined and do not incur risks of excessive or inappropriate use that may compromise the quality and functionality of public assets.

The following figure summarizes the contract issues and how the role of the main players adjusts to the construction of the proposed solution. The Grantor, in this case, the Municipality of Belo Horizonte, represented by BHTrans or another agent linked to the Municipality's direct or indirect public administration, becomes responsible for the acquisition along with the fleet and charging equipment for electric vehicle providers. To this end, different funding sources are used in projects and programs with a high social, economic, and environmental impact. These vehicles purchased by the Granting Authority are made available through rental or a simple section of using right assigned to the Concession Contract as a reversible asset.

In this organization of agents, it is up to the SPE's to provide services (Operation in favor of users) and maintain assets under conditions established in the terms outlined in the Concession Contract (Maintenance). The quality of the Operation and Maintenance continues to be regulated by the Regulatory Agent, BHTrans. Thus, there is a functional activity division between the Granting Authority, responsible for financing and acquiring assets related to electromobility, and the SPE, responsible for the operation and maintenance of the assets.

Figure 11 – Model of responsibility for the implementation and operation of electric buses shared between public and private entities



Source: Own elaboration. Note: LP – Long Term.

2.3.1 Operational aspects

The implementation of this model depends on three stages. The first stage is entirely contractual, in which the conditions for rental of the fleet acquired between the Government and the private initiative are negotiated. The rental contract involves the definition of values, as suggested in the next chapter of this Report, operating conditions such as lines, charging locations, the number of daily travels, and asset maintenance conditions. After this stage, in the second stage, the Granting Authority carries out the financing and acquisition of electric vehicles and systems, eventually contracting civil constructions for implementation. Finally, in the third stage, the vehicles are leased to the concessionaires and put into operation.

2.3.2 Legal aspects

In the shared model, the service is delegated to the private for the operation of the service. However, the acquisition of electric vehicles and the implementation of charging systems are under the responsibility of the Granting Authority. These assets go to the Concessionaire and are classified as goods linked to the Concession and, therefore, reversible.

At the time of delivery, it is vital to establish (i) what is delivered clearly, (ii) how the maintenance occurs, (iii) what is expected to be received, and under what conditions.

In ongoing contracts, attention is essential regarding the assets' lifetime and the Concession's time. Therefore, the reversal of assets present in the contracts is a topic that deserves attention. First, it has the possibility of forcing the public authority, at the end of the contract, to incorporate obsolete or useless goods. On the other hand, even if the burden of demobilizing and correctly destining these assets is attributed to the future concessionaire, the government assumes this cost since it is incorporated into the cash flow supporting the bidding.

Thus, considering that the assets return to the government at the end of the contract, it is essential to observe more rigorously the quality standards in the implementation and maintenance conditions.

2.3.3 Barriers and opportunities

This item presents the reflections on barriers and opportunities of this model from the discussions with the city teams.

Concerning the public and private shared responsibility model, as in the Public Operation model, the main opportunities highlighted were: the possibility of the local government to finance the pilot project, given the reduced number of vehicles, considering that the current contract has presented deficiencies and is the result of questioning and discontent. The model allows greater ease in obtaining the financing, with greater government control in the implementation of the project, and there would be no need for the government to maintain the acquired fleet. It also highlights that for a fleet escalation, the public and private shared responsibility model would be the most interesting, therefore, being a differential compared to other models, in addition to the current operators that already have the necessary expertise for the operation of services.

Some barriers to the model are the need to adjust the model legal risks (responsibilities) and the difficulty in ensuring the level of quality of the asset received at the end of the contract. One point that has been addressed is the possibility that the private sector has greater bargaining power to acquire the necessary assets due to the scale of its purchases. However, this topic has been discarded, given the municipality's sectoral conjuncture, and because, at this stage, electric vehicles will not be purchased in large numbers. Furthermore, it was discussed that compatibility of public and private interests would be necessary.

Table 8 – Barriers and opportunities of the public and private shared responsibility model

Barriers	Positive points and Opportunities
• Adequacy of the legal risks assumed by the parties would be necessary; • Greater difficulty in controlling the state of assets at the end of the contract; • Private stakeholders have higher bargaining power for the acquisition of vehicles and batteries than the government • Greater difficulty in the compatibility of public and private interests; • The government could not assume sole responsibility for acquiring the vehicles considering a large-scale implementation.	• It would allow the financing of the pilot project by the government, considering the number of vehicles considered; • Current contracts are the subject of questioning, discussion, and obstacles; • Easier to obtain financing; • The government would not currently have the capacity to carry out fleet maintenance; • It would allow greater control of the government in the implementation of the pilot project; • Allows fleet escalation; • Today's operators have the necessary expertise to operate the transport system.

Source: Own elaboration based on discussions.

2.3.4 Implementation and private operation in specialized contracts

By adopting this alternative, the city enables specialized contracting, a contract for deploying vehicles and systems, and other operating assets.

The separation of the implementation, management, and operation of electromobility in two contracts aims to bring the efficiency of specialized agents to the system. The first contract, aimed at implementation, defines the agent responsible for deploying vehicles and charging infrastructure, including civil constructions and systems, in a long-term contract. The remuneration of the contract may occur in two different ways:

(i) income for the availability of the assets to the Granting Authority or (ii) rental of assets to the private operator.

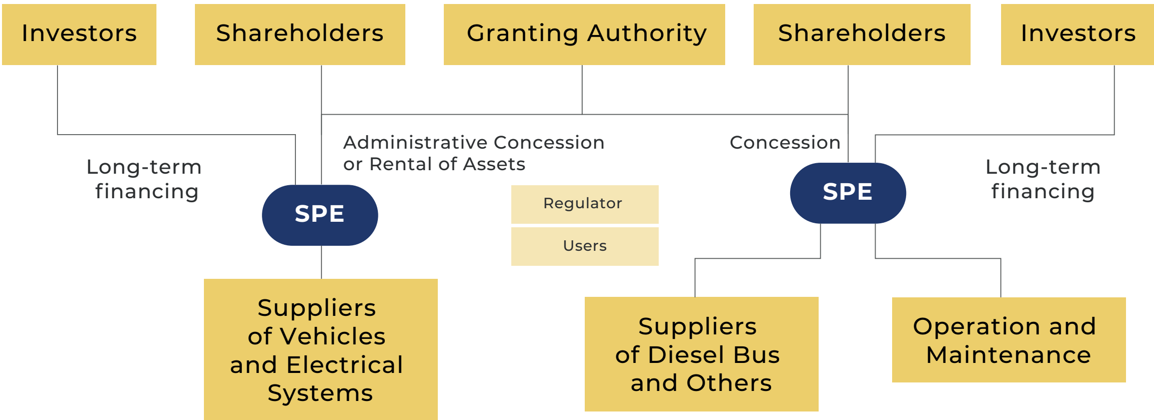
It is essential that this contract involves only, or predominantly, the deployment of such assets. As the maintenance of the systems and, where appropriate, the maintenance of the vehicles themselves enter into the contract, partially or completely, the arrangement would constitute an administrative public-private partnership (PPP), with long-term remuneration for the asset made available.

The second contract represents the current structure of operational concession contracts, in which the operating agents would lease, directly from the first SPE or indirectly through the Granting Authority, the electric vehicles for the performance of the electromobility operation.

Thus, operators would have the advantage of specialization in their activities, which reduces factors of use of drivers and personnel for operational support, supervision, and control, among others. The examples of implementation and operation in specialized contracts were observed in the implementation of the Santiago electromobility in “Red Metropolitana” or “Red.” The energy distribution company, ENEL, acquired and leased the vehicles for private operation with guaranteed receipt from the Central Government of Chile. In Colombia, a Joint Venture formed by Volvo with local operators successfully implemented and operated electric vehicles in the Transmillennium corridor.

The following figure summarizes the organization of agents in this conception. The first SPE has experience in acquiring assets and hiring long-term funders focused on electromobility. Through a Contract signed with the Granting Authority, the vehicles purchased and financed are made available to the second SPE, to the right of the figure, which has an operational nature, being responsible for the operation and, usually, for the maintenance of these assets. Based on the operation of assets related to electromobility, the second SPE provides the services directly to the end users of public passenger transport. Thus, in this model, the Granting Authority is not the borrower of financing necessary for acquiring assets but a specialized agent in purchasing and renting assets to third parties.

Figure 12 – Model of implementation and operation of electric buses under private responsibility in two specialized contracts



Source: Own elaboration. Note: LP – Long Term.

2.3.5 Operational aspects

The specialization of contracts in this model implies a more relevant active role of the Granting Authority in the planning and managing of contracts to manage the interfaces between the supply and use of electric vehicles and systems. To this end, the Granting Authority should initially carry out a comprehensive planning process on the lines for electric vehicles, carrying out appropriate locations for charging and sizing equipment and systems and detailing how to carry out the operation. Based on these projects, they can contract the acquisition or availability, of vehicles, systems, and civil reforms for their implementation, from a specialized operator. In the second contractual aspect, it is necessary to review the economic-financial balance of existing contracts. It must deal with replacing investment costs from the combustion vehicles' operation to the electric vehicles' one.

2.3.6 Legal aspects

In the implementation contract, regarding the acquisition of assets (bus, battery, systems, and civil constructions), the Government may opt for direct acquisition, ruled by Federal Law 14.133/2021, or rental, leasing, ruled by the norm. As it evolves toward a model that incorporates a greater number of functions associated with maintenance and, eventually, replacement of assets at the end of its useful life, the long-term contract may migrate to a Public Private Partnership model in the administrative concession modality. If well developed and managed, these two contracts can represent increased efficiency in the service provided and quality gain for the end user.

It's possible to plan an alternative in which you can split the contracts for operation, provision of vehicles, and infrastructure. In this scenario, the division of responsibility takes place between three stakeholders, with higher levels of specialization, different metrics of remuneration, and incentives for the search for efficiency. It is important to note that the greater the breach of contract, the greater the responsibility of the Granting Authority in planning and managing contractual interfaces.

2.3.7 Barriers and opportunities

The discussions on the model of implementation and private operation in specialized contracts pointed out as barriers the fact that the government could not immediately assume responsibility for the acquisition of large-scale vehicles. The second barrier is that this model may represent an adequate alternative as a long-term objective when hundreds of vehicles would be acquired in the electromobility transition process. However, for the acquisition of 25 vehicles, there would not be enough scale to attract the attention of a financial investor, such as an investment fund or a vehicle supplier. On the contrary, segregation into two contracts would result in the need to duplicate administrative structures for contract management, creating significant transaction costs.

In the positive aspects, there is a potential for improvement in service levels since the contracted companies would be more specialized in the specific activities under their responsibility. Furthermore, it was also assessed that introducing a financial agent would help alleviate operators' financial difficulties due to reduced demand in the COVID-19 pandemic context.

Among the barriers to the implementation of the model, the difficulty of the public authorities in ensuring that all stakeholders operate in sync stands out since it is more complex to manage several contracts compared to a single contract and the fact that the division into several contracts may be unattractive to other actors, especially in the case of a pilot project.

Finally, the observation of the recent case of failure in São José dos Campos points to the direction of waiting for the development of this model before adopting it in Belo Horizonte.

Table 9 – Barriers and opportunities of the implementation model and private operation in two contracts

Negative Points, Challenges, and Barriers	Positive points and Opportunities
• Greater difficulty for the government in ensuring that all stakeholders involved work in sync; • The management of several contracts is more complex and costly for the government than the management of a single contract; • The division of contracts is unattractive to private stakeholders, in the case of a small project, lack of economies of scale; • In a pilot project, with fewer vehicles, the number of stakeholders would be vast, considering the size of the operation; • Duplication of management costs across multiple contracts can result in higher long-term economic costs. • "Unsuccessful" experiences in Rio de Janeiro and São José dos Campos	• It would not be necessary for the government to take responsibility for the immediate acquisition of the fleet and equipment; • Different model from the current model, which is the subject of discussions and obstacles; • Less financial difficulty in fleet acquisition; • The pilot project would be the opportunity for companies that are interested in an increase in the scale of the subsequent operation; • Enables a phasing acquisition of the fleet; • It enables the decentralization of the system's operation, bringing more specialized companies to the operation.

Source: Own elaboration based on discussions.

3.

PILOT PROJECT DESIGN IN THE MUNICIPALITY

This chapter presents the discussion of the four central aspects of the Project (operational aspects, legal aspects, economic and financial aspects, and social aspects) according to the context and discussions with the municipality team.

First, the specificities of the municipal reality are considered, based mainly on the definition of its operational scenarios, such as the number of lines, characteristics of fleets, mileage total, type of vehicle technology, and charging, among others.

Next, guidelines on possible contractual solutions for the implementation of electromobility are pointed out, considering institutional, financial, and legal issues.

After, the chapter indicates the path to the design and development of the economic-financial evaluation model so that the municipality can structure its electromobility project.

The input data, such as energy, fuel, lubricants, parts, and accessories costs, are presented and considered, and the reflections and choices of the premises taken to obtain the operating costs of electric buses are addressed; the costs of acquiring vehicles and infrastructure, their useful life, residual value, depreciation, and remuneration rate.

We also present the analyses of the results and the comparison of possible scenarios for electrification in the municipalities:

- Complete CAPEX and OPEX assessment added or avoided in each of the scenarios for the project horizon
- Economic evaluation of replacing part of the fleet with electric vehicles.

Finally, the chapter explores the social perspectives related to the support of electromobility for the pilot project designed for the municipality. Social impacts, such as territorial, gender, race, income inequalities, and environmental impacts, are considered.

3.1 DEFINITION OF OPERATIONAL SCENARIOS

This item considers the specificities of the municipal reality for the study and definition of possible scenarios for the operation of new electric vehicles in the city, such as the number of lines, characteristics of fleets, mileage total, type of vehicle technology, and charging, among others.

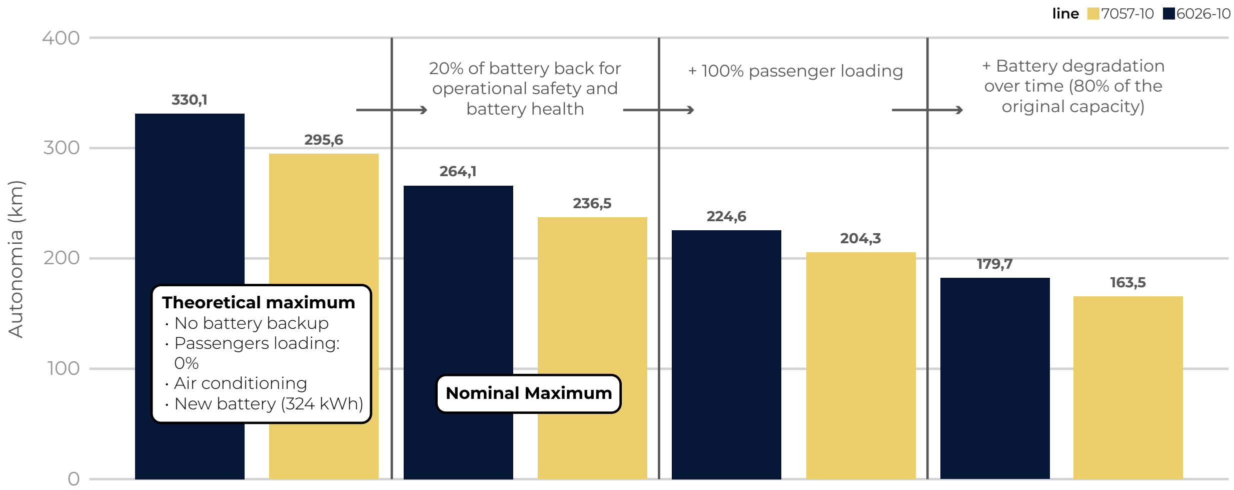
3.1.1 Autonomy of electric vehicles

Several experiments with electric bus projects point to the autonomy of 250 kilometers per load. Currently, some municipalities are defining the minimum autonomy in contracts, as in the following cases: Bogotá (260 kilometers), the pilot project of São Paulo (250 kilometers), and São José dos Campos (250 kilometers). However, these autonomies refer to the battery's maximum capacity. Therefore, an operational reserve of 20% of the total charge should be considered to preserve battery health and operational emergencies.

For the definition of the autonomy of electric vehicles to be considered in this study, we considered the study developed by the Zero Emission Bus Rapid-Deployment Accelerator (ZEBRA, 2022 [12]) project, which presented a discussion on the operational and economic performance of the transition from a fleet of diesel buses to a fleet of battery electric buses, considering the experience of São Paulo[8]. Results of simulation of energy consumption were obtained to analyze the impact of different parameters on the performance of electric bus autonomy. The simulation was performed for the 20 lines operated by a company, and the results of two lines were highlighted: the highest (705710) and the lowest energy consumption (602610). The results are shown in Figure 13.

