EletroMobilidade
Transição para a Eletromobilidade nas Cidades Brasileiras

TECHNICAL REFERENCE MANUAL

FOR ELECTROMOBILITY IN BRAZILIAN CITIES

VOLUME II

TRANSITION TO **ELECTROMOBILITY**
IN BRAZILIAN CITIES PROJECT

EletroMobilidade
Transição para a Eletromobilidade
nas Cidades Brasileiras

TECHNICAL REFERENCE MANUAL

FOR ELECTROMOBILITY IN BRAZILIAN CITIES

VOLUME II

TRANSITION TO ELECTROMOBILITY IN BRAZILIAN CITIES PROJECT

FEDERATIVE REPUBLIC OF BRAZIL

President

Jair Messias Bolsonaro

MINISTRY OF REGIONAL DEVELOPMENT

Minister of Regional Development

Daniel Ferreira

Executive Secretary

Helder Melillo

NATIONAL SECRETARIAT OF MOBILITY AND REGIONAL AND URBAN DEVELOPMENT

National Secretary of Mobility and Regional and Urban Development

Sandra Maria Santos Holanda

WORLD BANK

Senior Transport Economist

Ana Waksberg Guerrini

Transport Specialist Consultant

Aline Lang

Social Development Specialist

Gabriela Lima de Paula

Environmental Specialist Consultant

Márcia Noura Paes

EletroMobilidade
Transição para a Eletromobilidade
nas Cidades Brasileiras

TECHNICAL REFERENCE MANUAL

FOR ELECTROMOBILITY IN BRAZILIAN CITIES

VOLUME II

TRANSITION TO **ELECTROMOBILITY**
IN BRAZILIAN CITIES PROJECT

General coordination
Ana Waksberg Guerrini – World Bank
Fernando Araldi – MDR
Alejandro Muñoz Muñoz – IABS

Content development
Francisco Burgos – IDOM
Edgar Cortés – IDOM
Laura Gutiérrez – IDOM
Estefania Mejía – IDOM
Daniel Rosas Satizábal – IDOM
Maria Alejandra Rodríguez – IDOM
Andrés Gartner – GoAscendal
Nicolás Gómez – GoAscendal
Leonardo Bustos – GoAscendal
Carlos Botello – GoAscendal
Vladimir Maciel – Urbana
Manoel Gomes – Urbana
Lucía Farrando – Tanoira & Cassagne
Jaime Uranga – Tanoira & Cassagne
Ignacio Zambón – Tanoira & Cassagne

World Bank technical contributions
Ana Waksberg Guerrini – Senior Transport Economist
Aline Lang – Transport Specialist Consultant
Gabriela Lima de Paula – Social Development Specialist
Márcia Noura Paes – Environmental Specialist Consultant

Technical review
Fernando Araldi – MDR
Adriana Souza – IABS
Jady Medeiros – IABS
Anna Carollina Palmeira – IABS
Ariane Fucci Wady – IABS

Spelling and grammar proofreading
InPauta Comunicação

Editing coordination staff
Mariana Resende – InPauta Comunicação

Graphic design and layout
Esa Gomes Magalhães – InPauta Comunicação

Cover photo
Laís Moraes – InPauta Comunicação

Technical Reference Manual for Electromobility in brazilian cities (Volume II). Ministry of Regional Development - MDR and World Bank (authors). Clean Technology Fund - CTF (funder) - Brasília, 2022.

ISBN: 978-65-87999-57-9

156p.

1. Electromobility 2. Brazilian Cities I. Ministry of Regional Development - MDR II. World Bank III. Clean Technology Fund - CTF

UDC: 629.3. 908

INDEX

KEY TERMS

BANKABILITY A project's ability to have appropriate investment and liquidity conditions for the necessary capital and debt payments.

BATTERY A device that accumulates energy and produces electric current through electrochemical reactions between its elements (oxide reduction).

SMART CHARGING Smart charging allows charging point owners and grid operators to remotely manage their charging points, optimizing energy consumption and costs, for example, by configuring charging to start at night when rates are lowest.

CAPITAL EXPENDITURE (CAPEX) Initial capital investment that includes possible vehicle costs, infrastructure acquisition costs (including all purchase taxes), and financing costs over the entire debt period in the case of a loan.

CASH SWEEP Obligation to use available cash flows for debt service.

TAIL Ongoing income from the project after the debt is fully paid. In project financing, there is the constructing period and the operating period. Assuming a project needs 5 years of construction and operates for 25 years, the construction debt is amortized in 15 years, for example. The final period is the difference between the end of the planned debt amortization and the end of the operating period or the residual income.

CREDIT RATING This rating indicates the ability of the borrower to meet its financial obligations. Ratings can go from investment-grade (from AAA, the highest, to BBB-) to high-yield (from BB+ to B- or B3, the lowest).

COMPLETION / CLOSING	The final step in obtaining a loan.
CONCESSION	A concession is a process by which a public administration or company grants the right to exploit certain goods and services to another company, usually privately run.
ECO-FRIENDLY DRIVING	It is a way of driving that controls and reduces unnecessary fuel consumption, improves driver safety, and reduces risks for service users.
OFFTAKE AGREEMENT	An agreement in which one party agrees to buy a product from another party.
TAKE OR PAY CONTRACT	A contract with an obligation to purchase a product quantity at a stipulated price periodically.
LENDING AGREEMENT	Commitments in a debt agreement for ratios and activities that must be performed.
COVENANTS	These are obligations that apply to the borrowers of credit. They both impose certain conditions and restrict some activities of the object of financing.
COST OF CAPITAL	The cost of capital is the cost incurred by a company to finance its investment projects with its financial resources.
MAINTENANCE COST	Regular or preventive maintenance in the bus industry should frequently occur to ensure buses and the supporting infrastructure function correctly and determine whether parts' replacement is required. Periodic maintenance is performed less frequently and consists of a more detailed review of the operation of the machinery and equipment. For electric buses, the maintenance cost is usually included in the rental costs or the manufacturer's warranty.

COST OF FINANCING — Comes from the interest rate of the loan or the discount rate required by investors. In a securities issuance, for example, it would correspond to the placement fee for the instrument. The other factor to be considered in the cost of financing is the term of the financing. Commercial banks usually have a fixed term, while multilateral banks such as the World Bank have a flexible term.

WEIGHTED AVERAGE COST OF CAPITAL (WACC) — Cost of resources used by the company to operate. It is a financial measure that aims to encompass, in a single number, expressed in percentage terms, the cost of the different sources of financing used by a project in the future.

OPERATIONAL PERFORMANCE — A transport operator's ability to provide the service efficiently, that is, to meet performance indicators and minimize operating costs (fuel, lubricants, parts and accessories, tires, personnel, among others).

SENIOR DEBT — A type of debt in which the creditor has priority over the junior debt for obligations' payment.

JUNIOR DEBT — Type of debt in which the creditor has priority over the Equity but falls behind the senior debt.

DUE DILIGENCE — The process of checking a company's current technical and financial contractual situation.

EBITDA — Earnings Before Interest, Taxes, Depreciation, and Amortization. Accounting indicator of a company's profitability. It is calculated as income minus expenses, excluding financial expenses (taxes, interest, depreciation, and amortization of the company).

EQUITY — Capital invested in a project using own resources. A company's capital stock or equity represents the amount of money that would be returned to a company's shareholders if all the company's assets were liquidated and all the company's debts were repaid.

STATE OF CHARGE (SOC)	Indicator of the state of charge of the energy stored in a battery. This indicator is expressed as a percentage and ranges from 0 to 100. When the state of charge equals 100%, the battery is fully charged.
RELIEF EVENTS	Temporary force majeure events that affect the development of the project.
LIMITED RECOURSE FUNDING	A type of loan in which the implementer provides partial guarantees to cover certain project risks.
PROJECT FINANCE	Financing modality in which the project's cash flows are the only source of debt repayment.
OFF-BALANCE SHEET FINANCING	Financial transactions that do not affect the financial statements of a company.
TERM-SHEET	Document presenting the terms and conditions of the debt.
REGENERATIVE BRAKING	The vehicle's kinetic energy, dissipated as heat by the mechanical brake system, is captured and converted into electrical energy by the traction motor, acting as a generator, and is finally stored in the battery.
WARRANTY	Structuring mechanisms to guarantee the payment of the debt, such as contingency funds.
GREENHOUSE GASES (GHG)	Gases that absorb part of the sun's rays and redistribute them as radiation in the atmosphere. They can be emitted through the combustion of diesel fuel. Examples are carbon dioxide (CO_2), carbon monoxide (CO), nitrous oxides (NO_x), and volatile organic compounds (VOCs).
DISTRIBUTED POWER GENERATION	It consists of generating electrical energy through several small generation sources installed close to the consumption points. Distributed generation is based on cooperation between such microgeneration and generation from conventional power plants.

JOINT VENTURE Agreement between two or more companies in which they pool resources for a specific purpose.

KEY PERFORMANCE INDICATORS (KPI) Management metrics to measure the performance of the operation.

LIQUIDITY DAMAGE (LD) Liquidity damage is the stipulated level of loss due to a breach of contract.

LEASING Contract in which the lessor acquires an asset (in electromobility projects, usually the bus and/or battery) to rent to a customer (lessee). There are two modalities: financial Leasing and operational Leasing.

Leasing is a financial modality, also known as mercantile leasing in Brazil, which involves the fiduciary alienation of the asset. By regulation of the Central Bank of Brazil, it can only be carried out through a financial institution or a company authorized explicitly for this activity.

FINANCIAL LEASING This is a modality where the lessee intends to keep the goods at the end of the contract, exercising the purchase option for the value foreseen.

OPERATIONAL LEASING In this modality, the lessee does not intend to acquire the property at the end of the contract.

SPOT MARKET A market in which an asset is paid for and delivered on the same date.

REGULATED ENERGY MARKET The regulated energy market corresponds to the smallest demand for electricity in the market (predominantly residential), and its tariffs are regulated by the National Agency for Electrical Energy (ANEEL), an entity linked to the Ministry of Mines and Energy.

FREE ENERGY MARKET The Free Energy Market, created in 1995 by Law No. 9.074, is an initiative of the Brazilian government to create a legal framework for greater competition and structural expansion of the electricity sector (generation, transmission, and distribution of energy), mainly through private resources. Compared to the prices charged by energy distributors in the regulated market, the values of the Free Energy Market are highly competitive, allowing consumers significant savings in their energy costs.

NON-RECOURSE FINANCE Transactions where the debt is repaid with the cash flow from a project and not with the borrower's assets.

BATTERY ELECTRIC BUSES Also called pure electric buses, battery electric buses are vehicles that use electrical energy stored in the battery and converted into driving force by an electric motor. When the batteries run out of power, they must be refueled. Electrical power must be supplied from an external source (charger) to do this.

HYBRID BUSES Hybrid vehicles combine two different engines, usually thermal traction (internal combustion engine, which can be powered by diesel, gasoline, natural gas, or ethanol, among others) and electric traction (electric motor).

PUBLIC-PRIVATE PARTNERSHIP (PPP) A Public-Private Partnership is a contract for the concession of public services or works to the private sector. The latter (Private partner) is compensated for this provision by fees from the users themselves or by consideration from the Public Authority (Public partner).

AVERAGE MONTHLY ROUTE Average number of kilometers traveled by the bus fleet in operation during a month.

GRACE PERIOD Period granted by the financial institution in which the client does not need to make any payments on the debt.

PLAYERS Actors involved in the electromobility transition. Includes all those who are directly or indirectly affected by the transition.

NATIONAL URBAN MOBILITY POLICY (PNMU in Portuguese) The PNMU is an instrument of the urban development policy referred to in art. 21 and article 182 of the Federal Constitution, which aims to integrate the different transport modalities and improve accessibility and mobility for people and cargo.

CHARGING POWER Amount of energy needed for charging the vehicle, given in kW.

ELECTRIC POWER The amount of energy delivered per unit of time.

INSTALLED POWER Sum of the nominal powers of the electric equipment installed in the consumer unit, in conditions to go into operation, expressed in kilowatts (kW). In the case of the electric bus garage, this load depends on the number of bus chargers and their nominal powers added to the other existing equipment in the garage.