8 Analysis of the implementation of zero emission buses in the fleet of an operator in the city of São Paulo. ZEBRA, 2022. Available at: https://theicct.org/wp-content/uploads/2022/03/hdv-brasil-analise-da-implantac%CC%A7a%CC%83o-de-o%CC%82nibus-zero-emissa%CC%83o-sa%CC%83o-paulo-mar22.pdf .

Figure 13 – Impact of critical variables on the estimated autonomy of electric buses operating lines 705710 and 602610



Source: ZEBRA (2022).

The results indicate that the autonomy of an electric bus for the reality of the routes of the 20 lines under study, considering the operation with 20% battery reserve for operational safety and battery life and with 100% passenger loading, is between approximately 205 and 225 kilometers per charge. Considering a more conservative analysis and performing a rounding, **for this study, the autonomy of 200 kilometers was considered**, considering the battery reserve of 20% and the charging of 100% of passengers.

The manufacturer BYD's technical files were considered for a full charging time:

- **Padron Vehicle**: for a vehicle of 13.2 meters and a high floor, the **full charging period is 5 hours**. As charging rate (% of the battery per minute and kilometers per minute), the premise of linear charging was used considering the full charging time of 5 hours and full charge autonomy of 250 kilometers. Therefore, the values obtained were 0.83 km per minute.

- **Articulated Vehicle**: for a 23-meter vehicle and high floor, it is indicated that the **full charging period is 3 or 7 hours**, depending on the type of charger used. For the charging rate, the premise of linear charging was used, considering the complete charging time of 3 to 7 hours and full load autonomy of 250 kilometers. Therefore, the values obtained were 1.39 km per minute at fast charging and 0.59 km per minute on fast charging.

3.1.2 Evaluated scenarios

As discussed above, the issue of the daily autonomy of vehicles is a concern since, in the test previously conducted in Belo Horizonte, low autonomies were observed compared to the expected. Thus, it is worth considering options that can increase the use of electric vehicles since the higher the use, the greater the operational gains and gains in socioeconomic indicators.

Thus, for the design of this pilot financing project, two types of scenarios were evaluated for the charging infrastructure, following the **traditional plug-in technology** that the municipality had already opted for in the previous test conducted in 2021: i) slow charge in garages and ii) slow charge in garages and opportunity charging at the terminals, to extend the daily autonomy of vehicles.

For the definition of the scenarios, the technical specifications disclosed by the manufacturer BYD as basic references were considered. According to the manufacturer, two different chargers are currently available for the Brazilian market. The first of these, called in this study "slow chargers," has 2 charging plug-ins with a maximum power of 40 kW each. These chargers are recommended for use in both Padron and articulated vehicles.

The manufacturer's estimated charging time for Padron vehicles is between 4 and 5 hours using the two equipment plugs simultaneously, while the time for articulated vehicles considering the same conditions is between 6 and 7 hours.

This study's second type of charger is "fast chargers," which features 2 charging plug-ins with a maximum power of 100 kW each. The manufacturer recommends using fast chargers only for articulated vehicles, with an estimated charging time for these vehicles of 2 to 3 hours, using the two plugs of the equipment.

The types of chargers available for each type of vehicle were important for the definition of the scenarios studied and their variations. For Padron vehicles, only the use of slow chargers was considered, while for articulated vehicles, the two available possibilities were considered: slow chargers or fast chargers.

The table below shows the scenarios, variations, and respective charging times.

Table 10 – Evaluated scenarios

Scenario	Charging moment	Type of vehicles	Type of charging infrastructure	Full charging time
1A	Night charging only	Padron	Slow chargers (2 x 40 kW)	5 hours
		Articulate	Slow chargers (2 x 40 kW)	7 hours
1B	Night charging only	Padron	Slow chargers (2 x 40 kW)	5 hours
		Articulate	Fast chargers (2 x 100 kW)	3 hours
2A	Night charging and opportunity charging at terminals	Padron	Slow chargers (2 x 40 kW)	5 hours
		Articulate	Slow chargers (2 x 40 kW)	7 hours
2B	Night charging and opportunity charging at terminals	Padron	Slow chargers (2 x 40 kW)	5 hours
		Articulate	Fast chargers (2 x 100 kW)	3 hours

Source: Own elaboration from BYD technical specifications.

3.1.3 Study of the operation of electric vehicles

As previously mentioned, the municipality opted for the design of a pilot project with 25 electric vehicles, 20 Padron vehicles, and 5 articulated vehicles. It was also defined that the new fleet of electric vehicles should operate on the **trunk lines of the MOVE system** to take advantage of the bus corridors of segregated infrastructure to maximize operational gains and minimize possible losses or problems.

The BRT MOVE corridors are a more favorable environment because their paths do not present very accentuated slopes as observed in routes through which the lines that also operate outside the corridors pass. In addition, it was considered that the trunk lines present the highest levels of demand, which would cause the new electric vehicles to be experienced by a more significant number of users.

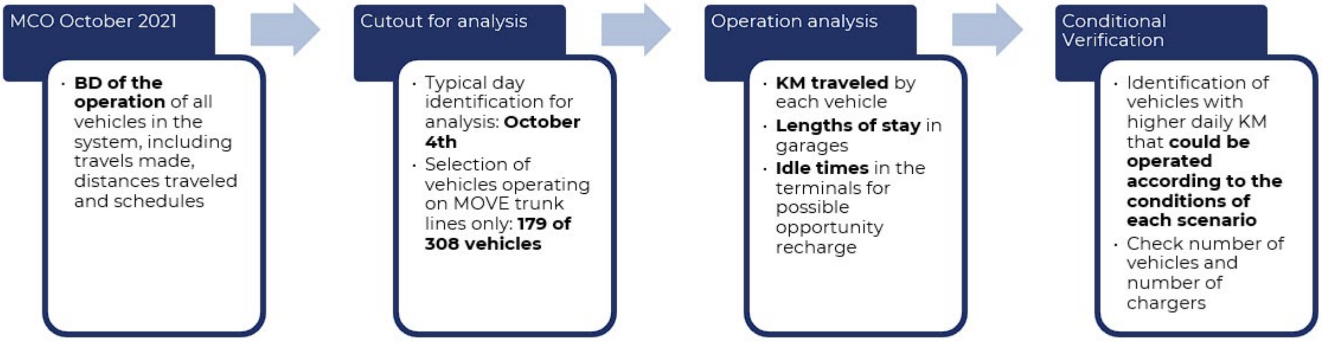
From this defined scenario, the vehicles' operation in the MOVE system's trunk lines was studied to identify vehicles that could be replaced, the associated opportunities, and the potential operational indicators obtained with the pilot project implementation.

The study of the operation of the vehicles in this item aimed to compare the total mileage to be replaced (of the current diesel vehicles by future electric vehicles) between the scenarios and the amount of charging infrastructure required for each case. However, it is important to highlight that the study is configured to evaluate the current operation of vehicles for including new technology. Therefore, it is not an operational optimization, which should be carried out during the implementation of the project in search of better results.

The study was carried out from the database provided by BHTrans, with the indication of the registration of the operation of all buses of the municipal system during October 2021, including all travels made, distances traveled, and starting and ending times of these travels. From the received database, a cutout was made for the evaluation, followed by the analysis of vehicles' operation and the conditional verification of the vehicles that would meet the criteria to be replaced by electric vehicles.

Figure 14 below illustrates the entire process of the operational study, described in sequence.

Figure 14 – Step-by-step study of vehicle operation



Source: Own elaboration.

The analysis of the registration of the buses' operation in the Belo Horizonte municipal system showed that there is no standard for the operation of each vehicle in the system. This is because system operators have no requirement to use a specific vehicle on a specific line. Thus, operators are free to allocate their vehicles for the operation of the departures and lines under their responsibility, respecting the contractual requirements in with the level of the service provided.

A vehicle operating on a specific line in a day will not necessarily operate on that same line in the following. The allocation of a vehicle can also consider operation on different lines and terminals for the same day.

This characteristic of the Belo Horizonte system, which is also common in several other transport systems, made it necessary to choose a "typical day" to analyze vehicles' operation. Thus, a comparison was made between the vehicles' operation patterns among all the days recorded from the database to identify the day on which the recorded operation presented the most negligible variation compared to the operation recorded on the other days of the month. Therefore, the "typical day" identified and selected for analysis was October 4, 2021, among all the days of the month provided.

Then, in the records of the chosen day was the clipping related to the lines of operation: the vehicles that presented, on that day, the operation only in the trunk lines of the MOVE system were selected. Thus, of the 308 vehicles currently in operation in the MOVE system, 179 vehicles were selected for the study. For each of these vehicles were calculated:

- The total mileage covered by each vehicle;
- The length of stay of each vehicle in the garages; and,
- The idle times of each vehicle in the terminals throughout the operation.

Based on this information, we set out for a conditional verification of each of these vehicles to identify those who presented standards of operation that could enable both the performance of the necessary charging and the performance of their travels with the battery's autonomy.

In the case of scenarios in which opportunity charging is considered in the terminals, the idle time is of at least 30 minutes for these charges. Thus, for each vehicle with idle times in the terminals, the total autonomy acquired on the day was calculated for verification. For calculating the autonomy acquired by the opportunity charging, the same charging rate as the night charges was considered. Then, the longer each vehicle's idle time over the day, the greater the acquired autonomy considered.

Table 11 below indicates the parameters for selecting vehicles that could be replaced by electric vehicles based on the operation studied.

Table 11 – Parameters considered for vehicle selection

Scenario	Charging moment	Type of vehicle and charger	KM maximum round per vehicle[9]	Minimum time in the garage
1A	Night charging only	Padron + slow charging	200 km*	5 hours
		Articulated + slow charging	200 km*	7 hours
1B	Night charging only	Padron + slow charging	200 km*	5 hours
		Articulated + slow charging	200 km*	3 hours
2A	Night charging and opportunity charging at terminals	Padron + slow charging	200 km + 50km per hour opportunity charing	5 hours
		Articulated + slow charging	200 km + 35km per hour opportunity charing	7 hours
2B	Night charging and opportunity charging at terminals	Padron + slow charging	200 km + 50km per hour opportunity charing	5 hours
		Articulated + slow charging	200 km + 80km per hour opportunity charing	3 hours

Source: Own elaboration.

Among all vehicles that met the parameters defined for each scenario, those with the highest daily mileage were selected to maximize the operation of electric vehicles in favor of better operational results. The vehicles selected in each scenario are presented in the following items, followed by a comparison between the results of each scenario.

9 Small variations in the daily mileage rounded per vehicle above the maximum values were admitted due to the degree of uncertainty considered in the analysis.

3.1.3.1 Scenarios 1A and 1B: night charging only

The vehicles selected in scenarios 1A and 1B were the same; therefore, their results are presented together. The only difference between the scenarios is the time required for the night charging of articulated vehicles in garages, 7 hours or 3 hours, and it was observed that among the vehicles with the highest daily mileage, all of them spent more than 7 hours in the garages.

The 20 Padron vehicles selected presented daily mileage between 202.3 and 100.5 km, with operation on lines 62, 63, 64, 67, and 85 of the MOVE system. The 5 articulated vehicles selected presented daily mileage between 202.6 and 182.0 km, with operation on lines 50, 51, 61, 67, and 82.

The table below lists all selected vehicles and their associated characteristics.

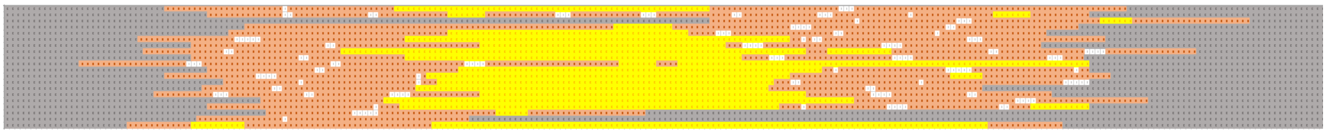
Table 12 – Vehicles selected in Scenarios 1A and 1B

Vehicle	Type	KMs traveled	Operated line	Operator	Operation terminal
10754	Padron	202,3	62	VIACAO JARDINS LTDA	Venda Nova
20565	Padron	185,3	85	VIACAO PROGRESSO LTDA	São Gabriel
20577	Padron	181,5	64	VIACAO TORRES LTDA	Venda Nova
10837	Padron	176,8	62	VIACAO JARDINS LTDA	Venda Nova
10816	Padron	176,8	63	MILENIO TRANSPORTES LTDA.	Venda Nova
30603	Padron	176,4	67	VIACAO SIDON LTDA	Vilarinho
10809	Padron	175,5	62	MILENIO TRANSPORTES LTDA.	Venda Nova
10815	Padron	172,0	63	MILENIO TRANSPORTES LTDA.	Venda Nova
30607	Padron	167,5	67	VIACAO SIDON LTDA	Vilarinho
20548	Padron	167,1	62	Unidentified	Venda Nova
20566	Padron	166,7	67	VIACAO PROGRESSO LTDA	Vilarinho
10691	Padron	163,1	64	CIDADE BH TRANSPORTES LTDA	Venda Nova
20570	Padron	160,2	67	VIACAO PROGRESSO LTDA	Vilarinho
30655	Padron	150,2	67	VIACAO SIDON LTDA	Venda Nova
20538	Padron	142,0	85	Unidentified	São Gabriel
10762	Padron	136,5	62	VIACAO JARDINS LTDA	Venda Nova
20567	Padron	135,9	67	VIACAO PROGRESSO LTDA	Vilarinho
20594	Padron	118,9	67	VIACAO GLOBO LTDA	Vilarinho
10813	Padron	101,6	63	MILENIO TRANSPORTES LTDA.	Venda Nova
10806	Padron	100,5	62	MILENIO TRANSPORTES LTDA.	Venda Nova
20515	Articulate	202,6	67	VIACAO PROGRESSO LTDA	Vilarinho
30542	Articulate	198,1	82	BETTANIA ONIBUS LTDA	São Gabriel
40527	Articulate	193,1	51	URCA AUTO ONIBUS LTDA	Pampulha
40545	Articulate	187,5	50	RODOPASS TRANSP. COL. DE PASSG. LTDA	Pampulha
10792	Articulate	182,0	61	MILENIO TRANSPORTES LTDA.	Venda Nova

Source: Own elaboration.

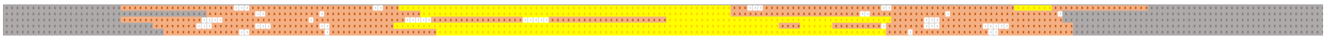
Additionally, the following figures illustrate the standard of operation observed in the selected vehicles. The schemes represent each vehicle operation between the night idle time (in the garages) observed. Night idle times appear in gray, times in operation or transit between garage and terminals in orange, long-day idle times (greater than 30 minutes) in yellow, and short-day idle times (less than 30 minutes) in white.

Figure 15 – Standard operation of Padron vehicles selected in Scenarios 1A and 1B



Source: Own elaboration with BHTrans data.

Figure 16 – Standard operation of Padron vehicles selected in Scenarios 1A and 1B



Source: Own elaboration with BHTrans data.

3.1.3.2 Scenario 2B: night charging and opportunity charging

The 20 Padron vehicles selected presented daily mileage between 267.2 and 167.1 km, with operation on lines 62, 63, 64, 67, and 85 of the MOVE system. The 5 articulated vehicles selected presented daily mileage between 257.1 and 228.5 km, with operation on lines 50, 51, and 65.

The table below lists all selected vehicles and their associated characteristics.