CA EXHAUST TESTING PROGRAM (PROCONVE) The body responsible for issuing regulations on motor vehicle emissions.

ROTA 2030 PROGRAM - MOBILITY AND LOGISTICS This program aims to support technological development, competitiveness, innovation, vehicle safety, environmental protection, energy efficiency, and quality of cars and trucks, buses, engine chassis, and auto parts.

DEBT SERVICE COVERAGE RATIO (DSCR) Indicates the availability of cash to pay off a purchased debt.

DISTRIBUTION-STOP RATIO Corresponds to the ratio on which the DSCR indicator is not met (defined by the financial institution). In this case, the payment to investors is stopped, and the money is used for debt repayment.

DEBT LIFE COVER RATIO (DLCR) The number of times the project's cash flows over the life of the debt can pay off the balance.

PROJECT LIFE COVERAGE RATIO (PVCR)	Ability to pay the debt after its original maturity if it could not be paid on time.
PERFORMANCE	It is the contrary of energy consumption, that is, how many kilometers it is possible to travel with one kWh of energy.
PAYBACK PERIOD	Period to recover the cost of an investment.
RISK OF NON-COMPLETION	Risk of default in project implementation.
DEBT SERVICE	Sum of the debt payments and the interest paid on the debt.
SPECIAL PURPOSE ENTITY (SPE)	A company created exclusively to develop a specific project or fulfill a specific objective.
SPREAD	The spread of a bond is the difference between the yield of that bond and the yield of a bond considered risk-free. Sometimes the spread is also calculated considering interest rates in the interbank market.
INTEREST RATE	The interest rate is the value of money, i.e., the price to be paid for using a given amount of money over a given period. Its value indicates the interest rate that must be paid in exchange for the use of a given amount of money in a financial transaction.
ALTERNATING CURRENT (AC) CHARGING TYPE	With AC chargers, the transformation from alternating current (coming from the electrical substation) is reversed into direct current within the drive system of the electric bus. This reversal in the bus's internal voltage inverter results in slower charging than with direct current (DC) chargers (charging power is 120 kW or less, with 3-10 hours for a full charge, depending on battery capacity).

DIRECT CURRENT (DC) CHARGING TYPE	In DC chargers, the transformation of alternating current (coming from the electric substation) is reversed into direct current in the charger before it reaches the drive system of the electric bus. This pre-version allows for much faster charging than AC chargers (charging power is 120kW or more, with 2-5 hours for a full charge, depending on battery capacity).
INTERNAL RATE OF RETURN (IRR)	Internal Rate of Return is the return on an investment. In other words, it is the percentage of profit or losses the investment makes for the amounts that were not taken from the project. It corresponds to the rate that sets the Net Present Value (NPV) equal to 0.
BLENDED EQUITY IRR	It is a measure of return that considers both Equity and junior debt. It is the same discount rate, including the cash flows from the investor's equity and junior debt. It is usually calculated after taxes.
TOTAL SHAREHOLDER'S INTERNAL RATE OF RETURN	Sum of IRR via Equity and junior debt.
SECURITIES	An instrument issued by companies and governments, among others, to finance themselves.
GREEN SECURITIES	These are fixed-income securities issued to finance actions aimed at combating climate change.
TOTAL COST OF OWNERSHIP (TCO)	TCO is an assessment of the costs of the entire life cycle of a project. The TCO analysis includes the asset's purchase price, operation, maintenance, and other financial costs during the project or concession period.

RESIDUAL VALUE

The value of a fixed asset at the end of its useful life, net of depreciation, and amortization charges. The residual value is the amount the company expects to realize on the sale of the fixed asset at the end of its useful life.

NET PRESENT VALUE (NPV)

Net Present Value is an investment criterion that discounts the revenues and payments of a project or investment to know how much is gained or lost with this investment.

WAIVER

It is the waiver of a requirement or obligation, usually for full or partial payment (principal, interest, etc.).

ACRONYMS AND ABBREVIATIONS

A/C	Air-Conditioning
ANTP	National Association of Public Transport *(Associação Nacional de Transporte Coletivo)*
ANEEL	National Electric Energy Agency *(Agência Nacional de Energia Elétrica)*
BA	Bahia
BMZ	German Ministry for Economic Cooperation and Development
BNDES	National Bank for Economic and Social Development *(Banco Nacional de Desenvolvimento Econômico e Social)*
CAPEX	Capital Expenditures
CC	Fuel cost (R$)
CCCP	Weighted fuel consumption coefficient (liters/km or kWh/km)
CDC	Direct Consumer Credit
CIF	Climate Investment Funds
CNAE	National Classification of Economic Activities
CO	Carbon monoxide

CO_2	Carbon dioxide
COFINS	Contribution for Social Security Financing *(Contribuição para Financiamento da Seguridade Social)*
EPE	Energy Research Company *(Empresa de Pesquisa Energética)*
EU	European Union
FGI	Investment Guarantee Fund *(Fundo Garantidor do Investimento)*
FINAME	Financing of machinery and equipment *(Financiamento de máquinas e equipamentos)*
GHG	Greenhouse Gases
GIZ	German Agency for International Cooperation
IABS	Brazilian Institute for Development and Sustainability *(Instituto Brasileiro de Desenvolvimento e Sustentabilidade)*
IADB	Inter-American Development Bank
ICCT	International Council on Clean Transportation
ICMS	Tax on Circulation of Goods and Services *(Imposto de Circulação de Mercadorias e Prestação de Serviços)*

II	Import Tax (Imposto de Importação)
IFC	International Finance Corporation
IPI	Tax on Industrial Products *(Imposto sobre Produtos Industrializados)*
ITDP	Institute for Transportation and Development Policy
KfW	German Development Bank
kWh	kilowatt-hour
LAGREEN	Latin American Green Bond Fund
LAIF	Latin American Investment Fund
LOA	Annual Budget Law *(Lei Orçamentária Annual)*
MDR	Ministry of Regional Development *(Ministério do Desenvolvimento Regional)*
MWh	Megawatt-hour
NO_x	nitrous oxides
OPEX	Operational Expenditures
PEE	Price of Electric Energy (R$/kWh)
PIS	Social Integration Program *(Programa de integração Social)*
PJ	Legal entity
PLC	Price per liter of diesel oil (R$/liter)

PNMC	National Policy on Climate Change
PNME	National Platform for Electric Mobility *(Plataforma Nacional de Mobilidade Elétrica)*
PNMU	National Policy for Urban Mobility *(Política Nacional de Mobilidade Urbana)*
PPA	Multi-Year Plan (Plano PluriAnual)
PQA	Annual Mileage Production (km) *(Produção Quilométrica Anual)*
RCL	Net Current Revenue *(Receita Corrente Liquida)*
R&D	Research and Development
SEMOB	Municipal Secretary of Mobility of Salvador
TCO	Total Cost of Ownership
VOCs	Volatile Organic Compounds
WB	World Bank
WRI	World Resources Institute
ZEBRA	Zero Emission Bus Rapid-deployment Accelerator
ZEV	Zero-Emission Vehicles

PRESENTATION

Global warming is the increasing process in the average temperature of the planet due to anthropogenic causes that can cause negative environmental impacts in the long term. One of the ways to avoid its increase is to reduce the emission of **greenhouse gases (GHG)**, pointed out by scientists as one of the main causes for the increase in the Earth's average temperature. Therefore, international treaties such as the 2015 Paris Agreement were initiated to mitigate an average temperature increase to a maximum of 2 degrees Celsius. Brazil is a signatory to international treaties **that aim to reduce the emission of GHG**, where emissions reduction targets were established for this decade and the next.

GHGs can come from a variety of mobile and fixed emission sources. Among the primary mobile transport sources of GHG emissions are vehicles powered by internal combustion engines that use fossil fuels such as gasoline and diesel. Therefore, a trend that appears irreversible over time is the **gradual replacement of combustion vehicles with electric-powered vehicles**. The gains from electromobility, such as reducing GHG emissions and other pollutants from mobile sources, are significant, and the effects on people's health and quality of life are considerable.

Therefore, there is interest from the federal, state, and municipal spheres in the decarbonization of transport systems. **Brazilian cities, especially major and medium-sized cities**, face a particular challenge in this regard. Fleet electrification cannot only be based on individual motor vehicles. This is because Brazilian cities already deal with urban congestion, and the result of individual electrification would be maintaining or increasing such congestion.

As long as the energy used for the components of the electric vehicles (mainly batteries) and charging operations come from renewable sources, with a sustainable financing and operation system, the transition to electromobility is an option for sustainable urban development in line with the goals and guidelines of the **National Policy for Urban Mobility (PNMU - Law No. 12,587/2012) in Brazil**.

Public and private institutions in Brazil have increasingly engaged in processes of preparation for a transition to electromobility in public transport in cities.

This Technical Reference Manual (TRM) for Electromobility in Brazilian Cities Volume II aims to **guide Brazilian** cities **in the financial structuring of projects to adopt electric fleets in their public transport systems**.

This TRM presents implementation steps for diagnosis, formulation of parameters, evaluation and selection of financing alternatives, and the implementation and monitoring of financial indicators during the operation stage to successfully achieve the transition.

PURPOSE OF THE TRM

TRM Volume II aims to guide municipalities, federal institutions, and transport authorities on best practices for financing and business models to facilitate the adoption of electric fleets through guidelines that seek to improve knowledge about fleet procurement and operation processes of grants and financing parameters.

The objectives to be addressed in TRM Volume II are:

- **Help improve the skills of urban mobility managers and technicians** from the public, private, and civil society spheres in financing electromobility.

- **Develop financing structures** for introducing electric buses in Brazilian cities, recognizing the similarities and differences between municipalities.

- **Guide cities and other stakeholders interested in the transition** to electromobility in identifying financial and operational inputs to properly selecting financing and business models.

- **Provide complete guidance on project structuring** through financial, operational, and regulatory technical recommendations to develop the best financing and business model.

TARGET AUDIENCE

The **Technical Reference Manual for Electromobility in Brazilian Cities Volume II** is directed to all **public agencies of all spheres**, technicians of public institutions, manufacturers, energy companies, public transport operators, national and international financial institutions, associations that promote **electric vehicles, and all those interested in sustainable mobility**. TRM Volume II is especially aimed at municipalities and transport authorities in small, medium, and large municipalities within the scope of public agencies.

STRUCTURE OF THE TRM

The Technical Reference Manual for Electromobility in Brazilian Cities Volume II is divided into two parts: **PART A- GUIDE FOR THE INITIAL STRUCTURING OF ELECTROMOBILITY PROJECTS and PART B- GUIDE FOR FINANCING IN THE ELECTRIC FLEET OPERATION STAGE.**

Part A aims to show the current context in Brazil regarding the financing mechanisms to implement electric fleets, the infrastructure to support their operation, and the Brazilian municipalities' fiscal and public finance capacity. Based on this context, **Part A** presents five steps to guide cities through the process of financing electric buses.

Based on this contextualization, **Part A** presents four steps to guide cities through this process:

1. **Step 1: Initial planning:** This chapter outlines the first steps municipalities can take before starting to structure the project. It contains a checklist and questions to be analyzed by the technical teams of the municipalities and related institutions. After identifying the most important elements for the design of the project, it is possible to proceed to the diagnosis.

   The next chapter shows the second stage within the main process, including instructions regarding the collection of key information for a later diagnosis of the situation and verifying the viability of mobilizing investments for the electromobility project.

2. **Step 2: Diagnosis:** This chapter presents a methodology for developing a diagnosis that describes the elements of the current public transport service concession and the municipality's most relevant financial and fiscal conditions. The identification of these elements is fundamental for structuring an electromobility project. The diagnosis includes a survey of the current regulatory framework for public transport, the stakeholders involved in the development of potential new business models, and the capacity of the municipality to mobilize **investments.**

3. **Step 3: Formulation of the project parameters:** This chapter presents cities' parameters for developing their electromobility project in public transport. Operational, financial, regulatory, socio-environmental, and governance criteria are presented, as well as the changes and adjustments cities need to make to finance and implement their projects.