Table 13 – Vehicles selected in Scenario 2A

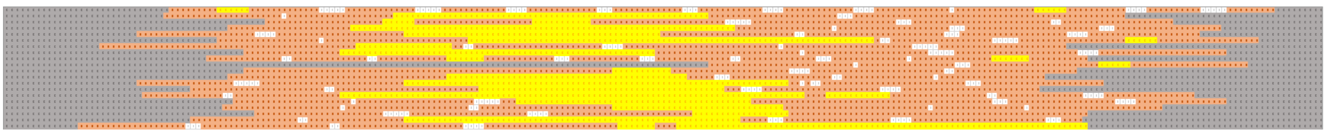
Vehicle	Type	KMs traveled	Operated line	Operator	Operation terminal
10777	Padron	267,2	64	RODAP OPERADORA DE TRANSPORTES LTDA	Venda Nova
10802	Padron	254,8	62	VIACAO JARDINS LTDA	Venda Nova
20589	Padron	245,2	67	VIACAO GLOBO LTDA	Vilarinho
20585	Padron	244,1	85	VIACAO TORRES LTDA	São Gabriel
10836	Padron	241,8	62	VIACAO JARDINS LTDA	Venda Nova
30602	Padron	240,6	67	VIACAO SIDON LTDA	Vilarinho
10756	Padron	240,1	62	VIACAO JARDINS LTDA	Venda Nova
10690	Padron	219,4	64	CIDADE BH TRANSPORTES LTDA	Venda Nova
10760	Padron	211,2	64	VIACAO JARDINS LTDA	Venda Nova
30630	Padron	211,0	67	VIACAO SIDON LTDA	Vilarinho

Vehicle	Type	KMs traveled	Operated line	Operator	Operation terminal
10754	Padron	202,3	62	VIACAO JARDINS LTDA	Venda Nova
20565	Padron	185,3	85	VIACAO PROGRESSO LTDA	São Gabriel
20577	Padron	181,5	64	VIACAO TORRES LTDA	Venda Nova
10837	Padron	176,8	62	VIACAO JARDINS LTDA	Venda Nova
10816	Padron	176,8	63	MILENIO TRANSPORTES LTDA.	Venda Nova
30603	Padron	176,4	67	VIACAO SIDON LTDA	Vilarinho
10809	Padron	175,5	62	MILENIO TRANSPORTES LTDA.	Venda Nova
10815	Padron	172,0	63	MILENIO TRANSPORTES LTDA.	Venda Nova
30607	Padron	167,5	67	VIACAO SIDON LTDA	Vilarinho
20548	Padron	167,1	62	Unidentified	Venda Nova
40505	Articulate	257,1	50	COLETUR -COLETIVOS URBANOS LTDA	Pampulha
10747	Articulate	256,5	65	RODAP OPERADORA DE TRANSPOR-TES LTDA	Vilarinho
40534	Articulate	239,3	50	URCA AUTO ONIBUS LTDA	Pampulha
40528	Articulate	229,5	51	URCA AUTO ONIBUS LTDA	Pampulha
10801	Articulate	228,5	51	VIACAO JARDINS LTDA	Pampulha

Source: Own elaboration.

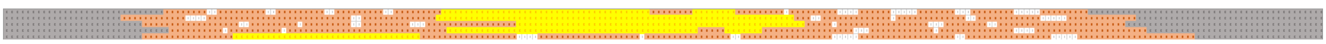
Additionally, the following figures illustrate the standard of operation observed in the selected vehicles. The schemes represent each vehicle operation between the night idle time (in the garages) observed. Night idle times are represented in gray, times in operation or transit between garage and terminals in orange, long-day idle times (greater than 30 minutes) in yellow, and short-day idle times (less than 30 minutes) in white.

Figure 17 – Standard operation of Padron vehicles selected in Scenario 2A



Source: Own elaboration with BHTrans data.

Figure 18 – Standard operation of Padron vehicles selected in Scenario 2A



Source: Own elaboration with BHTrans data.

3.1.3.3 Scenario 2B: night charging and opportunity charging

The 20 Padron vehicles selected were the same selected for Scenario 2B. The difference in this Scenario is in selecting the 5 articulated vehicles that, with the rapid charge, presented daily mileage between 325.4 and 299.4 km, with operation on lines 50, 61, 64, and 65.

The table below lists the selected articulated vehicles and their associated characteristics.

Table 14 – Articulated vehicles selected in Scenario 2B

Vehicle	Type	KMs traveled	Operated line	Operator	Operation terminal
20529	Articulate	325,4	65	VIACAO GLOBO LTDA	Vilarinho
10788	Articulate	306,5	64	MILENIO TRANSPORTES LTDA.	Venda Nova
10751	Articulate	303,7	61	AUTO OMNIBUS FLORAMAR LTDA	Venda Nova
10791	Articulate	301,3	61	MILENIO TRANSPORTES LTDA.	Venda Nova
40508	Articulate	299,4	50	COLETUR -COLETIVOS URBANOS LTDA	Pampulha

Source: Own elaboration.

The following figure illustrates the standard operation observed in selected articulated vehicles. The schemes represent each vehicle between the night idle time (in the garages) observed. Night idle times are represented in gray, times in operation or transit between garage and terminals in orange, long-day idle times (greater than 30 minutes) in yellow, and short-day idle times (less than 30 minutes) in white.

Figure 19 – Standard operation of Padron vehicles selected in Scenario 2A

Source: Own elaboration with BHTrans data.

3.1.4 Compared results

Table 15 below compares the evaluated scenarios, with the total daily mileage rotated by the replaced vehicles and the dimensioning of the number of chargers required in each scenario.

Table 15 – Results compared by Scenario

Vehicle Type		Padron		Articulated			
# of Vehicle		20		5			
Scenario		1A and 1A	2A and 1A	1A.	1B	2A.	2B
Charging pattern		Night	Night + Opportunity	Night		Night + Opportunity	
Type of charger		Slow		Slow	Fast	Slow	Fast
Daily KM traveled		3.156,6 km*	4.156,7 km*	963,3 km*	963,3 km*	1.210,9 km*	1.536,4 km*
Alternative: Night charging in garages and opportunity charging in terminals	**# Night chargers**	20	20	5	3	5	3
	# Opportunity charging	-	4	-	-	3	3
Alternative: Night charging in garages and opportunity charging in terminals	**# Combined charging pattern**	20	20	5	3	5	3

Source: Own elaboration.

For the calculation of the number of chargers required, an integrated analysis of the operating standard of each selected vehicle was performed, the distribution of its long day idle times used for the opportunity charging, and the operation terminal of each of these vehicles. Thus, it was possible to calculate the minimum number of chargers required, and each charger can be used by more than one vehicle in an interleaved manner, depending on its location, a specific terminal or garage, and the moments when the chargings would happen.

In addition, two alternatives for the location of the chargers were also considered, which are directly related to the business models discussed in the following items of this chapter. It was then considered the first alternative with night charging in garages and opportunity charging in the terminals, suitable for a business model acquiring vehicles and infrastructure by concessionaires.

Also, it was considered as another alternative, the night charging and opportunity charging in the terminals, suitable for a business model in which the acquisition of vehicles and charging infrastructure is under the responsibility of a public agency.

3.1.5 Potential for optimizing the operation of new vehicles

As mentioned in the previous item, the study of the operation performed did not aim to optimize the operation of vehicles to maximize the mileage rotated by electric vehicles or the efficient allocation of charging periods per opportunity. Instead, the study analyzed how the operation of electric vehicles could be fitted to the operating standards currently observed in the MOVE system of Belo Horizonte.

However, it is understood that, in possession of electric vehicles, operators will naturally seek to optimize the operation of vehicles to maximize their daily mileage and thereby reduce their operating costs. Therefore, optimizing the operation of vehicles is a frequent exercise practiced by system operators, who always seek a more efficient allocation of vehicles to reduce operating costs and maximize their financial returns. For this, they have software and professionals specialized in this procedure.

There is still a great potential for optimizing the operation to allow electric vehicles to operate daily mileage closer to the maximum autonomies of the batteries and the opportunity charging periods to extend the autonomies acquired throughout the day beyond that obtained by night charging.

In this sense, the following table presents an estimate of the total daily mileage obtained after optimizing the operation of electric vehicles. For this, it was considered that in scenarios with opportunity charging, each vehicle could have at least 90 minutes of idle time for charging in the terminals.

Table 16 – Operation optimization potential

Vehicle Type	Padron		Articulated		
# of Vehicle	20		5		
Scenario	1A and 1A	2A and 2B	1A and 1B	2A.	2B
Charging pattern	Night	Night + Opportunity	Night	Night + Opportunity	
Type of charger	Slow		Slow or fast	Slow	Fast
Daily KM traveled in the case study	3.156,6 km*	4.156,7 km*	963,3 km*	1.210,9 km*	1.536,4 km*
POTENTIAL Daily KM traveled	4.000,0 km*	5.500,0 km*	1.000,0 km*	1.250,0 km*	1.500,0 km*

Source: Own elaboration.

(*) Considering 90 minutes per opportunity recharging in the terminals

3.2 ECONOMIC AND FINANCIAL EVALUATION

The financial evaluation of the Electromobility Transition Pilot Project aimed to determine the impacts of adopting new technologies on the cost invested by the operating agents. Besides, it analyzes its effect on the variation in the need for revenues to be generated, by variation in the value of the user's tariff, or by municipal subsidy in favor of operating companies. The following are the methodological principles used to indicate the data sources and, finally, the final results.

3.2.1 Methodology

The methodology adopted for the economic and financial evaluation of the Pilot Project for Transition to Electromobility can be called "planned budget replacement." In this model, we used a typical cost sheet adopted by the public transport sector, which included the fixed and variable costs resulting from using electric vehicles, and the same costs of combustion vehicles replaced by electric vehicles are deducted. Thus, in the model of "planned budget replacement" enters the differential of system added costs with and without the adoption of electric vehicles.

The Tariff Worksheet was initially proposed by the Executive Group for the Integration of Transport Policy (GEIPOT)[10] in 1982, through the launch of the Practical Instructions for Calculating Urban Bus Tariff, and updated with the edition of the methodology in 1996. The conception of the tariff sheet model aimed to harmonize the calculation of the value for the public transport user among the various entities of the federation, unifying the methodological procedures and suggesting indicators that would assist the agency that had a technical limitation in making a complete survey of their prices and tariff parameters.

After the decision to restructure the federal transport sector in 2001, which led to the extinction of GEIPOT, the tariff sheet remained in use for most public transport managers in different municipalities, states, and the Federal Government.

Motivated by the popular demonstrations of June 2013, in 2016, the Frente Nacional de Prefeitos and the Associação Nacional de Transportes Públicos, ANTP, made a great effort to review and update the tariff sheet for the current conditions of provision of public passenger transport services. This

10 In 1965 the Executive Group for the Integration of Transport Policy (GEIPOT) was created through Decree No. 57,003 of October 11, 1965, with the objective of coordinating and developing a series of transport studies (as a Brazilian counterpart to an agreement signed with the International Bank for Reconstruction and Development). Later in 1969, GEIPOT was transformed into a Study Group for The Integration of Transport Policy, making it subordinate to the Minister of State for Transport. GEIPOT was transformed into a Empresa Brasileira de Planejamento de Transportes through Law No. 5,908 of August 20, 1973, maintaining the acronym GEIPOT.

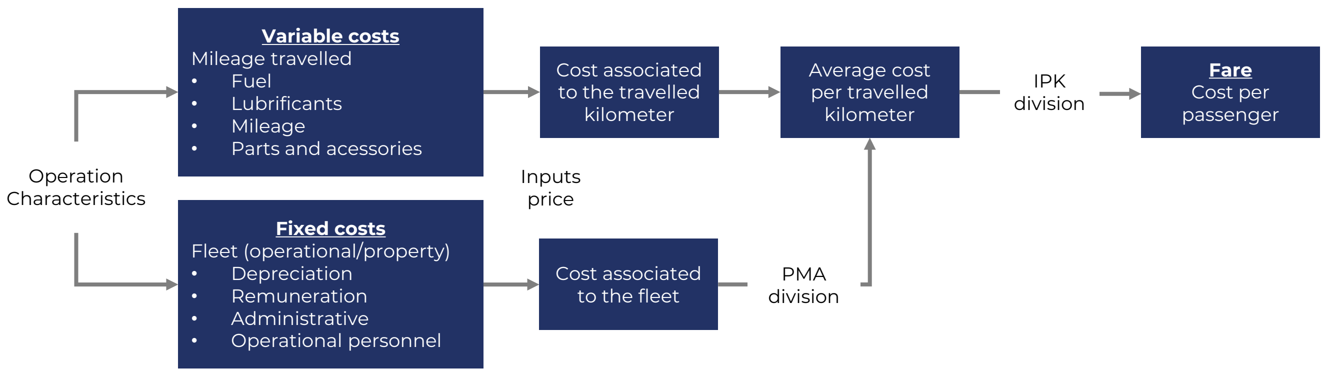
effort resulted in calculating new productivity parameters and sources of reference information, many of which used in the present Study.

The tariff worksheet is a synthetic representation of the economic costs arising from the provision of public transport services. Private companies contracted for public services must be adequately remunerated. The process must respect the form and quantity defined by the management agency, either directly by the grantor or by tariff user payment.

This being the case on screen, it is correct to state that the tariff worksheet aims to convert the costs arising from the provision of public services in the form and amount defined by the Granting Authority in tariff prices for users.

The following figure presents the schematic design of the methodology used in determining the user's tariff:

Figure 20 – Tariff calculation methodology



Source: Own elaboration.

It is appropriate to cite the calculations performed expeditiously from this general conception. Cost sheets are divided into two parts, variable and fixed. The variable costs are those arising from the operation of the vehicle and include the following items:

- Fuels
- Lubricants
- Mileage
- Parts and accessories

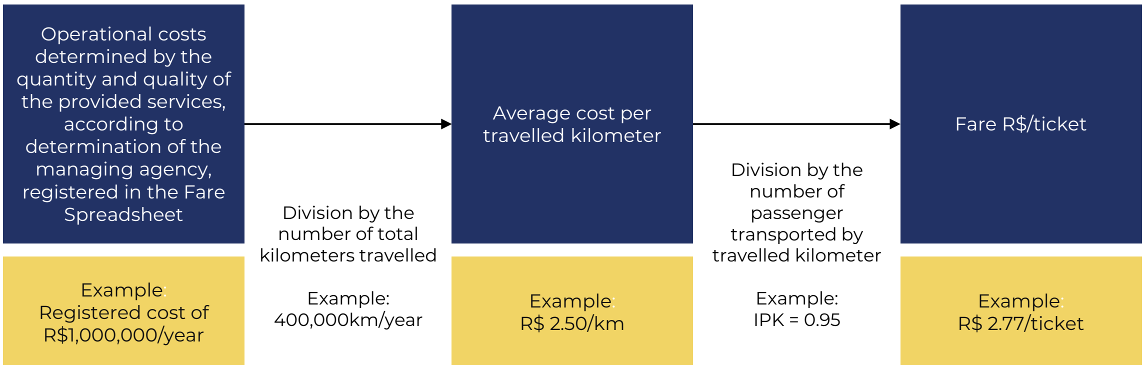
Variable costs are obtained according to the consumption of each input per kilometer traveled (by the vehicle) multiplied by its respective unit price. Fixed costs are independent of the operation of the vehicle, and the following items fall into them:

- Depreciation
- Remuneration
- Administrative
- Operation personnel

After the fixed costs of each vehicle are calculated, these are transformed into costs per kilometer. This transformation is made by the quotient between the total annual fixed cost and the Average Annual Route - PMA, which in turn is obtained by the total kilometers traveled annually in the operation of the lines, by service characteristic, divided by the number of vehicles destined to the operation of the system, including reserves.

The final value of the tariff per user is obtained by the sum of costs per kilometer (considered variable and fixed costs) divided by the Index of Passengers per Kilometer (IPK), calculated by the ratio between the number of passengers transported and the number of kilometers traveled. The following figure simplifies the methodological detailing described:

Figure 21 – Example of tariff calculation



Source: Own elaboration.

In the "planned budget replacement" model, adopted for the transition to Electromobility, the variable unit costs of electric vehicles and combustion were calculated, along with the variations in fixed costs with depreciation and capital remuneration. Therefore, the replacement of a part of combustion vehicles by electric vehicles shall not be considered to lead to relevant changes in:

- Operational staff costs, especially drivers, inspection, and operational control staff.As for maintenance staff costs, no relevant changes were considered. On the one hand, the processes associated with the maintenance of electric motors tend to be more straightforward than the maintenance of combustion engines. On the other hand, the new technologies introduced by electric vehicles should demand new specialized activities, creating new maintenance positions. For the Pilot Project, due to the proportionally reduced number of combustion vehicles replaced by electric vehicles, there should be no significant change in the number of employees allocated to these activities. But it is recommended to calculate these values before starting operations.

- Administrative staff costs should not change significantly due to technological replacement.

The productivity parameters and unit costs set out below were multiplied by the number of vehicles and by the operational and non-operational mileage detailed in the other chapters of this report to obtain the total costs of the situation with electric vehicles and without electric vehicles. This comparison, or "planned budget replacement," indicated what would be the monetary impact on the concession contracts of the operating companies.

3.2.2 Input data and assumptions

The Concession Contracts for the operation of the public transport system of Belo Horizonte have their equation signed at the time of bidding. In this equation, the various parameters that underpin the remuneration model of the Concessionaire companies were established.