4. **Step 4: Financing Evaluation and Selection:** This chapter consists of technical guidelines related to the available financing sources and their specificities, in order to facilitate the selection of the financing that is more adequate to the reality and context of the municipalities.

Part B presents the last step to guide cities during the implementation phase.

5. **Step 5: Implementation and monitoring:** This chapter describes the evaluation and monitoring of financial indicators during the operation phase of electric buses. Based on experiences from implementations in Latin American countries and Brazilian cities, this chapter presents best practices to support operators, manufacturers, and investor companies in the transition to electromobility in public transport.

Table 1 below presents the structure of the Manual indicating the main content of the Steps of the process for the financial structuring for electromobility projects

Table 1 – Electromobility in Brazilian Cities Volume II Technical Reference Manual Structure

Presentation			
Purpose of the TRM	Target Audience	TRM Structure	
PART A: GUIDE FOR THE INITIAL STRUCTURING OF ELECTROMOBILITY PROJECTS			
Introduction			
Advantages and barriers to the transition			
Step 1: Initial planning			
Initial steps for structuring	Project phasing and deadlines		
Step 2: Diagnosis			
Public transport concession	Capacity to mobilize investments	Stakeholders	Stakeholder's goals and objectives
Step 3: Project parameters formulation			
Operational parameters	Financial parameters	Regulatory parameters	Socio-environmental parameters
Step 4: Financing evaluation and selection			
Funding sources	Selecting of the best financing option		
PART B: GUIDE FOR FINANCING THE OPERATION PHASE OF THE ELECTRIC FLEET			
Step 5: Implementation and monitoring			
Monitoring of financial indicators and project evaluation	Granting mechanisms	Financing the public transport system operation	Implementation of a subsidy policy in the municipal budget

Source: Own elaboration.

PART A

GUIDE FOR THE INITIAL STRUCTURING OF ELECTROMOBILITY PROJECTS

1.

INTRODUCTION

Brazilian cities increasingly aim to transition to low-carbon mobility by allocating more significant portions of budgets to sustainable urban mobility projects [1]. However, solving the problem of **emissions from the transport sector requires a holistic view** that prioritizes social and environmental benefits for society as well as long-term **financial sustainability**.

Initial investments in electric buses in cities without an understanding of the technology and the physical, technical, and human resource infrastructure to support them are intended to be gradual, including a small fleet. The **current financial conditions** and **transport concessions** that allow the transition to electromobility in public transport in Brazil can be improved **through a thorough review of** best practices in the project structuring phase. This is one of the main objectives of this TRM.

The transition to electric public transport is a great opportunity and motto for cities to improve infrastructure and modernize the provision of public transport services - not only because electric buses are less noisy and do not emit GHG, but **also from the point of view of modernizing management and concessions**. Despite high initial investments, **this transition is possible by structuring financial conditions and guarantees**, reviewing current concessions, and the legal and regulatory frameworks.

Some barriers must be overcome, mainly **institutional and financial, to transition to electric fleets successfully**. At the **federal level**, ministries seek to provide **tax incentives** in line with a national plan with clear guidelines to stimulate the transition. At the **state and municipal level**, some new concession **contract models** also include **targets and incentives for electromobility**.

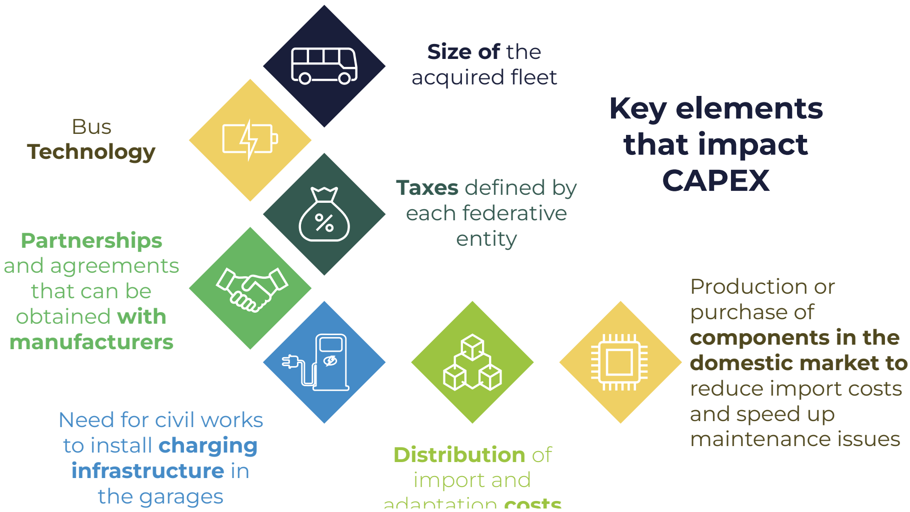
Electromobility is an opportunity to improve passenger satisfaction when the public bus transport system is facing a decline in demand, accentuated in recent decades with the covid-19 pandemic. Therefore, the transition to electromobility must be incorporated into a broader strategy for improving urban mobility.

The necessary transition to clean public transport in Brazilian cities is progressing amidst opportunities and challenges. First, there is a favorable context for change, such as high diesel prices and the prospect of increasing competitiveness in the battery electric bus market. The result of this trend means that the cost difference between the two technologies becomes smaller and smaller. The next section elaborates on the main advantages and barriers to the transition, starting from the financial aspect.

1.1 ADVANTAGES AND BARRIERS TO THE TRANSITION

The difference between the initial investment cost or CAPEX between diesel and electric buses is getting smaller and **smaller due to technological advances**. The charging infrastructure and battery are new elements that electric bus operation requires, but the lower operation and maintenance costs balance the two technologies in the long term. The initial investment cost can vary depending on **several elements**, among which are those described in Figure 1-1:

Figure 1-1 – **Key elements that impact CAPEX in the acquisition of electric buses**



Source: Own elaboration.

As noted in the literature and international experiences of deploying electric bus fleets to **provide passenger transport services**, the transition to an electric fleet requires high resources [2, 3, 4]. However, the high initial investment tends to be **compensated in time. This compensation occurs**, mainly if we take into account, in addition to lower operating costs, the impact of **reductions in GHG emissions**, **particulate matter**, other pollutant gases, and noise on a **lower occurrence of diseases**, especially **cardiovascular and respiratory** – reflecting on the quality of life and the reduction of expenses in the municipal budget for public health [5, 6, 7]. Hence, the importance of characterizing all aspects involved in the initial and operational investment.

According to studies by ICCT & C40 [8][1] and the National Platform for Electric Mobility PNME [9][2], the barriers shown in Figure 1-2, **specific to the financing of this type of fleet**, were identified:

1 ICCT; C40 Cities (2020), Accelerating a market transition in Latin America: New business models for electric bus deployment.

2 Plataforma Nacional de Mobilidade Elétrica (2021), 1º ANUÁRIO BRASILEIRO DA MOBILIDADE.

Figure 1-2 – Barriers to financing electric fleets

Lack of commercial and state articulation

It is highlighted the importance of achieving a commercial and state articulation that favors financing the electric fleet and the charging infrastructure, especially with preferential conditions and efficient allocation of risks and responsibilities.

Regulatory framework

Brazil is on the right track in terms of aligning the regulatory framework at the federal and municipal level with the National Policy on Urban Mobility and the Rota 2030 Agenda. As a result, transport concessions are starting to have more aligned approaches with electromobility needs (e.g., São José dos Campos, Salvador, or São Paulo). These approaches are described in chapter 3.1 Public transport concessions.

Funds for payment during operation

Most cities rely on subsidies to overcome the additional costs of purchasing electric buses, which can come from local, national, or international sources and can be in the form of cash, assets (e.g., land), or tax reductions. However, as a differentiating aspect, according to the characteristics of some Brazilian cities, contributions in the form of land and preferential tax measures could be useful and would reduce the need for high cash resources.

Involvement of energy companies

Energy companies could provide energy services to operators for charging the buses. However, current regulations do not yet allow distribution companies to include chargers as assets on their balance sheets. In addition, for the transition to electromobility, it is not helpful for government institutions to develop tax incentives to purchase vehicles if the energy companies cannot perform the work required for network deployment.

Incentives for electricity transmission

The key points to boost investments in the electricity transmission system are the exemption of import taxes, the reduction of operational taxes, the definition of incentives to companies for minimum percentages of the electric fleet and payment guarantees, and minimum income. The federal government must articulate these measures and include consensus among the energy and transmission market agents.

Fleet availability

It is essential to guarantee the permanence of the fleet in the public transportation system until the debt is fully paid, which can be achieved by granting differentiated licenses between the supplier and the fleet operator. These considerations contractually protect the implementation of new business models and ensure the continuity of public service provision.

Governance

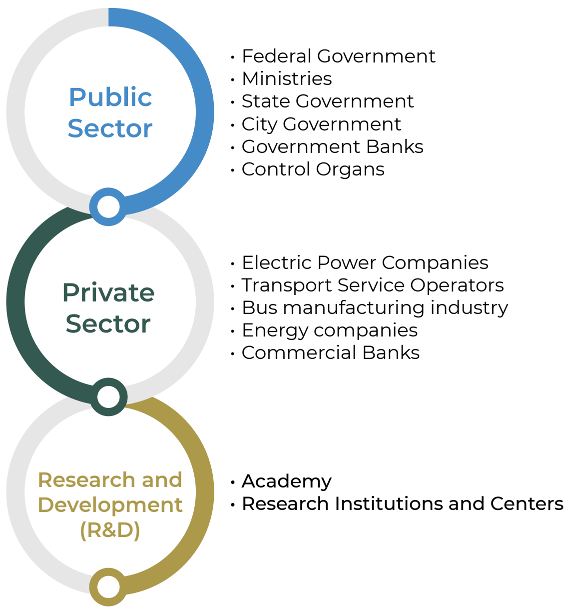
There is an articulation of the regulatory framework between the federal and municipal governments where the federal law supports the municipal governments' emission reduction initiatives. The transport service providers currently purchase the fleets and have direct contact with the passengers. However, the fleet change policies condition the fleet change to electric buses in place in the municipality or by federal law, which means, on the other hand, barriers to the transition.

Source: own elaboration based on ICCT & C40 [8] and PNME National Platform for Electric Mobility [9].

To overcome the mentioned barriers, all actors need to interact, starting from **Step 1: Initial planning** described in the CTR. The early involvement of stakeholders such as electric bus providers, energy companies, investors, public transport operators, and governments at the federal, state, and municipal level **allows for identifying various financing instruments to achieve synergies, economies of scale, and risk reallocation** among potential system players. Thus, seeking innovative and coordinated financing mechanisms between national development institutions and multilateral and international financing institutions is important. This articulated work facilitates a favorable distribution of risks and broadens access to, for example, funds with better conditions for rates, terms, and grace periods.

Given that there is a wide **range of possible actors** around electromobility (see Figure 1-3), it is necessary to ensure alignment between the different levels of government, the various institutional levels, public and private, so that governance barriers can be overcome. **Academia and research** and development **institutions** have developed studies contributing to a better understanding of electric technology and its operation in buses.

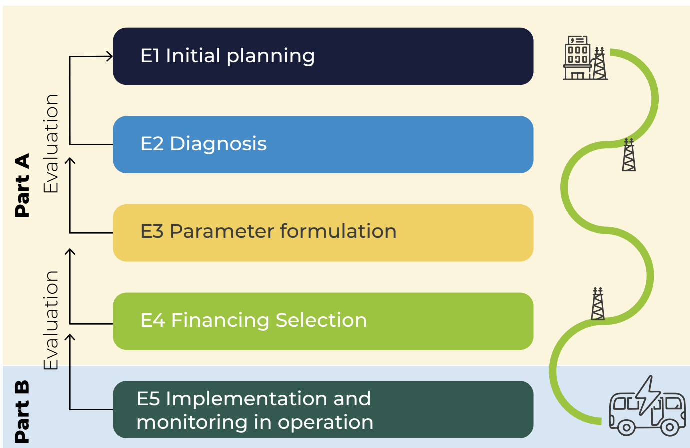
Figure 1-3 – **Sectors that need coordination and institutional strengthening for electromobility adoption**



Source: Own elaboration based on WRI BRASIL [10] and ICCT [11].