Nevertheless, many parameters are still under discussion in the administrative spheres. Defining which consensus parameters would produce satisfactory results for all parties would be challenging. For this reason, parameters from research and the New Tariff Sheet elaborated and published by the National Association of Public Transport, ANTP, were used instead of using parameters of concession contracts.

The data focused on February 2022, the focal point for the realization of the comparations. However, according to common fluctuations in prices such as fuel, energy, and vehicles, the comparison results may vary depending on the month of operation. The primary data sources are pointed out below:

- Parameters of consumption of diesel, oil, lubricants, parts, and accessories of combustion vehicles: Parameters researched and published in the new tariff worksheet elaborated and published by the National Association of Public Transport, ANTP.

- Diesel price parameters: average prices announced by the National Agency of Petroleum, ANP, for fuel distributors in Belo Horizonte. Note that the average size of a bus company is usually smaller than that of a distributor, so the value of diesel may eventually be underestimated.

- Price parameters of diesel vehicles (heavy, standard, and articulated): prices observed in invoice used for the preparation of economic-financial feasibility studies-bidding for the concession of the operation of the Public Passenger Transport System of the Metropolitan Region of Recife, STPP - RMR in February 2022. Other municipalities observed no recent public parameters, so the adopted values were maintained.

- Price parameters of electric vehicles with Plug In refill or by Ultracapacitor: Quotation formalized in the event of a Procedure of Expression of Interest carried out by the City of Rio de Janeiro in 2020 for the BRT Project of Avenida Transbrasil, adjusted for exchange variations. U.S. dollar values were compared at prices observed in other international projects.

- Possible differences are due to the incidence of taxes, which in Brazil is higher than in other countries, and to the circumstances in force in the production chain of heavy vehicles. Quotations may vary significantly between the present date and the effective acquisition date of the vehicles due to various factors such as exchange rate, supply offer or shortage, and others. There may be a reasonable difference in the price of vehicles for each State of Brazil due to the rates and ways of calculating the incidence of ICMS.

- Energy price parameters: values to consumers on average voltage, according to the tariff grid provided by CEMIG for February 2022, detailed in item 1.5.1 of this Report.

- Energy consumption parameters, lubricants, parts, and accessories of electric vehicles: bibliographic references on international experience, including the following studies:

    - Ministério de Desenvolvimento Regional do Brasil e Banco Interamericano de Desenvolvimento, “GUIA DE ELETROMOBILIDADE, Orientações para estruturação de projetos no transporte coletivo por ônibus.” 2022.

    - Grütter, Jürg, Grütter Consulting AG: “Rendimiento Real de Buses Híbridos y Eléctricos. Rendimiento ambiental y económico de buses híbridos y eléctricos basados en grandes flotas operacionales.” [13]

    - Orbea, Jone: “Modelos de negocio para la adopción de flotas eléctricas: Experiencias Internacionales”. World Resources Institute, october, 2017. [14]

    - Corporación Andina de Fomento: “La electromovilidad en el transporte público en América Latina”, 2019. [15]

    - The World Bank: “GREEN YOUR BUS RIDE, Clean Buses in Latin America, Summary report,” January 2019. [16]

Based on the bibliographic research formulated and the consolidation of the various sources used to calculate the “planned budget replacement” model, the following detailed parameters were consolidated:

Table 17 – Parameters considered for the calculation of the "planned budget replacement" model - Part 1 of 2

	Heavy			Padron		
	Diesel	**Plug-In**	**Ultracapa-citor**	**Diesel**	**Plug-In**	**Ultracapa-citor**
Vehicle Investment						
Initial Purchase Price - Vehicle	552,500	1.450.000	2.000.000	595,000	1.525.000	2.200.000
Price Renewal - Vehi-cle (year 7)	512,500	0	0	545,000	0	0
Price renewal - Battery (year 7)	0	725,000	0	0	725,000	0
Variable Cost	0,00	0,00	0,00	0,00	0,00	0,00
Fuel Consumption / Energy	0.498	1.149	1.300	0.546	1.282	1.600
Fuel price or Kw/h	5,2260	0,5882	0,5882	5.226	0,5882	0,5882
Consumption with Parts and Accessories	6.00%*	16,575	16,575	6.00%*	17,850	17,850
Lubricant consumption	5.00%*	0,25%	0,25%	3.00%*	0,25%	0,25%
Equipment	0	0	0	0	0	0
Cost of the Charging Station in R$	0	105,000	350,000	0	105,000	0
Infrastructure	0	0	0	0	0	0
Cost of the Charging Station in R$	0	15,000	15,000	0	15,000	15,000

*Cost reference of a diesel-powered vehicle

Source: From MDR, 2022; Grütter Consulting AG, 2015; Orbea, 2017; CAF, 2019; and World Bank, 2019.

Table 18 – Parameters considered for the calculation of the “planned budget replacement” model - Part 2 of 2

	Articulated 18 m			Articulated 23 m		
	Diesel	Plug-In	Ultracapa-citor	Diesel	Plug-In	Ultracapa-citor
Vehicle Investment						
Initial Purchase Price - Vehicle	1.150.000	3.229.067	4.057.000	1.650.000	3.610.480	4.350.000
Price Renewal - Vehi-cle (year 7)	0	0	0	0	0	0
Price Renewal - Bat-tery (year 7)	0	1.370.850	0	0	1.587.300	0
Variable Cost	0,00	0,00	0,00	0,00	0,00	0,00
Fuel Consumption / Energy	0.833	1.250	1.900	0.952	1.370	1.900
Fuel price or Kw/h	5.226	0,5882	0,5882	5.226	0,5882	0,5882
Consumption with Parts and Accessories	6.60%*	37,950	37,950	6.60%*	54,450	54,450
Lubricant consumption	3.00%*	0,25%	0,25%	3.00%*	0,25%	0,25%
Equipment	0	0	0	0	0	0
Cost of the Charging Station in R$	0	105,000	0	0	105,000	0
Infrastructure	0	0	0	0	0	0
Cost of the Charging Station in R$	0	15,000	15,000	0	15,000	15,000

*Cost reference of a diesel-powered vehicle

Source: From MDR, 2022; Grütter Consulting AG, 2015; Orbea, 2017; CAF, 2019; and World Bank, 2019.

3.2.3 Results

From the product between the unit values of productivity, the prices of inputs, and the volumes of kilometers traveled by electric vehicles and no longer covered by combustion vehicles, the variable operating cost values exposed below were reached:

Table 19 – Variable operating costs

	OPEX ADDED/ YEAR	OPEX AVOIDED / YEAR
Energy / fuel	1.125.477,64	4.729.644,10
Lubricants / arla	35.472,33	236.482,21
Parts and Accessories	546.750,00	1.093.500,00
TOTAL ANNUAL	1.707.699,97	6.059.626,31
TOTAL 7 YEARS	11.953.899,80	42.417.384,17

Source: Own elaboration.

The variable costs are expected to present the most significant differences in favor of electric vehicles. Considering the consumption parameters compiled from the literature on the subject and the prices in force in February 2022, energy expenses reach about 23.80% of the expenditure on fuel in combustion vehicles.

The costs of parts and accessories represent about 50% of the costs of combustion vehicles, while the costs of lubricants and arla represent only 15% of the expected costs. In total, the average cost for electric vehicles is, on average, 28.18% of the costs per kilometer per combustion vehicle. With a safe operation of 200 km per day, so as not to reach the minimum level of 20% of the battery, in 25 days per month, the annual cost differential reaches R$ 4,351,926.34. The total accumulated for the remaining seven years of the contract is R$ 30,463,484.37. After the end of the contract, the vehicle remains with its acquirer at the residual asset value.

On the investment side, the differential price between conventional combustion vehicles and electric vehicles, added to the costs of investments in charging systems and civil construction necessary for their implementation, results in the following table.

Table 20 – CAPEX added and avoided

	CAPEX ADDED	CAPEX AVOIDED
Fleet		
Initial Investments	46.645.337,00	17.650.000,00
Equipment		
Chargers	2.625.000,00	
Infrastructure	375.000,00	
TOTAL 15 YEARS	49.645.337,00	17.650.000,00

Source: Own elaboration.

Thus, there is an increase of R$ 31,995,337.00 due to the planned replacement of combustion vehicles with electric vehicles. This value is close to the savings in variable operating costs over 7 years. However, this account should add to the cost of the capital remuneration and amortization rates, resulting in the aggregate analysis set out in the following table.

Table 21 – Aggregate analysis

Electric Vehicles	Initial Inv.		Useful life (years)		Residual Value		Annual Depreciation		Annual Compensation				Variable Costs	Planned Costs
	Vehicle	Battery	Vehicle	Battery	Vehicle	Battery	Vehicle	Battery	Deadline	Int. Rate	Vehicle	Battery		
Articulated	9.291.087	6.854.250	15	7	5,00%	0,00%	588,436	979,179	7	8,95%	647,225	306,728	1.707.699,97	9.640.298,27
Padron	16.000.000	14.500.000	15	7	5,00%	0,00%	1.013.333	2.071.429	7	8,95%	1.114.573	648,875		
Heavy	0	0	15	7	5,00%	0,00%	0	0	7	8,95%	0	0		
Equipment	2.625.000		7		0,00%		375,000		7	8,95%	117,469	0		
Infrastructure	375,000		7		0,00%		53,571		7	8,95%	16,781	0		
TOTAL	**49.645.337**						5.080.947		2.851.651					

Diesel Vehicles	Initial Inv.	Useful life (years)	Residual Value	Annual Depreciation	Annual Compensation			Variable Costs	Planned Costs
	Vehicle	Vehicle	Vehicle	Vehicle	Deadline	Int. Rate	Vehicle		
Articulated	5.750.000	12	5,00%	455,208	7	8,95%	372,031	6.059.626,31	8.687.424,88
Padron	11.900.000	10	10,00%	1.071.000	7	8,95%	729,559		
Heavy	0	8	10,00%	0	7	8,95%	0		
TOTAL	**17.650.000**			**1.526.208**	**1.101.590**				

TOTAL DIFFERENTIAL OF FIXED AND VARIABLE COSTS IN THE MODEL OF “PLANNED BUDGET REPLACEMENT”	952.873,39

Source: Own elaboration.

It is concluded that, according to the calculation of costs per tariff sheet, there is an additional cost to be covered by some alternative sources of income, namely, tariff increase or direct subsidies, of approximately R$ 952,873.39 per year.

It should be noted, however, that this model has as an implicit premise the entire delegation of the activities of acquisition, implementation, operation, and maintenance of electric vehicles by the private initiative. Thus, if this model is appropriate to the Municipality conditions, the results may differ, as stated in subsequent chapters.

3.3 LEGAL ASPECTS OF THE DEFINED MODEL

In Belo Horizonte, the form of the execution of the public transport service is based on Federal Law 8.987/1995. The Government is responsible for the design and delegation of execution to the private sector, allocating financial risks to operators.

The capital of Minas Gerais has important legislative provisions that meet the premises of sustainability and, in particular, the mitigation of the effects of Climate Change, which are: (i) Municipal Law No. 10,134/2011, which establishes the Municipal Urban Mobility Policy, having as one of its guidelines, “stimulate the use of renewable and less polluting fuels” (Article 4, item IV); (ii) Law No. 10,175/2011, which instituted the municipal policy to mitigate the effects of climate change; (iii) Decree No. 14,794/2012, which aims at urban-environmental planning aimed at reducing and mitigating greenhouse gases and aiming to reduce greenhouse gas emissions to 1.05 tons of CO2 per inhabitant by the year 2030.

Concerning public transport, it is possible to start the transition by implementing an electric bus fleet. This passage brings together several challenges intrinsic to the activity. Among them stands out the need for alignment between all stakeholders (governments, operators, funders, manufacturers, and technology suppliers) so that the transition happens efficiently.

From a technical point of view, the premises started from the operation in the MOVE System with a plug-in charging battery, as shown in the table below:

Table 22 – Operational scenario

Vehicles replaced-quantity	Line	Charging infrastructure - chargers
20 Conventional vehicles	MOVE Trunk Lines	Night charging and/or night charging and opportunity chargingplug-in charge
05 Articulated vehicles	MOVE Trunk Lines	Night charging and/or night charging and opportunity chargingplug-in charge

Source: Own elaboration.

In this context, to formulate and evaluate the most appropriate business model for public transport projects (involving all or part of electric bus components), the city may consider four alternatives:

- Full public responsibility
- Private responsibility or Global Concession
- Shared responsibility between the public and private in a single contract
- Private responsibility in two contracts

During the Electric Bus Financing Pilot Project, all possibilities for the transition were explored and discussed through training and dialogue with the Government.

Given the legal and economic possibilities and considering the local characteristics of the municipality, the choice of the pilot project was that of Full Public Responsibility.

Therefore, the acquisition of electric vehicles and implementation of the charging systems goes the responsibility of the Granting Authority, and the Concessionaire receives the assets as assets linked to the Concession and, therefore, as reversible assets.

To this end, we focus on the contracts and some legal points that must be observed to carry out the proposal.

In Belo Horizonte, there are 4 contracts signed on July 28, 2008, whose term is 20 years (clause six) and with the possibility of changing the term of the concession, conditional on the revision of the contract (19.13 c/c 30.2)

The current concession of public transport by bus from Belo Horizonte is divided into four operational basins operated by different concessionaires, known as Transport and Services Networks ("RTS").

- Contract RTS n. 1: PAMPULHA Consortium (Milênio Transportes Ltda + Auto Omnibus Floramar Ltda + Cidade BH Transportes Ltda + Coletivos Asa Norte Ltda + Lig Transportes e Serviços Ltda + Plena Transportes e Turismo Ltda + Rodap Operadora de Transportes Ltda + São Dimas Transporte Ltda + Turilessa Ltda + Viação Carneirinhos Ltda + Viação Jardins Ltda + Viação Sandra Ltda)
- Contract RTS n.° 2: BHLESTE Consortium (Viação Globo Ltda + Coletivos Boa Vista LTDA + Sagrada Família Ônibus S.A + S&M Transportes S.A + Via Sul – Transportes Coletivos S.A + Viação Getúlio Vargas Ltda + Viação São Geraldo Ltda + Viação Progresso Ltda + Viação Torres Ltda)
- Contract RTS n° 3: DEZ Consortium (Betânia Ônibus Ltda + Auto Omnibus Nova Suissa Ltda + Coletivos São Lucas Ltda + Transcbel – Transporte Coletivo Belo Horizonte Ltda + Via BH Coletivos Ltda + Via Oeste Transportes Ltda + Viação Paraense Ltda + Viação Santa Edwiges Ltda +Viação Sidon Ltda + Viação Zurick Ltda)

- Contract RTS n.º 4: DOM PEDRO II Consortium (Rodopass Transporte Coletivo de Passageiros Ltda + Belo Horizonte Transporte Urbano Ltda + Coletur – Coletivos Urbanos Sociedades Ltda + Salvadora Empresa de Transporte Ltda + São Cristovão Transportes Ltda + Urca Auto Ônibus Ltda + Viação Anchieta Ltda + Viação Euclásio Ltda + Viação Fenix Ltda)

The general rules defined in the contract determine:

I. The contract term for 20 years, with the possibility of changing the term of the concession, after revision of the contract (Clauses 19.13 c/c 30.2 of the Contract)

II. The Grantor may unilaterally modify the provisions of the contract to better suit the public interest, respecting the economic-financial balance (Clause 13 of the Contract)

III. The Granting Authority, given the needs of the services, may, upon the prior manifestation of BHTRANS, modify the fleet standard and the minimum requirements for the operation of the service (Clause 14 of the Contract)

IV. BHTRANS may require the use of less polluting fuels or vehicles using cleaner technology (Annex III of the Public Bid – item 2.4.6)

V. Assets reverted to the Grantor shall be in the condition of use for at least 24 (twenty-four) months (Clause 7.6 of the Contract)

The Concession Contract defines the duration, obligations, and compensations from tariff collection and has a defined legal space for inserting the electric bus fleet.

Therefore, a technical study that underpins the contractual change and establishes the technical conditions that involve the insertion of the electric fleet is necessary. It must include the type and number of buses to purchase, the infrastructure required for charging and dimensioning the charges, the location of charging points, the training of personnel for operation with the definition of the manual to be observed, the definition of the delivery method of the vehicle to the Concessionaire, complete operation's starting date, specifications for operational issues that may compromise the provision of the service.

In addition, from an economic point of view, if there is an imbalance, the calculation of the value and the form of the payment of economic-financial

rebalancing of the contract must be specified. If the imbalance favors the Concessionaire, the respective budget allocation must bear the obligation.