The involvement of these stakeholders is a step embedded in the (1) **Initial planning of** the electromobility project, which corresponds to the first step proposed in this TRM. This participation ensures their positive impact on the project's implementation in the following stages. The four remaining steps to be followed by the municipality interested in implementing electric bus fleets are (2) **Diagnosis**, (3) **Parameter formulation**, (4) **Evaluation and selection of funding**, and (5) I**mplementation and monitoring in operation**. Figure 1-4 illustrates the process outline.

Figure 1-4 – **Electric Fleet Implementation Process**



Source: Own elaboration.

Next, the elements and steps required **at each stage are presented so that managers and technicians can use them to guide the research and definition of financing in** implementing an electromobility project, from conception to implementation and monitoring.

2.

STEP 1: INITIAL PLANNING

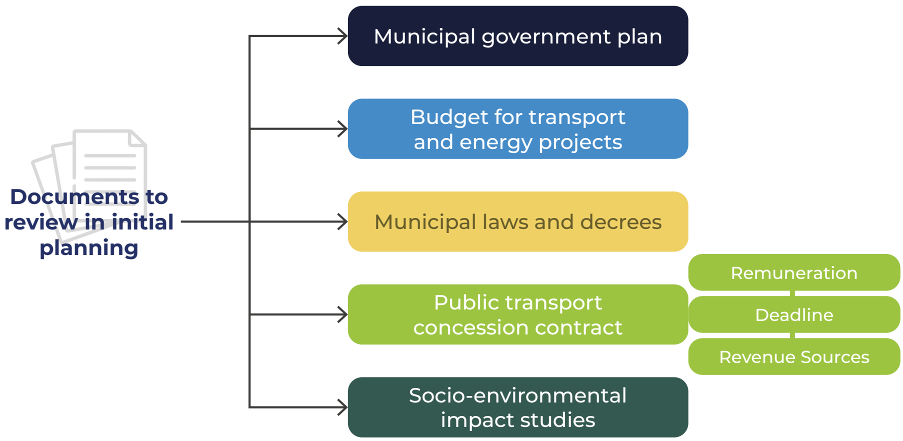
As with any new technology implementation, prior knowledge needs to be developed in electric vehicles in Brazilian cities. Therefore, municipalities, operators, and electricity companies are the first to be involved in the planning and implementation stages.

Financing electromobility projects in public transport in cities requires coordinated planning of programs by municipal, state, and federal institutions and authorities. Programs defined by municipalities can facilitate access to financing from commercial, international, or multilateral banks due to the support provided by the public authorities. Considering the proposed general structure, the first step defined in this TRM is **planning the project as a whole**, from its beginning to its implementation and monitoring. Planning from the strategic level (objectives, actors involved, and initial exploration of funding sources) defines the feasibility of the available funding options for the project.

2.1 INITIAL STEPS FOR STRUCTURING

The first step to begin identifying funding for an electromobility project is to build a strategic vision and understand the current situation in the municipality. Thus, it is recommended to review the documents described in Figure 2-1 to analyze their relationship to the transition to electromobility.

Figure 2-1 – Documents to review for the financial structuring of the electromobility project



Source: Own elaboration.

Based on these documents' review, it is assessed the **alignment of the visions of the municipality**, the transport authority, and the transport operators in the city to ensure the project's initial feasibility. The **municipal government** plan **and laws promoting the reduction of GHGs and local pollutants in the municipality through adopting new technologies** accelerate project implementation and attract a broad portfolio of interested funders. Therefore, the current condition of the municipal budget and these documents, especially the public transport concessions, need to be evaluated.

The project scope is defined at the strategic level, defining at least the following elements in Figure 2-2:

Figure 2-2 – **Project definition at the strategic level**

Project definition at the strategic level

- Size of the fleet to be replaced or new fleet
- Time frame for project implementation
- Two (2) sources for mobilizing financial resources

Source: Own elaboration.

Fleet size is a critical initial input, as it indicates if the project has characteristics of a smaller-scale project, such as a pilot project, or, on the contrary, a medium- or large-scale project. In addition, the size of the fleet and the implementation period allow the prioritization of some business models over others, as presented and discussed in this manual's Step 3. Finally, the definition at the strategic level includes the identification of at least two sources of funding for the project aligned with the city's and/or the project implementer's ability to pay.

Once the implementer has the project vision defined, the project phasing must be identified. In the following chapter, the main elements of this stage are indicated

2.2 PROJECT PHASING AND DEADLINES

After identifying the strategic vision, it is possible to estimate specific deadlines with greater precision and, thus, shape the project. The implementation time of an electromobility project depends on several factors, many of which arise from aspects related to the experience and context of the city where the project is carried out. In addition, consideration should be given to the relevance of factors external to the technical sphere of the project, such as the role of local authorities and how their actions may impact the project and the dimension or organizational structure of related services to the project, or the planned implementation pace for alignment with the operators.

In the financial sphere, it is essential to consider that the time required for effective financial structuring is variable. For instance, it depends on the technical staff's factual knowledge of managers with expertise in complex processes such as structuring a business model for an Electromobility project. Thus, adopting an adequate and efficient business model from a technical and operational point of view requires the model's structuring to be carried out with the financial sustainability of the system as its pilar, including not only the availability of resources for the project implementation and following stages, to guarantee its continuity.

Thus, this section seeks to identify the actions developed by some cities throughout their implementation processes. The objective is to present, in detail, the different stages that make up the process as a whole, assigning estimates of time intervals to the different stages of the process, and introduce, in a conceptual way, projections related to resources needed for each phase.

Deploying an electric fleet depends on several factors that can speed up or delay the process. The effective implementation deadline of the project has a direct impact on its financial structure, hence the importance of identifying the estimated deadlines and possible risks associated with the transition from the beginning of the project – and the possible approaches that can be adopted to minimize the risks and possible negative impacts.

When there is no political support, projects tend to take longer to define the initial objectives, define the business model, evaluate the steps to follow, implement the first measures and implement the first units to verify their suitability for the operating routes. After the initial deadline, the implementation can start, but deadlines can be affected by the government's financial availability or by the time needed to implement the changes required for the selected business model.

In general terms, four (4) distinct phases can be highlighted in the electric fleet implementation process (which corresponds to the steps indicated for this TRM in Figure 1-4). Each phase, objectives, and estimated deadlines are described below in Figure 2-3.

Figure 2-3 – Phases of electric bus project implementation

1. Design and Diagnosis	2. Preliminary implementation	3. Evaluation and Redesign	4. Gradual implementation and scale
Formulating the scope and objectives	Pilot Test Planning	Evaluation of pilot project results and performance	Identification of best practices and best charging technology based on the results of the pilot test
Incorporation of relevant actors	Definition of technical aspects and responsibility of the actors involved	Actual TCO estimation	Operational scheme of the electric bus project
Identification of available technology and suppliers	Financial structuring and initial TCO estimation	Evaluation of the support infrastructure redesign	Financial structuring of the project and definition of the business model
Resource estimation and risk mapping	Acquisition of initial assets (vehicles and batteries) and infrastructure (chargers)		Gradual implementation of electric buses in the transport system
	Operating electric buses under real-world conditions		
6 mounths - 1 year	**1-2 years**	**6 mounths - 1 year**	**Variable (up to 20 years)**

Source: Own elaboration.

2.2.1 Design and diagnosis

The design and diagnosis stage includes all project preparation activities, including the initial tasks that seek to formulate the scope and objectives. The project design also includes meetings with the different stakeholders, the definition of the strategy to be implemented, and the preparation of the necessary documentation for implementation, which incorporates all aspects (technical, legal, and financial, among others.). These permit the project to be carried out. In many cases, the initial idea or impulse may come from an authority or official responsible for the transport system. However, in other cases, it may be the result of more ambitious objectives defined by the political authority, seeking to reduce, for example, GHG emissions, with transversal and specific actions for each management area in the municipal organization chart. Therefore, the proposed objectives' formulation must occur in the design phase. A time scale including these objectives is also necessary to generate predictability for all actors involved.

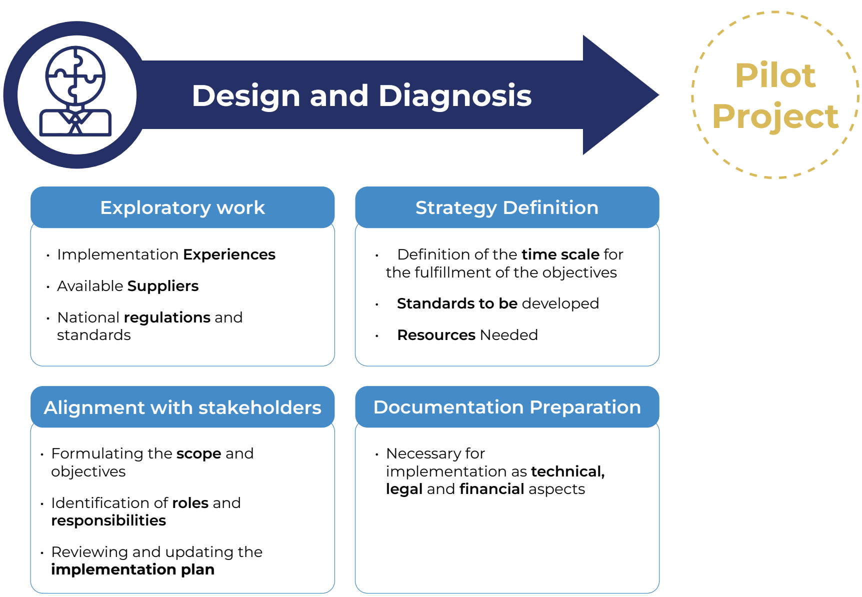
During the design phase, the involvement and engagement of all actors that might participate in the project are highly relevant for the execution of the project. This inclusion is also decisive for consolidating the adopted models and arrangements and, consequently, for system sustainability.

A sustainable project is achieved when most of the actors involved in pursuing the objectives are aligned and committed. During this stage, the objectives and the implementation plan are gradually reviewed, and the necessary modifications (adaptations) are made to the project to align with the involved parties' needs. To this end, solid communication with the industry, unions, and operators, among others, promotes effective alignment.

The strategy must also include a tracking timeline of milestones and objectives, map implementation risks, and identify required standards, resources (human, financial, data, infrastructure), and elements for carrying out the project, such as regulations. In addition, it must consider other experiences and their suppliers' availability, and national regulations and standards. Thus, this exploratory study, along with the aligned expectations, helps define the strategy.

The design phase can typically last from six months to a year, depending on the technical resources available for the responsible agency. The key aspects to consider in the design and diagnosis phase are presented in Figure 2-4.

Figure 2-4 – Design and diagnosis phase of electric bus projects



Source: Own elaboration.

2.2.2 Preliminary Implementation

In Latin America, several cities have already demonstrated significant progress in the transition to Electromobility. However, as it is a technology still consolidating documented data, cities such as Santiago, São Paulo, Bogotá, Guayaquil, and Cali use experiences acquired through "pilot tests" to effectively develop projects on a larger scale. Therefore, the main objective of this preliminary implementation format is to assess the feasibility and level of suitability of instruments designed for large-scale deployment. In addition, through "pilots," implementing cities can develop a more realistic analysis, using parameters resulting from an on-site operation instead of considering the theoretical parameters provided by the manufacturers.

In this way, authorities can operate a small number of buses under real-world operating conditions, from aspects related to the local context, such as weather conditions and temperature variations, average passenger load, lines' distance traveled per day, and potentially electrifiable, driving habits in response to local congestion conditions, among others. This can influence the expected productivity results, allowing a slightly more accurate estimate of the number of buses needed to implement the project without reducing the service quality and access.

The pilot tests have also proved to be quite effective as a tool for understanding the different technologies offered by manufacturers within local reality. This enables a prior performance assessment and the inclusion of interested parties already in the planning phase. (such as the asset supplier and the energy distribution company) . Thus, assessing the level of involvement these stakeholders may eventually have as the project progresses is of great value. Suggestions of potential roles and responsibilities of some stakeholders in the pilot test are presented in Figure 2-5:

Figure 2-5 – Pilot Test Responsibility Role

Government areas, usually federal

Granting exceptional and temporary licenses for operating buses that may not meet the current requirements for regular operation (in terms of operating weights, for example). Such franchises may also be required if importing foreign vehicles is necessary.

Transport operators

Making their facilities and routes available to evaluate the performance and productivity of the buses under actual operating conditions. This would also involve training drivers and maintenance personnel to perform specific tasks during the pilot test period

Bus Suppliers

Call for bus suppliers interested in entering the market, willing to supply the necessary units on loan to carry out the pilot test and verify that the performance defined in the manuals of their vehicles corresponds to the reality. In addition, they must make professionals available to carry out the necessary training for the operators' personnel to optimize the performance of the vehicles.

Electricity distribution companies

Even in the pilot test phase, it is crucial to provide the necessary infrastructure to the operators' facilities so that the operation can be carried out as regularly as possible. The possibility of having the electricity companies do some of the work should be evaluated to provide power lines to these facilities that can guarantee the necessary voltage current during charging periods.

Source: Own elaboration.

Pilot projects can be implemented in a shorter period to assess the operations' performance over a period covering different operating conditions. In addition, information collected during the implementation of pilots may indicate the need for adaptations in the available infrastructure, increasing the estimated time for the initial stages – an increase that can be incorporated into the overall project planning.

In this sense, it is essential to distinguish a pilot test from a gradual implementation process since they have different formats and objectives. In the examples below, the strategy adopted assumed a progressive implementation, a model in which the units or routes are renewed gradually. Thus, projects implemented in this format are not pilot tests and can be considered an effective part of the main implementation processes.

2.2.3 Evaluation and Redesign

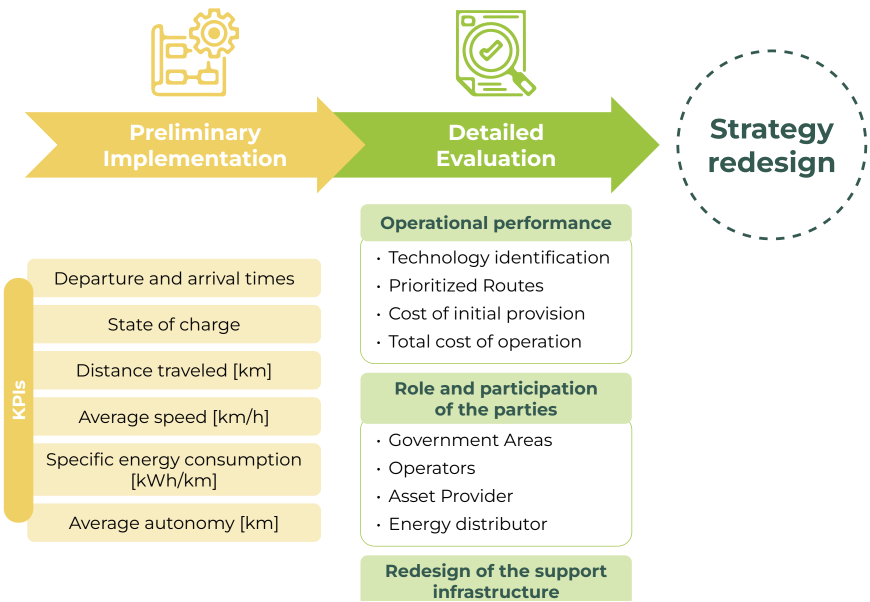
As indicated in previous sections, implementing a pilot project has excellent potential in collecting a series of information. Therefore, it is recommended to carry out a detailed assessment of the different aspects taken into account to redesign the strategy proposed at the beginning. This redesign can identify the best technology (if more than one is considered) to be implemented and which routes to prioritize by following the operational performance of pilot projects. Furthermore, more and better data would allow complete modeling of the operational parameters, evaluating the best alternative for which part of the system to cover.

Accurate information about vehicle performance and best options allows one to obtain accurate data about the initial provisioning cost and estimate the total operation cost over the entire fleet life, enhancing the possibility of making projections about the committed effort. At the same time, assessing the role and participation of stakeholders in the process supports institutional arrangements and governance of the process.

It is also crucial to evaluate the redesign of the supporting infrastructure estimated at an early stage to adapt it to the pilot test results. This occasion should also serve as a basis for modifying the strategy according to the information obtained.

It is important to document and standardize the entire process and metrics involved in the pilot test. In addition, the positive or negative data needs to be published for the information to be accessible and symmetric between stakeholders. For example, during recent pilot tests in Latin American cities [12], some KPIs were documented for each day and journey over one year of operation. These KPIs measured during the preliminary implementation phase, and the key elements of the evaluation and redesign phase are presented in Figure 2-6.

Figure 2-6 – Key KPIs in the preliminary implementation phase and elements of the detailed evaluation of electric bus projects



Source: Own elaboration.

The relevance of publishing the pilot test results and the technical studies derived from it justifies the reasons for the technological and operational choices, improving the transparency of the process, and avoiding future challenges.

For the evaluation of the pilot project, a period of approximately six months to one year can be considered, depending on the availability of technical resources to analyze the results.

2.2.4 Gradual implementation and the scale

The final implementation plan is built on the pilot test results. The objectives and goals are reviewed according to the lessons learned after submission for revision and joint analysis with all stakeholders. However, it is important to note that this does not prevent future changes or imply a straightforward implementation for the entire system involved. Instead, deployment involves a consolidated strategy that can be reviewed, updated, and adjusted to needs and technological changes.

Deployment depends on a long-term strategy whose costs are known with defined objectives over a long time horizon. Besides, it needs an alignment or commitment (including financial) of authorities, operators, and other actors for its execution. Deployment may be progressive through lines, routes, or sectors, or it may be rapid, seeking to replace the fleet in the shortest term. This process can be facilitated by introducing a new business model that favors new vehicles and operational practices.

Governance represents the most relevant aspect of deployment. According to WRI (2019), it is common for electric bus projects to face limitations due to a lack of institutional support or planning, or resources. For example, in many cities, there are no laws or programs to support an electric bus implementation strategy, or for an existing one, they may be ineffective and do not include clear targets or financial incentives. In other cases, there may be a lack of institutional capacity regarding resources or jurisdictional authority to allow adequate coordination between actors. Thus, as a result of the lessons learned from the pilot test, the institutional project must be well structured to manage the transformation process, with clear roles and responsibilities to lead the process and to make the necessary corrections as plans advance. On the other hand, new risks may emerge during the implementation process, and this leadership must be prepared to manage them and adapt to the new situation.

This governance needs to be transversal, dealing with aspects not currently managed by the transport system, such as the final disposal of batteries, a process necessary to achieve the best possible results. Such a process can also generate new needs and interests from other stakeholders; for example, local manufacturers may seek to integrate their products into the industrial development framework of vehicle manufacturing.

The implementation period can vary significantly according to the system's characteristics, the number of routes and vehicles to be replaced, and the percentage of the fleet to be replaced. Based on past experiences, such a project could take two to ten years[3] to complete.

Figure 2-7 shows a summary of Step 1.

Figure 2-7 Initial Structuring phases, Step 1 Summary

Source: Own elaboration.

The next chapter presents the second step within the main process, including instructions regarding collecting key information for later diagnosing the situation in question and verifying the feasibility of mobilizing investments for the electromobility project.

3 The timeframes can be shorter if small systems are considered where a purchase is made to replace all the buses in operation, or if only one line of a more comprehensive system is to be electrified.

3.

STEP 2: DIAGNOSIS

Step 2 of the process seeks to identify and systematize the characteristics of the public transport concessions and their **capacity to mobilize investments within the municipality**. Once this identification is achieved, the actors responsible for the necessary changes described in the following steps are defined.

This chapter presents a methodology to develop a diagnosis on the conditions of the municipality to structure an electromobility project. It includes an analysis of the current regulatory framework for public transport and the ability of the municipality to mobilize investments and stakeholders in the development of new business models.

The first Diagnosis step is to understand the nature of the current concessions for public transport services in the municipality. This diagnosis step aims to identify the current conditions of the concessions that make an effective transition to electromobility possible.

3.1 PUBLIC TRANSPORT CONCESSION

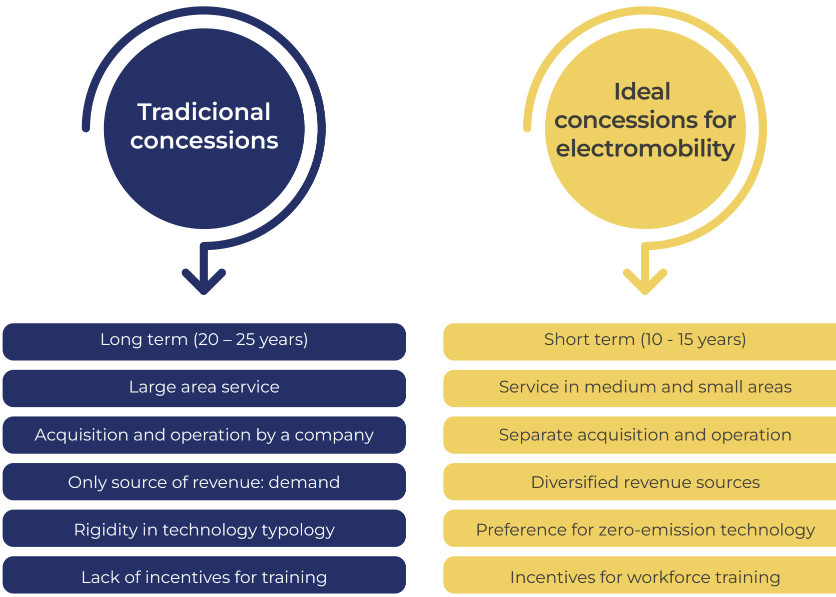
The long-term transition and scaling towards electromobility needs a tenders' management allowing operating companies to provide public transport services. In most cities, the granting authority provides public transport service through concessions to private companies. If services are transferred to a company, **this can only be done based on a public bidding process that results in a contract**. These contracts are governed by Federal Law 8.987/1995, with a subsidiary application of Federal Law 8.666/1993 [13]. In most Brazilian cities, the operators are private companies with different degrees of modernization [14].

The characteristics of traditional public transport concessions until 2020 can be summarized as follows: long-term contracts, **provision of services in the entire urban area or large areas**, acquisition and operation of buses by the same company, sources of income and remuneration of operators limited by user demand (tariffs), rigidity in the introduction of new technologies, few or no incentives to reduce emissions in operation and processes, and for the provision for staff training associated with new technologies.

New concessions, which include more desirable features for the inclusion of electric buses, tend to have the following characteristics: shorter duration contracts, provision of services in smaller areas to allow targeting of service improvements, separation of bus acquisition and operation to reduce risks, diversified sources of revenue and remuneration to operators (user demand, kilometers traveled, on-street parking, cross-subsidies, among others), **flexibility regarding the introduction of new low or zero emission technologies**, clear incentives to reduce emissions in operation and processes, and personnel training, observing a component of social inclusion, so that the same people who already work in the workshops and also new professionals can meet the needs of the electric operation.

Figure 3-1 shows the most relevant characteristics to be identified in the diagnosis of municipal concessions.

Figure 3-1 – Characteristics of traditional and new concessions for electromobility



Source: Own elaboration.

In line with the importance of recognizing these characteristics of traditional public transport concessions and those involving new technologies is the mobilization of more agile investments due to contracts with distributed risks.

3.2 ABILITY TO MOBILIZE INVESTMENTS

The aim is to include new business models for electromobility in the municipalities' bidding and concession contracts or Public-Private Partnerships. In this sense, it is essential in this stage of diagnosis to identify environmental criteria in the specifications and evaluation of services, schedules, and targets for reducing pollutants, as well as the mechanisms and financial conditions for implementing the transition to electromobility.

Besides the financial conditions, the diagnosis must include **access to development institutions and investment funds and the guarantee conditions made possible by the municipalities** as the granting power. Possibilities and restrictions of municipal and state public finances deserve particular attention at this stage.

This section, therefore, deals with the conditions and limits associated with budgetary and financial constraints of municipalities, considering the different business models - acquisition, and leasing, among others; and the different mechanisms for contracting services - bidding and concession contracts or structuring public-private partnerships. This diagnosis of the ability to mobilize investments and the municipal budget allows the definition of responsibilities of the granting authorities or the concessionaires.