Sure, too, that the Granting Authority should prepare its staff for the due inspection of the operation since the vehicle has new technology and will integrate the standard operation.

Finally, after studies, the addendum concluded should be published in the official gazette and forwarded to the External Control Agency (Court of Audit).

3.4 ASPECTS OF SOCIAL IMPACT

This item explores the social perspectives related to the support for electromobility for the pilot project designed for the municipality. Social impacts, such as territorial inequalities, gender, race, and income, are considered.

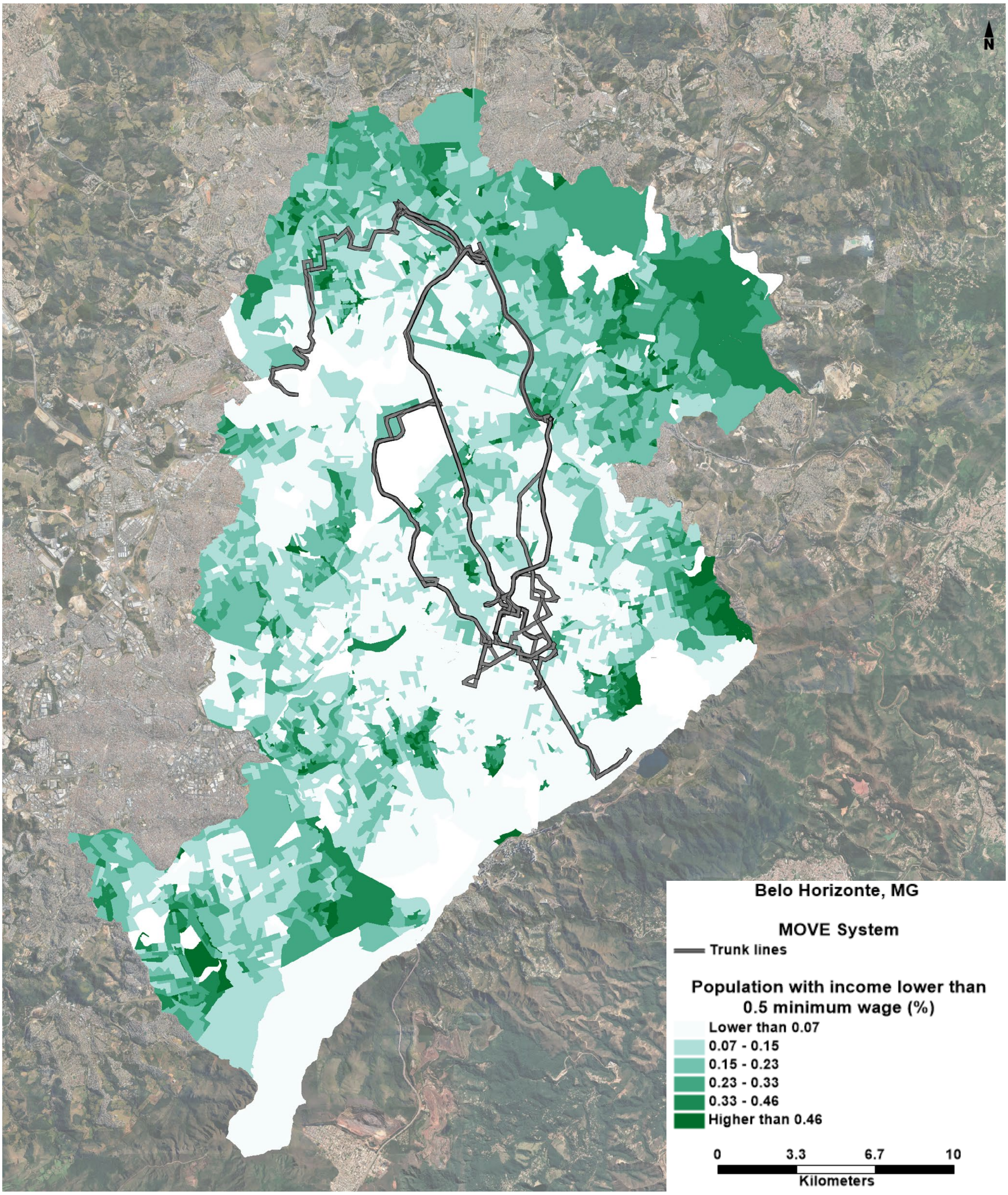
For the analysis, the spatial distributions of the trunk lines of the MOVE System and two groups of the resident population of Belo Horizonte were considered: people with incomes less than half the minimum wage; and the women who declared themselves black. For the analysis, IBGE data from the 2010 Census were used.

The chosen groups represent the socially less favored populations of Belo Horizonte. The first represents the lowest-income social group, that is, with less financial access to the city's opportunities and, consequently, more dependent on the system of easier access to public systems. The second group of black women was chosen because it represents the social group historically less favored due to gender and race issues.

The evaluation of these groups' access to the MOVE System's trunk lines can be considered a parameter of choice to support decisions in future phases of implementing the electric bus pilot project in Belo Horizonte. Identifying the trunk lines that provide greater access to less favored populations to the city's transport system may indicate the choice of lines on which electric buses will operate.

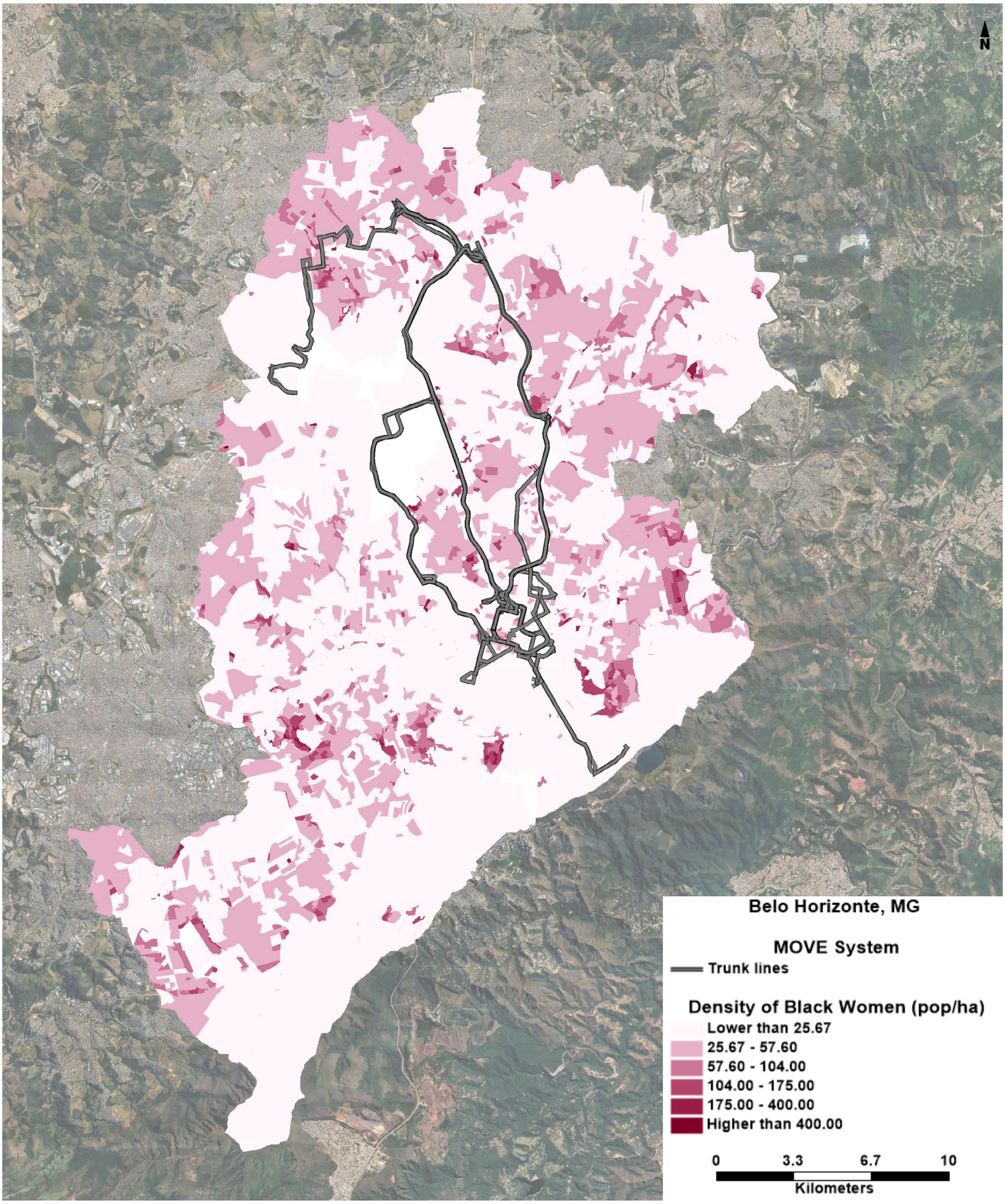
Initially, IBGE data were considered to evaluate the spatial distribution of these groups in the municipality's territory. As a result, the following figures show the spatial distribution of people with incomes up to half the minimum wage (Figure 22) and black women (Figure 23) in the territory of Belo Horizonte.

Figure 22 – Distribution of the population with income less than half minimum wage



Source: Own elaboration with IBGE data, 2010 and BHTrans, 2021.

Figure 23 – Distribution of the population of black women



Source: Own elaboration with IBGE data, 2010 and BHTrans, 2021.

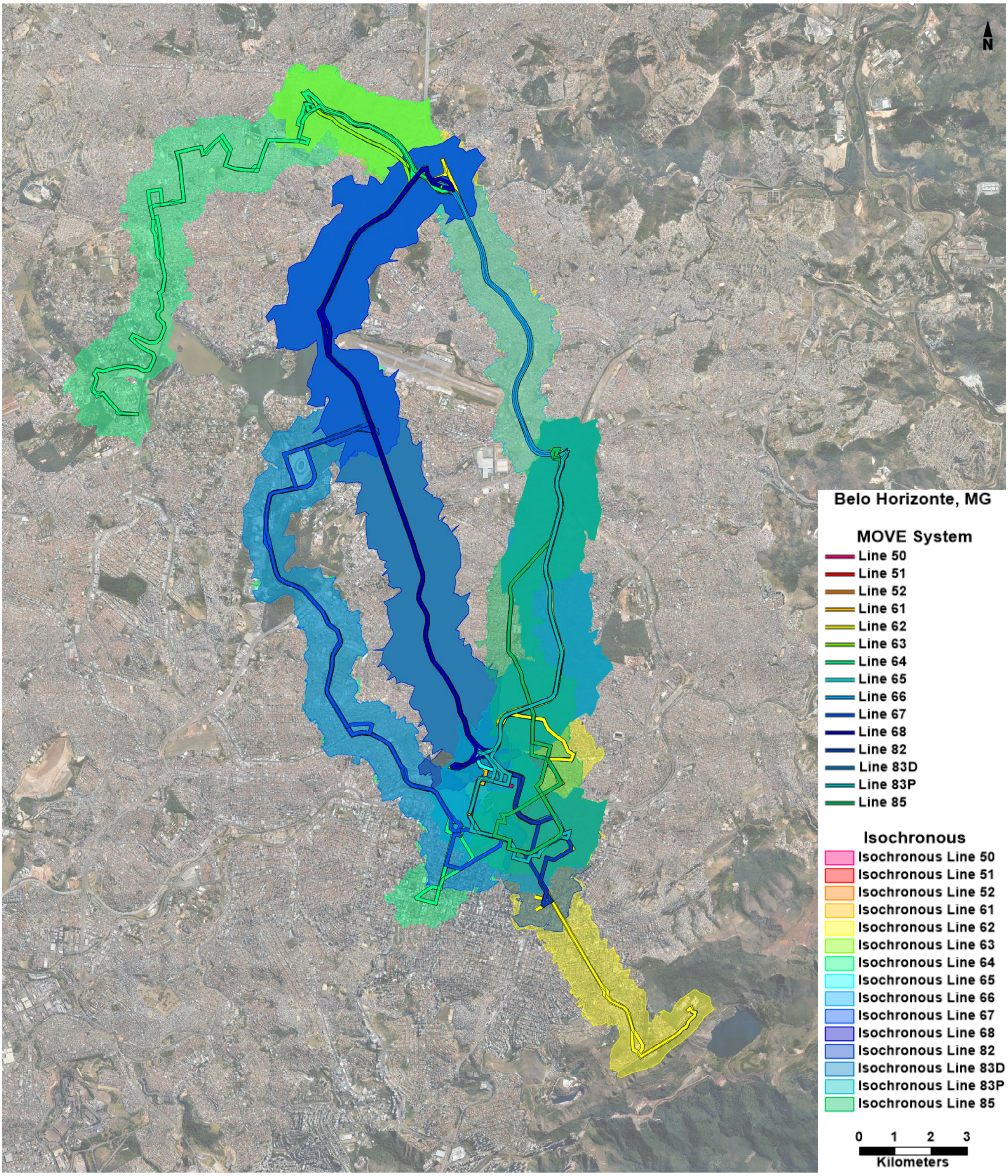
To evaluate less favored groups' access to each of the trunk lines of the MOVE system, the station's isochronous and the tracings of the lines considered were calculated.

For the station's isochronous, a distance of 1 km was considered for access to the station. The area around the station where the population travels a maximum of 1 km in the existing road system to access the station was considered for each station.

For the trunk lines isochronous, a distance of 500 meters was considered for direct access to the line. This represents the surrounding areas where people travel 500 meters or less to access the lines.From the calculated isochronous, a consolidation of the isochronous from the stations and the lines corresponding to each of the trunk lines was carried out to obtain, for each trunk line of the MOVE, the area to consider for the evaluation of their resident populations regarding the socially less favored groups of lower income and black women.

Figure 24 on the next page represents the calculated isochronous for each MOVE trunk line.

Figure 24 – Isochronous calculated for MOVE trunk lines

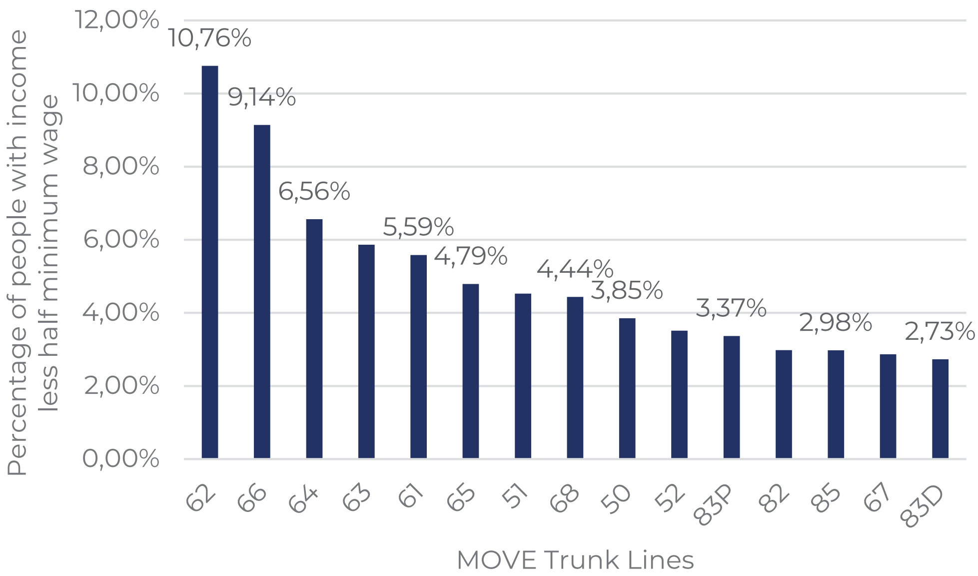


Source: Own elaboration with IBGE data, 2010 and BHTrans, 2021.

From the calculated areas, the percentages of the population of people with income smaller than half minimum wage and the population of black women living in these areas were calculated by the total of these populations in the municipality of Belo Horizonte.

Figure 25 below shows the percentage of people with incomes less than half a minimum wage with access to each of MOVE's trunk lines.

Figure 25 – Percentage of people with income lower than half a minimum wage with access to MOVE trunk lines

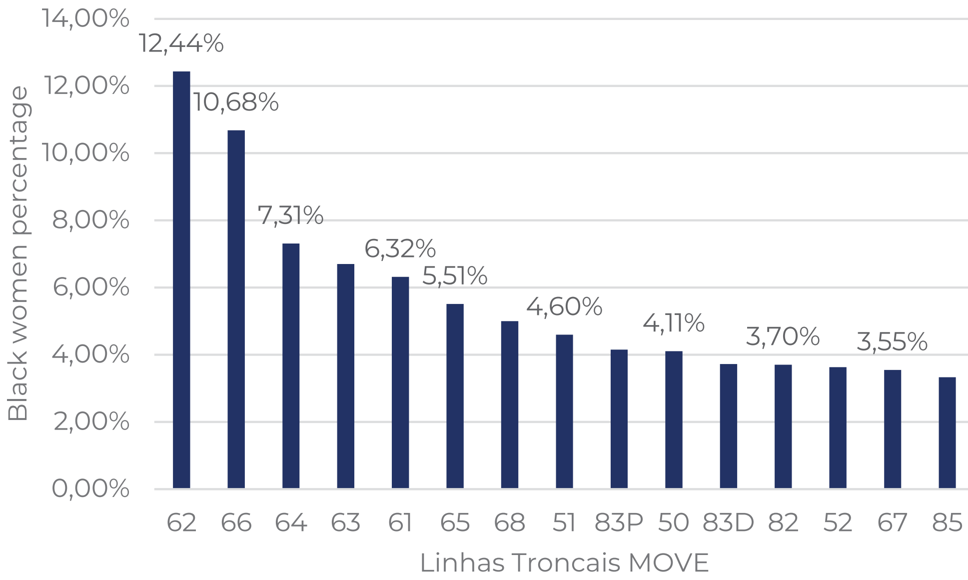


Source: Own elaboration with IBGE data, 2010 and BHTrans, 2021.

The analysis shows that the trunk lines that have access to a majority of the people with lower income in the city of Belo Horizonte are lines 62 and 66, with, respectively, 10.76% and 9.14% of people with income lower than half the minimum wage of Belo Horizonte living in its surroundings.

Figure 26 on the next page shows the percentage of black women accessing MOVE's trunk lines.

Figure 26 – Percentage of Black women with access to MOVE trunk lines



Source: Own elaboration with IBGE data, 2010 and BHTrans, 2021.

The results show that the trunk lines that provide greater access to black women in the city of Belo Horizonte are lines 62 and 66, with 12.44% and 10.68% of black women in Belo Horizonte living in their surroundings.

3.5 ENVIRONMENTAL ASPECTS

It is also worth noting that replacing Euro 5 technology vehicles with electric vehicles will lead to a considerable reduction in total emissions.

To calculate the reduction of emissions of polluting gases, we used the methodology of the U.S. Environmental Protection Agency - USEPA, also adopted by the Environmental Technology and Sanitation Company - CETESB. This methodology was adapted to reflect the parameters imposed by the current legislation regarding the renewal of the vehicle fleet.

It is common sense that pollutant emissions and fuel consumption are related to speed variation and distances traveled. However, the emission of pollutants is also influenced by the characteristics of the fuels and conditions of the vehicles themselves (model, type, age, state of conservation, among others.). Five primary pollutants resulting from evaporative emissions are considered: carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbons (HC), nitrogen oxide (NO_x), and sulfur oxide (SO_x).

The emission of pollutants such as HC, CO, CO_2, and NO_x is inversely proportional to the average speed of the vehicles, being the other constants. However, replacing combustion vehicles with electric vehicles on the average speed of public or individual transport was considered irrelevant. Thus, no changes in the emission standards of diesel vehicles were considered between situations with and without the project.

This methodology calculates the emission factors for light and heavy vehicles, considering the speed of the test cycle of 31.5 km/h (USEPA - U.S. Environmental Protection Agency). Then, the volume of emissions is multiplied by the estimated volume of kilometers for each type of vehicle, Padron, and articulated.

In the case of the Public Transport System of Belo Horizonte, there is a new situation: since January 1, 2012, all new vehicles have been adequate to the emission standards of type Euro 5. However, the standards established by Proconve (Vehicle emission control program) indicate that from 2022 it has become mandatory to use Euro 6 technology so that in the future, the expectation of emissions of vehicular pollutants will be reduced again.

The following table shows the emission patterns of toxic gases and particulate matter based on the different vehicle profiles.

Table 23 – Emission standards of toxic gases and particulate matter based on different vehicle profiles

	Heavy Bus - Euro 5	Heavy Bus - Euro 6
	g/km	g/km
CO	1,876368472	0,538525438
HC	0,284858743	0.018
NO_x	8,430206915	2,631368031
SO_x	0,82	0.164
CO_2	1209	1209
Mat Particulate	0,151048327	0,021488924

Source: CETESB.

The volume of gas emissions proportional to fuel consumption was considered for the other vehicle profiles, according to the table presented on the next page.

Table 24 – Gas emission volume

	Heavy		Padron		Articulated 18 m		Articulated 23 m	
	Euro 5	Euro 6	Euro 5	Euro 6	Euro 5	Euro 6	Euro 5	Euro 6
Fuel Consumption	0.498		0.546		0.833		0.952	
Emissions (g /km)								
CO	0,00170	0,00050	0,00186	0,00055	0,00284	0,00084	0,00325	0,00096
HC	0,00120	0,00010	0,00132	0,00011	0,00201	0,00017	0,00229	0,00019
NO_x	0,04020	0,01260	0,04406	0,01381	0,06727	0,02108	0,07688	0,02410
SO_x	0,01490	0,00300	0,01633	0,00329	0,02493	0,00502	0,02849	0,00574
CO_2	0,18010	0,18010	0,19740	0,19740	0,30137	0,30137	0,34442	0,34442

Source: Own elaboration.

For the case on screen, it was also considered the replacement of diesel vehicles by Euro 6 vehicles, according to the standards established by Proconve for 2022, reaching the conclusion that some 405 kilos of pollutants emitted per year will be avoided, according to the results set out below.

Table 25 – Avoided emissions

Avoided emissions (Kg/year)	Padron	Articulate
CO	2,04	0,85
HC	1,44	0,60
Nox	48,24	20,18
Sox	17,88	7,48
CO2	216,12	90,41
TOTAL	**285,72**	**119,53**

Source: Own elaboration.

Thus, only the vehicles contemplated in the Pilot Project of Transition to Electromobility will avoid almost three tons of pollutants over a 7-year horizon.

4.

ASSET FINANCING

This chapter explores the options and alternatives related to funding sources for public transport, with particular emphasis on the possibilities for the defined business model.

In addition to these perspectives, viable sources of funding for the pilot project are presented that can contribute to the municipality's understanding of its alternatives for financing vehicles and equipment.

4.1 SOURCES OF PRIVATE FUNDING

The sources of financing aimed at the private sector seek to create funding channels for operating companies to acquire vehicles, equipment, and systems. But of course, this can only occur if this responsibility is effectively allocated to this agent.

According to practices adopted in the sector, there are two primary sources of financing: the National Bank for Economic and Social Development, BNDES, mainly the Finame Line (Financing of Machinery and Equipment), and commercial banks linked to vehicle manufacturers.

In the case of the acquisition of vehicles and small financial volumes of systems, the financing operation with BNDES must necessarily be carried out through transfer by a financial agent. The financial agent assumes the credit risk of the operation, usually recounting the assets (vehicles and equipment) as collateral for their loans.

However, given the inherent difficulty in rescuing assets that are used in the provision of an essential public service as collateral, it is common and necessary for financial agents to have additional guarantees. These guarantees may be surety guarantees from the Concessionaires' shareholders or the subrogation of contractual guarantees in the Concession Contracts.

If the line used for financing is FINAME, the most common line for the acquisition of combustion vehicles, the cost of the operation corresponds to the Long-Term Rate, TLP (currently in IPCA + 5.0% per year), plus a sector spread of 1.3% added to the transfer cost and risk of the financial agent. The default is a funding rate corresponding to the IPCA plus about 12.5% per year. For this type of supply to be implemented, it is necessary to accredit the equipment supplier with FINAME, according to requirements set by BNDES

An alternative source of vehicle financing, often less costly, is financing via banks of automakers in the form of direct credit to consumers. To this end, automakers have their fundraising sources and naturally associate financing with acquiring vehicles. The financing conditions generally follow the market conditions, and the vehicle is the main guarantee of the operation. Similar to the financing operations carried out with the BNDES transfer agent, the credit analysis include the contractual aspects associated with providing services and financed companies' balance sheet.

Depending on the source, direct credit to the consumer may be less costly than operations that originated in BNDES, mainly if the source used by automakers is international funding.

The progressive migration of this market to operations characterized as "Project Finance" is also worth mentioning. In this modality, the financing credit is based on the cash generation of the project, with limited guarantees from the Operating Company. To organize a Project Finance operation, it is necessary:

- That the borrower is an SPE

- Linking system receivables to a specific account, which will pay financial agents in the order of preference contractually established

- SPE's shares are linked as an additional guarantee

Such operations are highly complex, so there are currently no Project Finance operations in mobility projects on buses, although these are common in rail projects. However, it is observed that the market is migrating to this model to reduce the balance sheet dependence of operating companies as a subsidiary guarantee for financial agents.

As a positive aspect, when these financing solutions are adopted, there will be positive implications on topics such as governance, transparency, and financial management of the system.

4.2 SOURCES OF PUBLIC FUNDING

It is important to consider the existence of several municipal funding channels based on programs and projects. In particular, projects involving issues such as environmental sustainability, technological innovation, and social impact tend to be well evaluated in various funding channels. On the other hand, administrative and institutional aspects may represent a time challenge, given the need to approve indebtedness with the city council. In the case of international financing operations, it will still be necessary to approve the operation with the External Financing Commission, COFIEX, a body composed of different spheres of federal management and whose Executive Secretariat is the Secretariat of International Economic Affairs - SAIN, from the Ministry of the Economy. In addition to the approval of COFIEX, the seal of the Brazilian Senate's international committee of international affairs is necessary.

In addition to institutional aspects, limits to indebtedness can be an additional challenge for different municipalities, although this is not yet the case in Belo Horizonte.

As for transactions directly contracted with commercial banks, it is observed as the main challenge to accept credit risk. In case of default by the Municipality, the Bank must resort to the queue of creditors, being subject to receiving a judiciary bond representing a fraction of the amount financed. For this reason, credit analysis usually prevents conventional financing operations.

As main sources of national financing, we find economic, social, and technological development agencies, such as BNDES, FINEP, and Caixa Econômica Federal, CEF. These agencies transfer constitutional credit lines, which often favor conditions compared to commercial banks' operations. Nevertheless, these agencies prioritize projects with high social, economic, and technological impact, as is undoubtedly the case with the transition to electromobility. In addition to conventional operations, we also highlight the possibility of using ProTransporte, a line developed and managed by the Ministry of Regional Development, with the Caixa Econômica Federal as the main transfer agent.

At the international level, multilateral development agencies have a significant presence to finance states and Municipalities. As cited, these agencies work with dedicated funding for a program or project with a high social, economic, and technological impact. As a counterpart, the favored financing conditions need approval in the committee of international affairs of the Senate and COFIEX.

In addition to direct credit operations to the municipality, it is observed the possibility that the borrower is a public operational company or a public investment company. Independent public companies may be indebted outside the public sector limit but need to prove that the cash generation of their operation is sufficient to pay off the contracted indebtedness.

On the other hand, investment companies are a specific solution for managing the city's assets, such as PBH Ativos. Moreover, investment companies have regulatory autonomy to operationalize financial decisions within specific public policies of the municipality, given their long-term sustainability.

As stated below, PBH Ativos was understood as the key piece for the feasibility of the financing plan and the consequent financial viability of the Electromobility Transition Pilot Project in Belo Horizonte.

5.

RECOMMENDATIONS FOR IMPLEMENTATION AND MONITORING

This chapter guides the objectives of the public administration for the construction of short, medium, and long-term goals for the electromobility of public transport in the municipality – mainly considering the inputs identified and shared by the team during discussions and training. It addresses the importance of building a shared vision for the implementation of electromobility and the definition of clear objectives that should be aligned. Here are also addressed the guidelines for defining measurable goals that allow evaluating the progress of the transition to Electromobility and the definition of deadlines for the execution of associated activities.

In addition, it recommends instruments for the definition of indicators and for monitoring the desired results. Besides, it highlights how electrification can contribute to the qualification of public transport in the country and the data needed for monitoring and evaluating the efficiency of electric buses in the face of these expectations.

5.1 VISION, OBJECTIVE, GOALS, AND DEADLINES

Although the pilot project is an initial step toward the transition of the bus fleet from the public transport system to Electromobility, this stage requires a strategic definition of how the implementation of the policy takes place in the municipality of Belo Horizonte, with the establishment of vision, objectives, goals, and deadlines.

The Vision deals with what one wants to achieve in the future, defining the project's ambition. The vision must incorporate the framework one wishes to achieve, and one should avoid extensive definitions or visions that are very difficult to reach, considering the current level. It is important that the vision is also of consensus of all the stakeholders involved and is aligned with the multiple interests and the other strategies adopted by the municipality. For the Belo Horizonte project, based on the discussions in the context of the project elaboration, the vision was identified as:

VISION:

"In 2040, the municipality of Belo Horizonte shall have 50% of its public transport system fleet operating with battery electric buses on."

For the vision to become a reality, it is necessary to establish clear and concise objectives to develop the changes that must occur and must be aligned with the vision. The objectives must reflect especially the benefits that the transition to Electromobility will bring to the municipality of Belo Horizonte. Therefore, as objectives, the following can be considered by the city:

OBJECTIVES:

a) **Reduction of emissions from the public transport system;**

b) **User attraction to the system;**

c) **Reduced system operating costs.**

After defining objectives, measurable goals should be established to monitor the defined objectives. The goals seek to guide the actions to perform in the short, medium, and long term. The goals that can be adopted for the Belo Horizonte project, according to the discussions held and the PREEGE (Greenhouse Gas Reduction Plan of Belo Horizonte), are presented below:

GOALS:

a) **Reduction in 2.01% of total emissions (tCO2e) compared to total emissions from the Transport sector in 2040. Goal aligned with PREGEE;**

b) **Achieve 32% of the modal ratio in 2030 (aligned with PlanMob) and expand it by 2040;**

c) **Reduction of the operational costs of the municipal public transport system by 25% in 2040.**

The actions and deadlines for meeting the vision, objectives, and established goals are presented in the following table.

Table 26 – Actions and deadlines to achieve the vision, objectives, and goals established

Actions	2022	2024	2026	2028	2030	2032	2034	2036	2038	2040
Definition of the scope of the pilot project	■									
Charging infrastructure planning	■									
Business model planning and definition	■									
Definition of the financial equalization of the pilot project	■	■								
Implementation of the pilot project (25 vehicles)	■	■								
Training and capacitation of technical, management, and mechanical staff		■								
Evaluation of the benefits, challenges, and learnings of the pilot project		■	■							
Study to define routes that can use electric buses, due to the road condition of Belo Horizonte and technology		■	■							
Business model review for transition escalation			■							
Planning for fleet transition escalation in the medium term (20% of the fleet)			■							
Transition in 5% of the fleet			■	■						
Transition in 10% of the fleet				■	■					
Transition in 15% of the fleet					■	■				
Transition in 20% of the fleet						■				
Evaluation of the partial achievement of the goals established through the commitments signed by the City (PREGEE, PlanMob, and Race to Zero)					■	■				
Review of the business model for fleet transition escalation in the long term (50% of the fleet)						■				
Planning for the escalation of the fleet transition in the long term (50% of the fleet)						■				
Transition in 30% of the fleet						■	■			
Transition in 40% of the fleet							■	■		
Transition in 50% of the fleet								■	■	■
Evaluation of the total achievement of the goals established through the commitments signed by the Local Government (PREGEE, PlanMob, and Race to Zero)										■
Business model review for complete fleet transition									■	■
Planning for the escalation of the fleet transition in its entirety (100%)										■

Source: Own elaboration.

5.2 MONITORING

As discussed in the previous item, a pilot project to finance electric buses inserts itself in the context of the beginning of the transition from a city towards Electromobility. In this sense, it is crucial throughout the operation of the new vehicles to monitor the efficiency of the new technology concerning its social, environmental, and economic objectives.

An electric bus pilot project is the main tool for evaluating the implementation and operation of the new technology in the context of a municipality. Through a pilot project, it is possible to obtain an estimate of how electric buses will behave in the local context and whether they will be able to meet the needs and expectations of the city considering its public transport challenges.

The data collected during a pilot project are fundamental and will determine whether the observed performance reaches expectations. Thus, the pilot project must be conducted in a feedback manner so that, after the beginning of data collection and based on the evidence produced, the planning and operation of the vehicles can be revisited, as well as the chosen business model itself.

For the results obtained through the pilot project to allow the evaluation and reflection on the insertion of the new technology, all data and information must be collected and monitored for the two types of technology: the electrical technology that is being tested and the previous technology remaining in operation in the rest of the transport system, in this case, diesel buses.