3.2.1 Identification of alternatives

Different types of bidding and concession contracts and investment alternatives are highlighted. For example, there are direct purchases or rental of vehicles by the granting authority, where the **operators are responsible for maintaining the** system and providing services. In other cases, the operators are responsible for purchasing the vehicles, aiming to meet the requirements and schedules for the reduction of pollutants, leaving the municipality with the responsibility of **guaranteeing the operational revenues** necessary to maintain **the** system. The best alternative's definition depends on the transition program's extent and municipalities' technical and financial conditions.

In the first case, the acquisition of vehicles and the necessary infrastructure depends on budgetary and extra-budgetary resources (grants or other means), combined with financing from development institutions and agreements with other levels of government. For this, one should consider the legal limits of indebtedness, payment capacity, and guarantee conditions. Furthermore, for the risks of the operators in maintaining the system, associated with the combination of the demand met and tariffs, there may be a need to share such risks with the granting authority **by complementing the values of the tariffs with subsidies**, which depends equally on the budgetary and financial conditions in the short, medium and long term.

Some business model conditions must be considered in concession contracts where operators assume responsibility for fleet renewal. The operators can make the bus purchases viable or combine the acquisition of the chassis with leasing operations for the batteries. In both cases, municipal indebtedness needs are minimized in the short term. In the second case (**acquisition + leasing**), the initial costs and their impacts on the operational conditions are diluted.

In any case, if such models reduce, in the short term, the financing and indebtedness needs of the municipality, on the other hand, it imposes the need to structure guarantee conditions to the operators to ensure the necessary operating revenues to maintain the services, including the amortization of investments and the cost of leasing operations. Here one can **also** consider **the distribution of responsibilities in infrastructure construction**. Generally, the construction or renovation of garages and charging points can be diluted similarly, maintaining public responsibility for the road system.

Table 2 and below systematize the responsibilities/attributions of the agents in the electromobility transition projects based on the concession contracts.

Table 2 – Concession Agreement with fleet and infrastructure acquisition assumed by municipal management

Responsible	Responsibilities
Local Public authority: Grantor	• Structuring the electromobility project; • System Management • Enabling the necessary resources for the investment (budgetary and extra-budgetary); • Articulation with development institutions or other government levels, seeking financing lines compatible with the municipal limits and conditions (debt limits and other conditions established in the Fiscal Responsibility Law (LRF)); • Definition of the values of the tariffs and conditions for the economic-financial balance of the contracts; • Programming of budget resources, aiming for necessary subsidies in the short, medium, and long term, ensuring the operating conditions.
Concessionaires or operator	• Operation of the system with services maintenance, according to environmental, social, and economic rules and parameters established in the public tender and contract

Source: Own elaboration.

Table 3 – Concession Agreement with fleet renewal by the concessionaire

Responsible	Responsibilities
Local Public authority: Grantor	• Structuring the electromobility project; • System Management • Definition of the values of the tariffs and conditions for the economic-financial balance of the contracts; • Constitution of guarantees/structuring of a Credit Guarantee Fund aiming at concessionaires' financial cover; • Programming of budget resources, aiming at short, medium, and long-term subsidies, assuring operational costs, including investment amortization and the cost of leasing operations..
Concessionaires or operator	• Providing the necessary resources for the acquisition of vehicles and the construction or renovation of garages and charging points within deadlines compatible with the pollutant reduction schedules assumed in the contract; • Constitution of guarantees or partnerships with investors, aiming at obtaining the necessary financing; • Enabling leasing operations for the batteries; • Operation of the system with services' maintenance, according to environmental, social, and economic rules and parameters established in the public tender and contract.

Source: Own elaboration.

In this characterization phase, the municipality must understand the roles of the granting authority (usually the mayor's office or an agency responsible for the transport system) and the current concessionaire providing the service. Based on this identification, more stakeholders can be included in the process to ensure the success of the process regarding the acquisition of electric buses, their financing, loading conditions in the garages, insurance of the new vehicles and facilities, involvement of the operator's current workforce, and other needs for adopting the new technology to be taken into account in the operation.

3.3 STAKEHOLDERS

Based on the experiences of Latin American cities such as Santiago [15], Bogotá [16], and Lima [17], among the first steps for the implementation of an electric bus project is the prior involvement of stakeholders who can stimulate the development of the project.

The roles of all stakeholders in an electromobility project in Brazil are presented below. Stakeholders can play a role in obtaining funding for the project implementation. In addition to the granting public authority, the operators (or concessionaires), and the transport authority, some actors can be decisive in obtaining funding for the acquisition and operation of electric buses.

3.3.1 Federal Government

The federal government is responsible for providing regulatory guidance for projects at the state and municipal levels. Climate change laws at the federal level are fundamental for cities to structure projects to contribute to achieving emissions targets at the national level. The federal government can issue green bonds to expedite investments in low- and zero-emission projects. The financing of electromobility projects through Green Bonds in Brazil can be boosted by Federal Decree 10.387/2020, which aims to encourage infrastructure projects with social and environmental benefits [10, 18].

DECREE N° 10.387, OF JUNE 5, 2020

Amends Decree No. 8,874 of October 11, 2016, to provide **incentives for financing** infrastructure projects with environmental and social benefits among which it supports the **projects of acquisition of electric buses**, by fuel cell, and biofuel or biogas hybrids.

3.3.2 Municipalities

The municipalities are in charge of managing the budget allocation and the strategies to reduce emissions from the transport sector in the city. With the approval of the city council and control bodies, the municipality can create guarantee funds to allocate resources for investments in projects that reduce climate change impacts. They should also define the main characteristics of public transport service concessions and the value of transport tariffs.

The transport authority provides guidelines, grants, and supervises public transport services. This entity plays a key role in requiring minimum standards and indicators for service provision and an adequate definition of concessions' conditions to operators.

Besides the transport sector, entities at the municipal level from the industry, energy, health, and environmental sectors must be involved in implementing transport projects. Therefore, it is essential to identify all the entities mentioned to understand their interaction dynamics.

3.3.3 Financial Institutions

Given the acquisition costs of electric buses and charging infrastructure, financial institutions must receive effective incentives to increase the participation of these players in this transition and mitigate the effects of municipalities' fiscal constraints and operators' warranty conditions.

Financial institutions can leverage projects that mitigate the impact of climate change on cities. Some development banks, such as BNDES, offer financing lines with better options than commercial banks for those seeking financing for green projects. For example, the funding lines offer soft loans, lower rates, extended grace periods, and more. Many commercial banks rely on the resources released by the BNDES to make large loans. However, Brazil's condition as an automotive vehicle producer country and the growing interest of cities to make the transition attract commercial banks to open new funding lines, and international banks are looking to Brazil for financing offers [1, 5].

3.3.4 Manufacturers

The low presence of domestic manufacturers of electric buses and batteries generates competition from international manufacturers with the national ones, which can count on tax incentives. This disparity exerts considerable pressure on the market, and prices are not yet competitive with the costs of diesel buses. Manufacturers' influence on the financing models is strong by participating in the business model as financers of the bus or battery or by offering battery leasing to the operator or the municipality.

3.3.5 Energy companies and subsidiaries

Companies in this sector have been major players in electric mobility in Brazil, considering their role as suppliers of electric energy, which is indispensable for the supply of electric vehicles. Their main actions have focused on demonstration project initiatives to research and understand electric vehicle technology, its applications, and its implications. Above all, they seek to identify the possibilities of action for companies in terms of electricity supply, charging infrastructure, and new business models associated with electric vehicles [10]

In this sector, these efforts to develop electric mobility are justified by the compulsory investment in research and development through the ANEEL's R&D Program (Law No. 9991/2000). Although most of the projects are not exclusively linked to electromobility, they have significantly impacted the actions derived from the electrical sector in favor of electric vehicles in Brazil, promoting broader reflection on the subject. However, electric distribution companies are not yet able to invest in transport assets to support the implementation of electric buses (charging infrastructure).

3.3.6 Public Transport Operators

Public transport operators are crucial since new business models depend on the transition for compensation from items other than passengers transported. Therefore, as part of the Diagnosis, it is fundamental to identify the operators' demands, the financial problems, and dynamics regarding the service remuneration and the costs and revenues from the sale and purchase of diesel buses.

3.3.7 Insurance Companies

Insurance companies are becoming increasingly confident in providing insurance for a technology still under development. Therefore, they are key players in the diagnosis of the city, and their integration is sought in the initial phase of the project because, in the financing process, financial institutions require any business to consider insurance for buses, batteries, and supporting infrastructures for the operation.

3.3.8 Research & Development

It is important to identify the presence of universities that have conducted research and development in electromobility. These institutions provide relevant technical evidence and documents for implementing such projects and are often linked to the reality of the municipality or state where they are located.

The interests of all these stakeholders do not always align. The goals and objectives of the stakeholders need to be aligned to facilitate the transition. The next section presents an analysis of the alignments of the most important goals among the stakeholders.

3.4 STAKEHOLDERS' GOALS AND OBJECTIVES

Implementing an electric bus fleet project brings complexities that can be addressed from the beginning. However, as a good practice, the authorities involved must initially have an overview of the public transport system and the power grid to define the challenges and opportunities and identify and measure the benefits [1].

In this context, it is essential to clearly define the project's scope to establish short and long-term goals. The transition to electric mobility is not only a matter of improving the quality of the public transport services provided but an initiative that aims to meet an environmental protocol to reduce greenhouse gases and pollution in the municipality by improving health conditions and the quality of life of the population. In other words, its environmental proposition is an excellent opportunity also to modernize the public transport system and, potentially, offer a better service to the user.

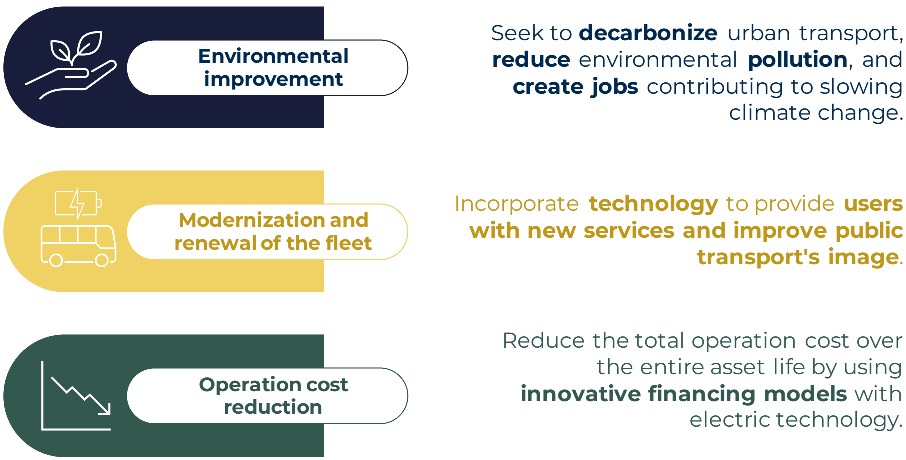
On the other hand, the project scope may vary according to the transport authorities' interests and the system's current state, stakeholders' positions, and financial possibilities. Therefore, it is important to keep in mind that no formula justifies the development of such a project, and considering the specific characteristics of each location results in better outcomes. From this perspective:

- A pilot project is sought to have better information about the necessary parameters and the technologies to be adopted in a large-scale deployment.
- The goal is to initiate a process of electric fleet deployment that covers the entire urban system. In this case, a gradual transition scenario is proposed in which vehicles are incorporated per line, per route, per operator, or staggered for all city operators.
- Modernizing the commercial and operational model can favor the adoption of electrical systems.

Identifying **clear and defined objectives** is essential not only to establish a baseline and a progress-tracking model (as well as the tools and metrics to be used) but also to generate expectations and alignment among the various actors that make up the system. In many cases, undertaking a process of electric bus deployment may imply a change in the institutional and organizational form of the system. Thus, it is important to involve all institutional actors that are part of this process.