The monitoring of the pilot project of electric buses should consider several groups of information to be collected and compared, based on data from the equipment vehicles and economic-financial model, and user perception surveys.

The following table presents compiled indicators that can be used to evaluate the pilot project of electric buses and their objectives within the monitoring process.

Table 27 – Indicators that can be used for the evaluation of the pilot project of electric buses

Type of Information	Objectives	Possible indicators
Characteristics of vehicles	Comparison between similar vehicles, diesel and electric.	• Model. • Weight. • Dimensions. • Passenger capacity. • Battery capacity, among others.
Capital costs	Comparison of initial investments for each technology.	• Cost of the vehicle. • Cost of charging infrastructure.
Operating conditions	Lays down the boundary conditions of the operation to allow comparison between vehicles with similar operations	• Topographic conditions. • Weather conditions of the city or test site • Extension traveled with road priority in the planned route. • Number of pick-up and drop-off points.
Operation of vehicles	Evaluation of the performance of vehicles and batteries	• Daily mileage traveled per vehicle. • Average daily route. • Average speed per trip. • Vehicle availability. • Energy consumption per trip. • Passengers transported per journey. • Passenger rate per km.
Charging	Comparison of energy consumption of each technology and associated costs	• Electricity tariff. • Energy consumed by charge. • Charging status per vehicle. • Average charging time per vehicle. • Cost of diesel. • Diesel consumption per kilometer traveled.
Maintenance of vehicles and infrastructure	Comparison of maintenance demand and possible failures reported between technologies	• Reason and duration of maintenance stops • Average mileage between failures • Failure rate per month • Qualitative perception of the challenges of maintenance and satisfaction of the professionals responsible for this function
Environmental benefits	Verification of avoided emissions with the inclusion of electrical technology	• Energy saving • Avoided greenhouse gas emissions • Avoided emission of local pollutants • Reduction of noise emissions
Perception of users and drivers	Comparison of the level of comfort and satisfaction reported by users for each of the types of vehicles	• Qualitative perception of the satisfaction of users and drivers. - Internal noise level. - Internal vibration level. - Conservation status. - Points of pick-up and drop-off. - Drivers' performance (user perspective). • General satisfaction with the experience.

Source: Own elaboration, based on the records of the Tumi E-bus Mission and ITDP (2021).

Some information is crucial in establishing conditions for indicators' comparability for these two technologies. Among them, we highlight the topographic conditions of the route in which the vehicles operate, the distribution and number of stops, and the climatic conditions.

Routes that run through steeper topographies usually present a higher energy expenditure for both technologies. In contrast, routes with a higher number of stops may present a lower energy expenditure in electrical technology due to the existing mechanisms of energy regeneration[11] at times of stop, which does not happen in conventional diesel vehicles. In addition, the need to record climatic conditions is highlighted since the local temperature can directly affect energy consumption.

It is recommended to establish an information recording routine for each new electric vehicle that should also be performed in those diesel vehicles that present the operating conditions closest to the conditions to which electric vehicles will be subjected. The records should be daily, also considering the periods of permanence of vehicles in garages or terminals and the trips made outside the operation with passengers.

The evaluation and comparison of indicators should be performed more frequently at the beginning of the pilot project operation since this is when technical failures or the need for operational adjustments will be more likely. In addition, indicators should be evaluated to identify the most sensitive points of the new operation, which may be subject to immediate adjustments as they are identified.

To conduct satisfaction surveys with users and drivers, it is recommended to apply them after the stabilization of the operation of new vehicles to avoid the natural challenges of starting the operation of the new technology do not generate negative perception results contrary to the continuity of the pilot project. Conducting satisfaction surveys from the moment the initial challenges have already been overcome can bring a better perception of the opinion of users and drivers about the new technology with diesel technology.

5.3 INITIAL TRAINING

It is essential to consider that the pilot project in question deals with introducing a new technology in public transport operation in the city, which represents the new operational peculiarities compared to the technology currently used. These include new procedures for drivers and staff responsible for maintaining the new fleet.

Given this change, the teams involved in the operation of the new vehicles

11 Energy regeneration mechanisms in electric vehicles allow the conversion of the vehicle's kinetic energy into electric energy. Thus, at specific moments of the mechanical cycle, energy storage is transformed for use in the vehicle itself, reducing the use of batteries. The conversion of kinetic energy into electric energy happens when the vehicle reduces its speed, such as in obstacles, curves and at stations and stop points.

should go through a training cycle before the start of the operation. Such training is essential for disseminating knowledge concerning new vehicles currently centered among their manufacturers, already used to the new technology and procedures related to their use and maintenance.

Thus, the knowledge transfer from manufacturers/suppliers to the operations' responsible agents of the vehicles must be effective and occur soon after their acquisition, before the preparation of the operation.

For the transfer of knowledge to be effective and contribute to implementing the pilot project in the city, manufacturers and equipment suppliers must be involved in the project soon after acquiring the assets. This involvement must occur during the negotiations of the purchase for the conclusion of the contracts, so the city can receive all the necessary support for training its local staff.

The training must then be provided directly by manufacturers and suppliers to those responsible for operating new vehicles and equipment, i.e., drivers and maintenance technicians.

The table below lists the minimum training expected for a successful operation of the new technology.

Table 28 – Recommended training for new vehicle operator teams

Topics	Target public	Content	Objective
Operation of electric fleets	Operator's team responsible for the design of the operation	• Operation of electric vehicles • Procedures and charging times • Maintenance procedures and periodicity • Energy expenditure optimization practices • Practices for maximizing battery useful life and electrical components	Capacitate operators for introducing new technology to their operating schemes to ensure effective and efficient use of assets
Driving electric vehicles	Drivers of new electric vehicles	• Characteristics and devices of vehicles • Good driving practices • Safety equipment • Good security practices • Emergency protocols • Basics of mechanics	Motivate safe and professional driving practices and facilitate a disciplined operation of the acquired vehicle fleet.
Formation of trainers for the driving electric vehicles	Selected team of operators for future trainings	• Characteristics and devices of vehicles • Good driving practices • Safety equipment • Good security practices • Emergency protocols • Basics of mechanics	Capacitate operators team to provide training to future drivers

Topics	Target public	Content	Objective
Vehicle maintenance	Responsible maintenance team	• Characteristics and components of vehicles • Mechanics of electric vehicles • Electrical components and battery maintenance • Component check and replacement routines	Enter recommended maintenance practices for maximizing the useful life of vehicles and components
Formation of trainers for the driving electric vehicles	Selected team of operators for future trainings	• Characteristics and components of vehicles • Mechanics of electric vehicles • Electrical components and battery maintenance • Component check and replacement routines	Capacitate operator team to provide training to future maintenance technicians
Charging of vehicles and chargers	Team responsible for charging and maintenance of equipment	• Characteristics and components of vehicles and equipment • Safety procedures when charging • Electrical components and equipment maintenance	Insert the best practices for charging vehicles and maintaining equipment, as well as ensuring the necessary safety procedures
Formation of trainers for the driving electric vehicles	Selected team of operators for future trainings	• Characteristics and components of vehicles and equipment • Safety procedures when recharging • Electrical components and equipment maintenance	Capacitate operators' staff to provide training to future technicians

Source: Own elaboration.

As shown in the table, the training scheme agreed with the manufacturer and suppliers must consider that there should be continuity in the transfer of knowledge during the pilot project's operation. This happens because the renewal of the staff responsible requires the repetition of training as new drivers or maintenance technicians enter the operation of electric vehicles. Thus, it is also important to train professionals within the responsible teams who can provide the same training in the future, with the necessary adjustments as the operators' knowledge about the new technology develops.

Another possibility to ensure good maintenance and operation of the new vehicles is to agree directly with the manufacturer and suppliers to supervise maintenance at the time of acquisition of the assets. This supervision can happen only in the initial periods of the operation of the pilot project, as it can also extend for a long term, ensuring a better transition of knowledge about the assets and contributing to the rapid solution and any problems or failures that may occur.

6.

FINANCING PILOT PROJECT

This last chapter discusses the financing strategy for the solution chosen by the stakeholders consulted. The following items include the implementation steps from the consolidation of public definitions to the request for financing and the issues related to the financial balance of the proposal.

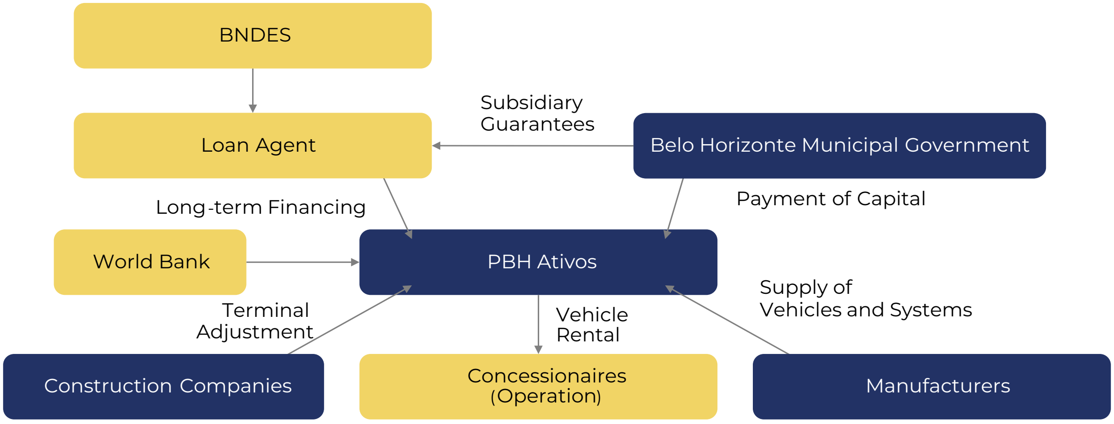
6.1 FINANCING STRATEGY

The Financing Pilot Project is a financial structure proposition demonstrating the sustainability of contracting resources to make long-term investments in the public transport system. Among the various alternatives evaluated together with agents from the Municipality of Belo Horizonte, the Ministry of Regional Development, the World Bank, and other agents involved in the design of the best-proposed solution, it was understood that the main guidelines would be:

- Business Model: acquisition of fleet by the Public Sector and corresponding rental to the private sector.
- Agent receiving the funds: PBH Ativos
- Funding agents: BNDES or World Bank.

The following synthesized solution was constructed on these premises, where the main agents and contractual relationships bidding them are presented.

Figure 27 – Agents and contractual relationships



Source: Own elaboration.

In this model, the Government, through PBH Ativos, finances and acquires future specialized companies' fleet, equipment, and systems, according to the dimensioning completed by the Basic Engineering Projects. These acquired assets go to the private sector's operation, responsible for supplying energy, guarding, and maintaining vehicles during charging.

For this model, PBH Ativos can count on two sources of financing, the National Bank for Economic and Social Development, BNDES, or the World Bank, via the International Bank for Reconstruction and Development. Together with BNDES, the available financing lines will be:

- **BNDES: Urban Mobility Climate Fund**
    - Financing up to 50% CAPEX of the project or program for which the applicant requires resources, limited to R$ 80 million per beneficiary per year.
    - Interest Rate: fixed 3% per year as funding cost, added to a BNDES Remuneration rate of 1.3% per year, added to a risk spread and financial agent transfer limited to 3% per year.
    - Maximum term of 20 years of financing, with a maximum of 3 years of grace.
- **BNDES: Climate Fund Efficient Machinery and Equipment**
    - Financing up to 100% CAPEX of the project or program for which the applicant requires resources, limited to R$ 80 million per beneficiary per year.
    - Interest Rate: fixed 3% per year as funding cost, added to a BNDES Remuneration rate of 0.9% per year, added to a risk spread, and financial agent transfer limited to 3% per year.
    - Maximum term of 20 years of financing, with a maximum of 3 years of a grace period.

- **BNDES: FINAME (only for complementation, if necessary, of equipment not categorized into the other categories)**
    - 50% of CAPEX value
    - Interest Rate: TLP (IPCA + 5.0% per year) as funding cost, added to a BNDES Remuneration rate of 1.45% per year, added to a risk spread and transfer of financial agent to be defined.
    - Maximum term of 15 years of financing, with a maximum of 1 year of grace.

Transfer agents are necessary regardless of the financing line triggered since it is a small operation. In this case, it is recommended to use the Development Bank of Minas Gerais, BDMG, or a Commercial Bank of relationship closer to PBH Ativos, such as Banco do Brasil or Caixa Econômica Federal. The following form summarizes the registration for framing the operation.

Table 29 – Registry overview for the operating framework

Borrower Agent	PBH Ativos
Transfer Agent	BDMG Banco do Brasil Caixa Econômica Federal
Investment Value	R$ 49.650.000,00
Loan Value	R$ 49.650.000,00
Objects: Vehicles, Systems, and Civil Constructions	20 Padron vehicles, high floor, with vehicle body shell up to 13.2 m and battery of 324 kWh; 5 articulated vehicles, BRT standard high floor, with body shell of up to 23m and battery of 516 kWh 20 “slow” chargers, AC, with 2 plugs of 40kW each; 3 “fast” chargers, DC, with 2 plugs of 100kW each; Installation of chargers and adequacy of electrical installations in the Terminals Venda Nova, Vilarinho and Pampulha
Guarantees	Linking receivables from vehicle rentals Assets unlinked from PBH Ativos Additional guarantees provided by the Municipality of Belo Horizonte, such as the connection of FPM resources or assignment of credit rights from economic activities performed in the Municipality.
Disbursement Schedule	Single disbursement upon presentation of invoice and local survey
Convenants	Non-allocation of assets given under guarantee

Source: Own elaboration.

The Flexible Loan or Rapid Disbursement Loan lines should be used if the financing option is made with the World Bank. The Rapid Disbursement Loan lines have more than 60% of their releases made in less than 2 years, which would certainly be the case for a Pilot Project. In this case, the loan limit would follow the needs of the Municipality and its CAPAG index. Belo Horizonte currently has CAPAG Note "B," with surplus space for an opening credit of R$ 50 million.

The lines are characterized by high flexibility to customize forms of amortization, grace periods, and even maximum payment terms, limited to 35 years, with a maximum duration of 20 years. For these lines, the estimated base rates are the Secured Overnight Financing Rate, SOFR, added to a spread of 1.07% per year. The base fees add up to the front fee corresponding to 0.25% of the amount financed and a commitment fee of 0.25% per year, paid every six months, on undisbursed balances. There is a certain possibility of converting all conditions to pre-fixed rates in Reais. In this case, the pre-framing form of the project is:

Table 30 – Project pre-framing sheet

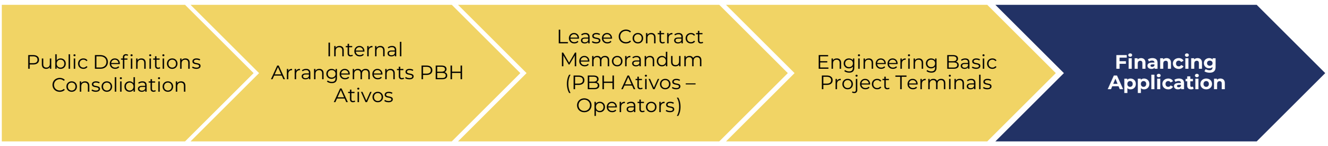
Borrower Agent	Belo Horizonte City Hall / PBH Ativos
Transfer Agent	Does not apply
Investment Value	R$ 49.650.000,00
Loan Value	R$ 49.650.000,00
Objects: Vehicles, Systems, and Civil Constructions	20 Padron vehicles, high floor, with vehicle body shell up to 13.2 m and battery of 324 kWh; 5 articulated vehicles, BRT standard high floor, with body shell of up to 23m and battery of 516 kWh 20 "slow" chargers, AC, with 2 plugs of 40kW each; 3 "fast" chargers, DC, with 2 plugs of 100kW each; Installation of chargers and adequacy of electrical installations in the Terminals Venda Nova, Vilarinho and Pampulha
Guarantees	Linking receivables from vehicle rentals Assets unlinked from PBH Ativos Additional guarantees provided by the Municipality of Belo Horizonte Government Endorsement (COFIEX approval / Senate Foreign Relations)
Disbursement Schedule	Single disbursement upon presentation of invoice and local survey
Convenants	To be negotiated

Source: Own elaboration.

6.2 IMPLEMENTATION STEPS

For the implementation of the project under the proposed conditions, the main steps are summarized in the following figure.

Figure 28 – Steps for the implementation of the pilot project



Source: Own elaboration.