Although the objectives need to be well defined, the motivations for accelerating an electric bus deployment project can respond to different incentives, stimuli, and justifications, such as those indicated in Figure 3-2.

Figure 3-2 – Incentives from municipalities for the transition to electric buses



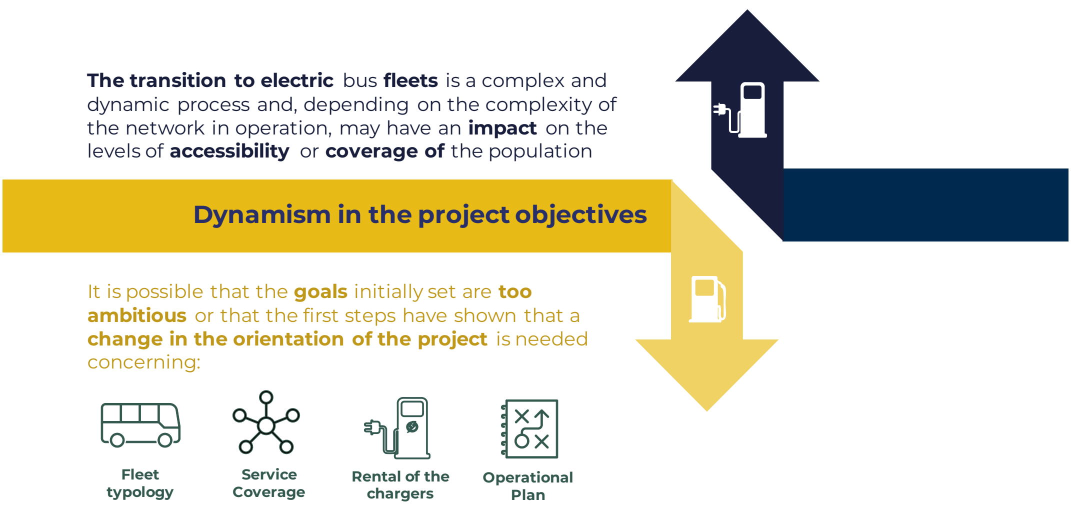
Source: Own elaboration.

Thus, the project authority must define the objectives and, eventually, its hierarchy. For example, the latter definition of targets and evaluation of the project's progress varies according to the predefined objectives. A project that seeks to achieve predefined environmental impact targets set by the municipal authority involves a different process and planning than a project that seeks to achieve cost efficiency or improved passenger service.

In addition, it is necessary to identify the goals and consider the government administration's potential to achieve them on time. Thus, it is important to ponder existing constraints and commitments to be made with all stakeholders when structuring the project for a realistic implementation plan. Therefore, this plan incorporates intermediate progress goals and objectives and, above all, includes the necessary resources to ensure that the intermediate goals are met according to the initial plan.

A final aspect to consider when defining objectives is that they are not static but can be adapted and modified with project progression and lessons learned along the way. Figure 3-3 presents the key elements related to the dynamic nature of electromobility projects.

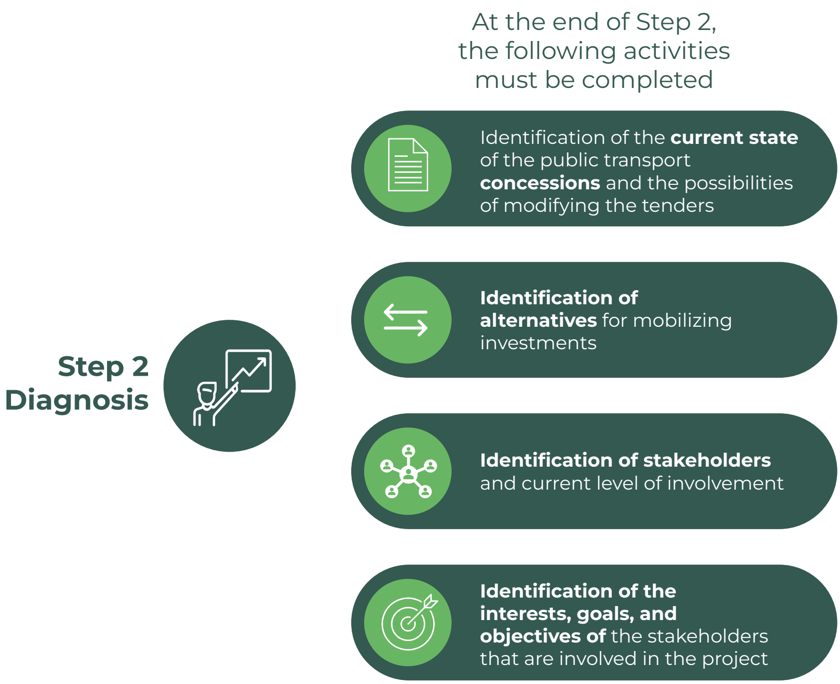
Figure 3-3 – Project objectives' dynamics



Source: Own elaboration.

Figure 3-4 summarizes the most important activities of Step 2.

Figure 3-4 – Diagnosis Steps, Step 2 summary



Source: Own elaboration.

The following chapter presents Stage 3, where the operational, financial, regulatory, socio-environmental, and governance parameters are formulated after identifying the stakeholders and their objectives and interests.

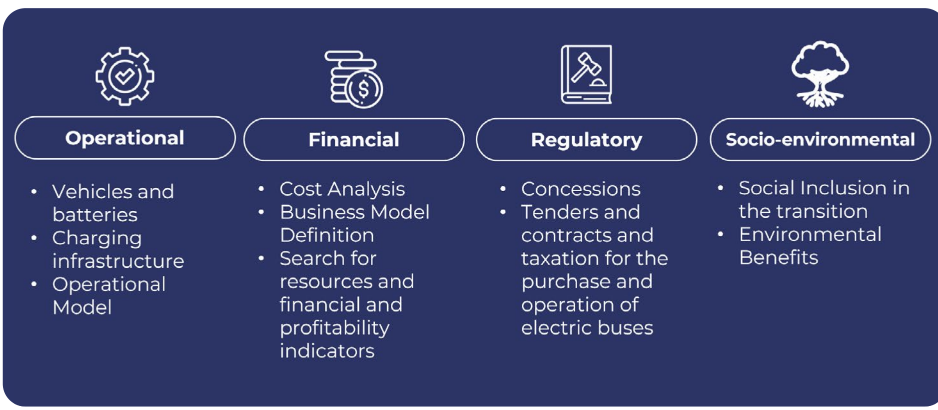
4.

STEP 3: PROJECT PARAMETERS' FORMULATION

To meet the objectives and goals of the stakeholders identified in the Diagnosis, operational, financial, and regulatory parameters should be identified for the project feasibility assessment.

Parameter Formulation describes the objectives and goals of the stakeholders to identify where there is congruence and where objectives diverge. The parameters on which this Manual focuses are shown in Figure 4-1:

Figure 4-1 – Parameters evaluated in the TRM for the financing evaluation



Source: Own elaboration.

Prior identification of the parameters described allows municipalities to:

- Enhance municipal institutional and public transport operators' knowledge of electric technology.

- Increase public authorities' understanding of the benefits of transitioning to electric mobility.

- Map stakeholders in the municipal context.

- Understand the need for changes in the regulatory framework at the municipal level to accelerate the transition.

- Increase efficiency in the coordination processes between financial institutions, insurance companies, bid control agencies, investors, bus manufacturers, assemblers, electric power companies, and others.

Figure 4-2 shows the components related to each parameter analyzed in Stage 3 of the electromobility project implementation. Stakeholders are involved in all parameters that affect the conditions for project financing.

Figure 4-2 – Components and stakeholders involved according to the parameter type

Parameter Type	Components	Stakeholders involved
Operational	Vehicles and batteries Charging infrastructure Operational Plan	Operators City Hall Electric power companies Manufacturers
Financial	Total Cost of Ownership Business Model Revenue Sources	Financial Institutions Special Purpose Entities City Hall Operators Electric power companies
Regulatory	Current Concessions Bids and contracts Taxation	Federal Government State Government City Hall Insurance Companies
Socio-environmental	Emission Reduction Social Inclusion	Civil Society Federal Government State Government City Hall Operators Electric power companies

Source: Own elaboration.

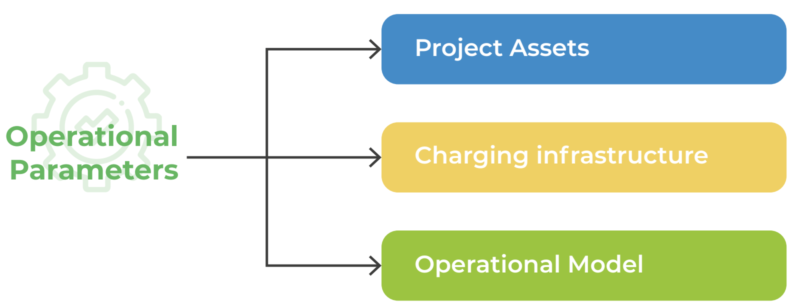
This chapter presents the parameters for cities to achieve electromobility projects in public transport quickly. It presents operational, financial, regulatory, socio-environmental, governance criteria, changes, and adjustments municipalities could make to finance and implement their projects.

4.1 OPERATIONAL PARAMETERS

Although the size of an electromobility project **can vary considerably depending on the needs of the public transport system**, considering the level of modernization of the current fleet and the financial capacity of the municipality, **operational parameters of the project can be identified in advance to assess the technical feasibility** and the best option in technical terms for further implementation.

These elements are related to the **project assets** (vehicles and batteries), the **charging infrastructure**, and the **operational** model **described below**. Depending on the specific business model of the project, there may be different actors responsible for defining these operational aspects.

Figure 4-3 – **Operational parameters of the project**

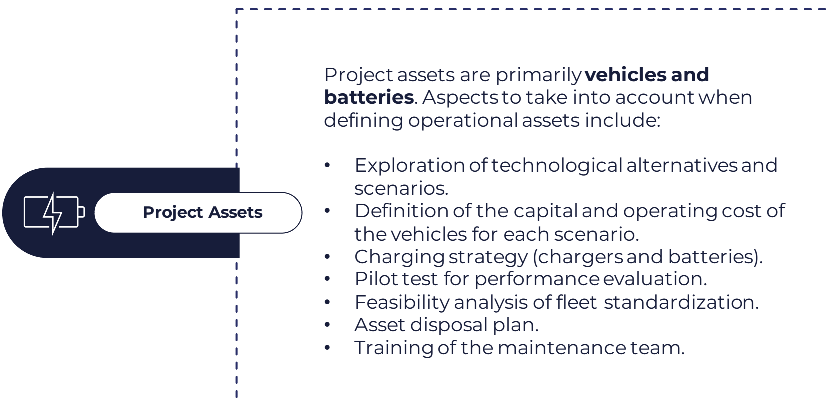


Source: Own elaboration.

4.1.1 Project Assets: Vehicles and Batteries

The vehicles and batteries correspond to the **most significant capital investment for the electromobility project** and determine several other parameters relevant to project planning. The most important decision during this project phase is the technology choice for vehicles and the **charging strategy**, which affects both the chargers to be purchased and the batteries inside the vehicles (Figure 4-4).

Figure 4-4 – **Electromobility project assets**



Source: Own elaboration.

Studies in Brazil have been conducted to identify the alternative vehicle models and battery suppliers and the technology associated with electric bus operation available in the Brazilian market [19, 20, 21]. Therefore, for the technical structuring of the project, it is recommended to explore all technological alternatives, analyze the cost required for the project, both capital and operational, and compliance with operational requirements. Table 4 **references the**

operational parameters for planning the operation of electric buses with overnight charging. Depending on the requirements of the operation (i.e., **kilometers traveled, Air-Conditioning use**) and the battery capacity of the buses, the operation may have **different financial costs related to assets' replacement in the long term**.

Table 4 – Reference operational parameters for Padron and articulated electric buses with overnight charging

	Padron	Articulated
Energy consumption with A/C (kWh/km)	1,05	1,92
Battery capacity (kWh)	350	580
Time for full charge (h)	4,4 (150 kW charger(	3,9 (150 kW charger(
Minimum battery state of charge for safety *State of Charge - SOC* (%)	10%	10%
Autonomy of new battery with A/C (km)	300	272
Maximum allowable battery degradation (%)	20%	20%
Battery life (years)	8	8
Autonomy with degraded battery in year 8 (km)	233	211

Source: Own elaboration based on interviews with BYD Brazil and WRI Brazil [22].