Step 1: Consolidation of Public Definitions

At this stage, the Government transfers and reviews the topics developed throughout the Report, presenting adjustments and updates regarding the set of lines, vehicle number, and mileage of vehicles to be replaced by electric vehicles. The vehicles' operators are identified in this sense, and the charging points are defined.

Finally, assets' conditions over the rental period will be defined.

Step 2: Internal Measures PBH Ativos

For PBH Ativos to start the designed project, adjustments in internal regulations, untying of assets or other sources of guarantees, and evaluation of its physical, human, and technical resources may be necessary for executing the proposed operation.

Step 3: Rental Contract Memorandum PBH Ativos - Operators

Once the municipality's stages have been completed, the next step involves negotiating rental values, consolidating the increased and avoided costs, with the acquisition of vehicles and variable costs, in search of a contract that results in a neutral impact on the financial balance of the system.

Step 4: Basic Project of Terminal Engineering

In parallel to the negotiations and accurate definition of the charging points, the dimensioning of charges, comparison to current capacity, and calculation of needs for new investments in transmission and distribution systems should be carried out. After this dimensioning, the adequacy project of civil constructions with the respective budgeting is elaborated.

Step 5: Funding Request

Once the previous steps are complete, the Granting Authority can enter the Proposal Letter Protocol with the desired funding agent. To do so, you must forward the loan taker's documents, engineering, environment, and other specific project conditions, as requested by each funding agent.

6.3 FINANCIAL BALANCE

Based on the studies conducted in Chapter 3, it is simple to calculate the financial equation of the Electromobility Transition Pilot Project. As previously developed, the company PBH Ativos is responsible for financing, acquiring, and renting electric vehicles and systems for Concessionaires. Thus, on the cash receipt side, the company has (i) a receipt of the rental values signed with the Concessionaires and (ii) the disbursement of the financing made by one of the financial agents developed in Chapter 4, BNDES or World Bank. Therefore, the company's cash outflows correspond to the investments made.

On the other side, the Concessionaires of the municipality of Belo Horizonte rent these vehicles - with the rental and variable costs associated with the operation of electric vehicles. Besides, they avoid disbursements with variable costs associated with the combustion vehicles' operation and the depreciation and remuneration of the capital invested in the vehicles that have been rented.

The objective of the project is to start from a neutral balance for the cost of the system, that is, from a position in which, in principle, there is no expected gain or loss for the operating company, which replaces the current costs of purchase, operation and maintenance of combustion vehicles by new costs of rental, operation, and maintenance of electric vehicles in the same way. In this context, the equation of this is presented below[12]:

Table 31 – Included and excluded costs

Included Costs		Excluded Costs	
Electric vehicle rental	7.072.930,57	Capital Depreciation: Combustion Vehicles	1.526.208
		Capital Remuneration: Combustion Vehicles	1.101.591
Variable Costs of Electric Vehicles	1.614.494,59	Variable Costs of Combustion Vehicles	6.059.626,31
Energy	1.032.272,26	Fuel	4.729.644,10
Lubricants / arla	35.472,33	Lubricants / arla	236.482,21
Parts and Accessories	546.750,00	Parts and Accessories	1.093.500,00
TOTAL	8.687.425	TOTAL	8.687.425

Source: Own elaboration.

12 One point to be highlighted is that the substitution of costs used as a reference reduces the need for investments of current operators in the system, representing a relief in the pressure on the cash of companies, which is pressured by the losses resulting from the drop in demand throughout the period of COVID 19.

Based on this methodology, PBH Ativos may charge a lease of R$ 7,072,930.57 per year to generate a neutral impact on the economic-financial balance of the system.

In a first simulation, if PBH Ativos goes to BNDES to finance the acquisition of vehicles, the following operating conditions are considered:

- Financing period equivalent to the asset's useful life horizon, 15 years;
- 100% of the financed asset, corresponding to an investment value in physical assets of R$ 49,645,337;
- The investment value was added to a "hypothetical" contractual insurance on the battery's useful life for 7 years from the delivery of the vehicle, insurance representing a contractual guarantee of functionality to be included in the purchase value of the vehicles. The increase in value corresponded to an additional 7.5% in batteries' values, representing a value of R$ 1,601,568.75 to the amount financed[13].
- Total amount financed of R$ 51,246,906.
- All in financing costs of 4.0% per year;
- Increase of administrative costs with the hiring of an independent verifier, responsible for daily monitorization of the conditions of operation and maintenance of vehicles leased by PBH Ativos to operating companies. The management team is estimated to be two employees whose assignments should require about 90 to 120 minutes of work per day, with an additional 8 hours per month to prepare technical reports. The estimated cost for the independent verifier is R$ 32,000.00 / month.

The cash flow of PBH Ativos is presented on the next page.

13 Values indicated as a hypothesis by insurance companies in informal consultation, with no formalization of a proposal on the subject due to the absence of a database. The contractual functionality insurance should be carried out in the "self-insurance" model by the battery supplier companies.

Table 32 – PBH Ativos Cash Flow

	Year 0	Year 1	Year 2	Year 3
Revenue	0.00	7,072,930.57	7,072,930.57	7,072,930.57
Taxes	0.00	258,161.97	258,161.97	258,161.97
Variable Costs	0.00	0.00	0.00	0.00
Investments	51,246,905.75	0.00	0.00	0.00
Debt Raising	51,246,905.75	0.00	0.00	0.00
Financing Costs	0.00	4,609,203.09	4,609,203.09	4,609,203.09
Interest	0.00	2,049,876.23	1,947,503.16	1,841,035.16
Amortization	0.00	2,559,326.86	2,661,699.94	2,768,167.94
CASH BALANCE	0.00	2,205,565.51	2,205,565.51	2,205,565.51
	Year 4	**Year 5**	**Year 6**	**Year 7**
Revenue	7,072,930.57	7,072,930.57	7,072,930.57	7,072,930.57
Taxes	258,161.97	258,161.97	258,161.97	258,161.97
Variable Costs	0.00	0.00	0.00	0.00
Investments	0.00	0.00	0.00	0.00
Debt Raising	0.00	0.00	0.00	0.00
Financing Costs	4,609,203.09	4,609,203.09	4,609,203.09	4,609,203.09
Interest	1,730,308.44	1,615,152.65	1,495,390.64	1,370,838.14
Amortization	2,878,894.65	2,994,050.44	3,113,812.46	3,238,364.96
CASH BALANCE	2,205,565.51	2,205,565.51	2,205,565.51	2,205,565.51
	Year 8	**Year 9**	**Year 10**	**Year 11**
Revenue	7,072,930.57	7,072,930.57	7,072,930.57	7,072,930.57
Taxes	258,161.97	258,161.97	258,161.97	258,161.97
Variable Costs	0.00	0.00	0.00	0.00
Investments	0.00	0.00	0.00	0.00
Debt Raising	0.00	0.00	0.00	0.00
Financing Costs	4,609,203.09	4,609,203.09	4,609,203.09	4,609,203.09
Interest	1,241,303.54	1,106,587.56	966,482.94	820,774.13
Amortization	3,367,899.55	3,502,615.54	3,642,720.16	3,788,428.96
CASH BALANCE	2,205,565.51	2,205,565.51	2,205,565.51	2,205,565.51

	Year 12	Year 13	Year 14	Year 15
Revenue	7,072,930.57	7,072,930.57	7,072,930.57	7,072,930.57
Taxes	258,161.97	258,161.97	258,161.97	258,161.97
Variable Costs	0.00	0.00	0.00	0.00
Investments	0.00	0.00	0.00	0.00
Debt Raising	0.00	0.00	0.00	0.00
Financing Costs	4,609,203.09	4,609,203.09	4,609,203.09	4,609,203.09
Interest	669,236.97	511,638.33	347,735.74	177,277.04
Amortization	3,939,966.12	4,097,564.77	4,261,467.36	4,431,926.05
CASH BALANCE	2,205,565.51	2,205,565.51	2,205,565.51	2,205,565.51

Source: Own elaboration.

If the option for financing with the World Bank +is made, the equation is:

Table 33 – PBH Ativos Cash Flow

	Year 4	Year 5	Year 6	Year 7
Revenue	0.00	7,072,930.57	7,072,930.57	7,072,930.57
Taxes	0.00	258,161.97	258,161.97	258,161.97
Variable Costs	0.00	0.00	0.00	0.00
Investments	51,246,905.75	0.00	0.00	0.00
Debt Raising	51,246,905.75	0.00	0.00	0.00
Financing Costs	0.00	4,126,861.61	4,126,861.61	4,126,861.61
Interest	0.00	1,260,673.88	1,190,165.66	1,117,922.94
Amortization	0.00	2,866,187.73	2,936,695.95	3,008,938.67
Up Front Fee	128,117.26	0.00	0.00	0.00
CASH BALANCE	-128,117.26	2,303,906.99	2,303,906.99	2,303,906.99
	Year 4	Year 5	Year 6	Year 7
Revenue	7,072,930.57	7,072,930.57	7,072,930.57	7,072,930.57
Taxes	258,161.97	258,161.97	258,161.97	258,161.97
Variable Costs	0.00	0.00	0.00	0.00
Investments	0.00	0.00	0.00	0.00
Debt Raising	0.00	0.00	0.00	0.00
Financing Costs	4,126,861.61	4,126,861.61	4,126,861.61	4,126,861.61
Interest	1,043,903.05	968,062.27	890,355.81	810,737.76
Amortization	3,082,958.56	3,158,799.34	3,236,505.81	3,316,123.85
Up Front Fee	0.00	0.00	0.00	0.00
CASH BALANCE	2,303,906.99	2,303,906.99	2,303,906.99	2,303,906.99

	Year 8	Year 9	Year 10	Year 11
Revenue	7,072,930.57	7,072,930.57	7,072,930.57	7,072,930.57
Taxes	258,161.97	258,161.97	258,161.97	258,161.97
Variable Costs	0.00	0.00	0.00	0.00
Investments	0.00	0.00	0.00	0.00
Debt Raising	0.00	0.00	0.00	0.00
Financing Costs	4,126,861.61	4,126,861.61	4,126,861.61	4,126,861.61
Interest	729,161.12	645,577.69	559,938.10	472,191.78
Amortization	3,397,700.50	3,481,283.93	3,566,923.51	3,654,669.83
Up Front Fee	0.00	0.00	0.00	0.00
CASH BALANCE	2,303,906.99	2,303,906.99	2,303,906.99	2,303,906.99
	Year 12	**Year 13**	**Year 14**	**Year 15**
Revenue	7,072,930.57	7,072,930.57	7,072,930.57	7,072,930.57
Taxes	258,161.97	258,161.97	258,161.97	258,161.97
Variable Costs	0.00	0.00	0.00	0.00
Investments	0.00	0.00	0.00	0.00
Debt Raising	0.00	0.00	0.00	0.00
Financing Costs	4,126,861.61	4,126,861.61	4,126,861.61	4,126,861.61
Interest	382,286.90	290,170.37	195,787.76	99,083.35
Amortization	3,744,574.71	3,836,691.25	3,931,073.85	4,027,778.27
Up Front Fee	0.00	0.00	0.00	0.00
CASH BALANCE	2,303,906.99	2,303,906.99	2,303,906.99	2,303,906.99

Source: Own elaboration

It can be concluded that the operation of financing, acquisition, and rental of assets by PBH Ativos should result in a significant cash flow. This surplus, guaranteeing a debt service coverage index of more than 1.50, results from a financing cost lower than the cost of capital remuneration avoided by Concessionaires. This differential of fees, financing jointly with the remuneration of avoided capital, added to the differential of variable operating costs, makes the transition to Electromobility take place with clear financial, social, and environmental advantages for the municipality.

7.

REFERENCES

[1] Prefeitura de Belo Horizonte. Contrato de concessão RTS N° 1. Contrato de concessão de serviço público de transporte coletivo urbano de passageiros no Município de Belo Horizonte, na área de operação Venda Nova/Pampulha, que fazem entre si o Município e Consórcio DEZ.

[2] Prefeitura de Belo Horizonte. **Contrato de concessão RTS N° 2**. Contrato de concessão de serviço público de transporte coletivo urbano de passageiros no Município de Belo Horizonte, na área de operação Norte/Nordeste/Leste, que fazem entre si o Município e Consórcio BH LESTE.

[3] Prefeitura de Belo Horizonte. **Contrato de concessão RTS N° 3**. Contrato de concessão de serviço público de transporte coletivo urbano de passageiros no Município de Belo Horizonte, na área de operação Barreiro/Oeste, que fazem entre si o Município e Consórcio DEZ.

[4] Prefeitura de Belo Horizonte. **Contrato de concessão RTS N° 4**. Contrato de concessão de serviço público de transporte coletivo urbano de passageiros no Município de Belo Horizonte, na área de operação Noroeste e área de operação em comum, que fazem entre si o Município e Consórcio DOM PEDRO II.

[5] Justen Filho, Marçal. **Teoria geral das concessões de serviços públicos**. 1 ed., 2. Reimpressão. São Paulo: Dialética, 2003, p. 61.

[6] Mahmoud, M., R. Garnett, M. Ferguson, and P. Kanaroglou. Electric Buses: A Review of Alternative Powertrains. **Renewable and Sustainable Energy Reviews**, v. 62, p. 673–84, set. 2016. DOI https://doi.org/10.1016/j. rser.2016.05.019

[7] World Resources Institute. **How to enable electric bus adoption in cities worldwide**: a guiding report for city transit agencies and bus operating entities. Ross Center for Sustainable Cities program. Washington, D. C., 2019. Disponível em: https://wrirosscities.org/sites/default/files/how-to-enable-electric-bus-adoption-cities-worldwide.pdf

[8] Ministério do Desenvolvimento Regional, World Resources Institute e Banco Interamericano de Desenvolvimento. **Guia de Eletromobilidade**: Orientações para estruturação de projetos no transporte coletivo. Brasília, 2022. Disponível em: https://www.gov.br/mdr/pt-br/assuntos/mobilidade-e-servicos-urbanos/Guia_Eletromobilidade.pdf

[9] BNEF (Bloomberg New Energy Finance). **Electric Buses in Cities — Driving Towards Cleaner Air and Lower CO2**. 2018. Disponível em: https://about.bnef.com/blog/electric-buses-cities-driving-towards-cleaner-air-lower-co2/

[10] Stringer, D., and J. Ma. **Where 3 Million Electric Vehicle Batteries Will Go When They Retire**. Bloomberg Businessweek, 2018. Disponível em: https://www.bloomberg.com/news/features/2018-06-27/where-3-million-electric-vehicle-batteries-will-go-when-they-retire

[11] Walker, S. B.; Young, S. B.; Fowler, M. **Repurposing electric vehicle batteries for energy storage to support the smart grid**. Institute of Electrical and Electronics Engineers, 2015. Disponível em: http://canrev.ieee.ca/en/cr73/Repurposing_Electric_Vehicle_Batteries_for_Energy_Storage_to_Support_the_Smart_Grid.pdf

[12] ZEBRA – Zero Emission Bus Rapid-deployment Accelerator. **Análise da implantação de ônibus zero emissão na frota de um operador de ônibus na cidade de São Paulo**, 2022. Disponível em: https://theicct.org/wp-content/uploads/2022/03/hdv-brasil-analise-da-implantac%CC%A7a%CC%83o-de-o%CC%82nibus-zero-emissa%CC%83o-sa%CC%83o-paulo-mar22.pdf

[13] Grütter, J., Grütter Consulting AG. **Rendimiento Real de Buses Híbridos y Eléctricos**. Rendimiento ambiental y económico de buses híbridos y eléctricos basados en grandes flotas operacionales. Plataforma REPIC. Suiça, fevereiro de 2015. Disponível em: https://www.repic.ch/wp-content/uploads/2020/07/Spanisch.pdf

[14] Orbea, Jone. **Modelos de negocio para la adopción de flotas eléctricas**: Experiencias Internacionales. World Resources Institute, outubro de 2017. Disponível em: https://ledslac.org/wp-content/uploads/2017/08/09-Capacitacion-2_Tendencias-mundiales-en-modelos-de-negocio-para-buses.pdf

[15] CAF. Corporación Andina de Fomento. **La electromovilidad en el transporte público en América Latina**. 2019. Disponível em: https://scioteca.caf.com/handle/123456789/1466

[16] The World Bank. **Green your bus ride**. Clean Buses in Latin America, Summary report. Janeiro de 2019. Disponível em: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/410331548180859451/green-your-bus-ride-clean-buses-in-latin-america-summary-report

[17] ITDPBRASIL. **O papel da regulamentação na transição para eletromobilidad**e. Blogpost, 29 de junho. 2020. Disponível em: https://itdpbrasil.org/o-papel-da-regulamentacao-na-transicao-para-eletromobilidade

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