One relevant aspect is related to the **scale of the project** and how this impacts the associated investment costs. It is advisable to start the process **progressively**, and the incorporated fleet's initial planning and evaluation process must evaluate the **cost of a pilot test and its objectives as a future investment**. Many projects incorporate a pilot phase with a few units to evaluate their performance under operational conditions. In this way, we identify which bus typology is most appropriate to optimize the total deployment costs on a larger scale.

A pilot test could impact future decisions. For example, if an investment is made in infrastructure for the test and one wants to opt for vehicles or chargers with other characteristics after the results, these first units would represent a non-recoverable investment for the authorities. Therefore, the City Hall should not purchase the units' parts of a pilot test. Instead, the supply companies should make these vehicles available for a certain period to evaluate their performance, allowing authorities to make the most objective decision possible.

As for the impact on operating costs, for most electric bus designs, these costs are expected to **decrease compared to a diesel bus operation**, primarily due to lower energy costs (lower and more stable electricity costs than diesel) [23]. These lower costs are also ensured through proper battery management, following the good practices in Figure 4 5.

Figure 4-5 – Battery life management for electric buses

Battery Life Management

- Perform the charge cycles at regular intervals
- Do not allow the state of charge to fall below the manufacturer's minimum *State of Charge* (*SOC*) limits
- Avoid excessive use of the vehicle:
  - Do not exceed the maximum number of passengers carried
  - Maintain regular average travel speeds
  - Make use of regenerative braking through eco-driving practices
- Monitor the temperature at which the battery operates
- Perform proper maintenance:
  - Periodic review according to the manufacturer's recommendations
  - Regular balancing of the cells
  - Replacement of official spare parts

Source: Own elaboration based on Glücker et al. (2021) [24].

For proper battery management, the technical staff in charge of battery management must be trained, and the manufacturer needs to develop a monitoring process. In addition, it is recommended to realize standardized performance tests at specific moments of the battery's useful life in discharge cycles to monitor its performance.[4]

When deciding on the vehicles required for each project, it is important to consider these differences by estimating operating cost scenarios with the alternatives available on the market, considering manufacturers' benchmarks. For example, a vehicle **with a higher battery charge capacity** and, therefore, **greater autonomy** may **only** require **overnight charging in garages rather than opportunity charging during operating hours**, reducing both charging costs and the capital costs required for **more advanced charging infrastructure**. However, overnight charging buses require a more significant capital investment due to the larger battery pack.

It is important to define aspects related to vehicle acquisition, such as standardization of the technology that applies to the system and compatibility with elements such as charging infrastructure. The same technology can be applied to the whole city or region. This point becomes very relevant in the initial design phase of the project. The **fleet standardization allows savings in** the supply of spare parts, driver training and maintenance, and **large-scale purchases that reduce the unit price per unit purchased**.

4 Technical standards IEC 62660 [IEC, 2018] and ISO 12405 [ISO, 2018] define the standards for performance and reliability tests on lithium batteries for electric propulsion vehicles, as well as safety requirements.

Therefore, the entity responsible for planning the deployment must make the correct assessment of the technical and operational requirements and, if necessary, **design in advance the typology and characteristics of the network to be operated** to assess whether the technical characteristics of the vehicles to be incorporated have, for example, sufficient autonomy to operate the routes determined. In addition to the technical specifications shared by manufacturers, **it is important to check that these characteristics have been verified in real operating environments (Table 4 only shows reference values).**

Related to the previous point, the incorporation of electric fleets needs to consider the current operating model and its actors. For example, while **some cities are** migrating to business models that seek to concentrate fleet operations in one or a few companies, in others, the current operation is provided by several companies [8]. In this scenario, it is essential to discuss whether **fleet uniformity among operators is a necessary condition** or whether the regulator should establish unified parameters regarding fleets and their components (**internal configuration of the vehicle, batteries, type of charger, and type of power**) to reduce the risks associated with interoperability.

Finally, the management and disposal of assets at the end of the project term is not a minor aspect (see Figure 4-6). Regarding the final disposal of the chemical waste from the batteries, alternatives should be evaluated so that the batteries can be recycled for other uses. One possibility for proper disposal of the assets is to evaluate alternative uses for batteries once their useful life is over by reusing them in stationary storage applications, such as households or industries. It is important to consider waste treatment in the designs as electric vehicle technology expands, including exploring measures for developing a secondary market [25].

Figure 4-6 – End-of-life asset management

End-of-life asset management is a task to be done by the operator, the transport authority, or the manufacturer from the **moment the decision to migrate the fleet is made**.
The control bodies and the operators decide on the destination of the assets at the end of useful life:

- bus reuse or safe disposal of the vehicle
- battery recycling

To this end, it is essential that public transport fleet renewal projects:

- Incorporate local multi-disciplinary entities (e.g., the environmental agency) to understand the environmental and economic impact of waste disposal
- Long-term project costs for disposal and recycling of assets

Source: Own elaboration based on IDB (2019) [16].

Given that electromobility projects in public transport are recent, most projects have not yet reached their useful life initially estimated. In an industry where technological innovations are occurring rapidly, it is possible that current battery life diagnostics are conservative and that, with proper management, batteries could have a life between 10% and 20% longer than projected [24, 26].

The more extended payback periods of electric buses, compared to diesel buses, require transport operators to operate these vehicles for longer periods (from 10 to 15 years). However, after this period, the electric bus market may be further developed, **and parts' replacement and sales may reach a similar maturity as diesel's** [25, 27].

4.1.2 Charging infrastructure

The charging infrastructure required for the project **is defined together with the electric buses chosen by the city**. Thus, the technology and total cost of the chargers depend on the technology of the electric buses **(i.e., standard or articulated, overnight or opportunity charging, low-floor or high-floor, etc.)**. The cost of chargers and charging infrastructure is often inverse to the cost of electric buses, as the economics of a bus with fewer batteries represents a higher cost due to more charging points to achieve the required operation.

It is worth remembering that the cost of the charging infrastructure impacts the amortization period. Therefore, it is recommended to evaluate the operational needs to define the charging type and, consequently, the necessary infrastructure:

- **Overnight garage charging:**
  - The bus has a larger battery pack than the opportunity charging buses (ranging from 150 kWh to 550kWh) because charging is only done at the end of the day.
  - Ideal for getting to know the technology and moving forward in the transition.
- **Opportunity charging:**
  - The bus is charged along or at the route's end. Therefore, a smaller battery is required than overnight charging buses (ranging from 80 kWh to 150 kWh).
  - Implemented in systems that already have experience and advances in infrastructure by installing strategic charging points in the system.
- **Mixed charging (night and opportunity)**

4.1.2.1 Responsibility for the charging infrastructure

The definition of operation and maintenance responsibilities for the charging infrastructure must be **considered at the beginning of the projec**t. Who is responsible for the charging operation in the garage depends on the business model chosen for the project. In a traditional model, the **operator himself is responsible for the vehicle charging process. However**, depending on the project's business model (as defined in chapter 4.2 Financial Parameters), the responsibility for this process may be with the **energy**

subsidiary, the battery supplier, or the charging infrastructure provider.

A project aiming to deploy electrical technology usually requires incorporating a **key actor: the concessionaire that provides electrical services in the project area** [7]. The operators usually manage the supply for diesel fleets and are experienced in building fuel pumping stations. In the case of electric charging stations, they require **special garage linkages and technical expertise that is usually concentrated only in companies in this field**. When chargers are installed along routes, coordination with the electric power distribution company is even more critical for the **correct coverage and availability of power at the points of location of these chargers.**

Incorporating new actors demands greater coordination to ensure **that service delivery is not affected**. Power companies are increasingly interested in participating in these business models in Latin America [28], making their expertise in electric power transmission and distribution available. For example, in the case of power failures, complications with charging infrastructure, or similar issues, the power company can anticipate and avoid service interruptions and a **negative** impact on the **remuneration of the transport operator**. Therefore, system coordination and management must be addressed from the beginning, and the regulator needs to be strengthened institutionally to establish mitigation guidelines and ways to resolve conflicts beforehand.

The availability of **charging infrastructure requires additional construction work**, which can impact the operator's costs (by renting a new site temporarily or not having space to maintain the fleet), or for the city if current sites are deemed unsuitable for the installation of the required infrastructure. In addition, moving to another location can impact the project's operating model and financial costs.

Figure 4-7 – **-Summarizes the key points for defining the charging infrastructure aspects**

- **Define the charging strategy**
  - Overnight charging in Garages
  - Opportunity charging
  - Mixed charging
- **Define the responsibility for the charging service**
  - Can be assumed by the operator, energy subsidiaries, battery suppliers, or charging infrastructure providers
- **Define the location for the installation of the infrastructure and chargers**
- **Define the coordination of the actors from the beginning**
  - Aiming to mitigate possible risks and ensure continuous service delivery

Source: Own elaboration.

4.1.3 Operational Model

The operational model includes all **logistical and technical aspects necessary for the operation of the electric bus system**. These aspects refer to the definition of parameters (such as the number of vehicles in operation per driver) and the structuring of charging plans, allocation of vehicles to bus routes, the management system for the operation of electric buses, and the technical training plan for the staff.

All these aspects are defined by the city's public transport regulator for the electromobility project before bidding or allocating the operation contract. This ensures a steady and linear service quality throughout the system, **regardless of the operator or the different business models used in each project**. Figure 4-8 shows the phases of the operational model for the deployment of the electric fleet.

Figure 4-8 – Phases of the electric fleet operational model

Operational Model

All logistical and technical decisions that ensure the operation of the electric bus system

Optimization of the bus service network

- Bus line network redesign
- Allocation of vehicles to bus routes
  - Conversion Planning by Lines
  - Iterative process evaluating bus performance
- Schedule optimization of electric bus lines

Incorporation of new actors

- Coordination of power requirements with distribution company
- Definition of responsibilities of involved actors
- Definition of data sharing requirements
- Structuring an electric bus management system

Technical personnel training

- Definition of personnel requirements of the actors involved
- Mitigation of staff redundancy:
  - Capacity building planning for current actors' personnel
  - Personnel movement of bidding consortia
- Training in driving techniques to improve battery life and performance
- Alliance with international strategic players

Operation of the garages

- Modification of the garages for the implementation of the charging infrastructure
- Structuring charging plans for electric buses

Source: Own elaboration based on WRI BRASIL [10] and ITDP [29].

An electric fleet implementation project is, in essence, different from a conventional fleet implementation project. In this sense, local authorities must **be involved, and it is suggested to follow the following steps**:

- **Evaluation of** the traditional system in operation
- **Identification of** changes in the operational model for the transition from the traditional system to the system with electric buses (Figure 4-8)
- **Formulation of** the minimum technical and network parameters for electrical operation
- **Comparison of** the technical specifications of the different bidders to evaluate the best option
  - Require operational performance plan from bidders (if possible).

4.1.3.1 Otimization of the bus service network

Many energy transition projects involve the redesign of the operating grid to optimize the autonomy of the new vehicles. Developing an iterative process of a detailed analysis of the basic operational parameters is recommended, considering the implementation of vehicles with limited autonomy on the lines. Some adjustments may be necessary to the routes in operation since the performance of the buses may not be as expected (due to environmental and geographical issues beyond the scope of this authority).

Since these adjustments may result in changes in route design or system coverage area, public administrators can frame these changes in **a broader communication and marketing strategy** by completely renovating the transport system (which may include changing the name of the lines or the colors of the buses), **involving the users and getting them to participate in the foreseen changes.**

4.1.3.2 Incorporation of new actors

Implementing these projects often requires incorporating new actors that are commonly absent at the decision-**making tables of traditional public transport projects. Public transport electrification projects**, in many cases, are realized through the provision of new business models, **promoting vertical separation in the service delivery chain**, as described above. This requires new consensus, strengthening new capacities by the authorities responsible for regulation and enforcement, and developing new relationships between key players.

4.1.3.3 Technical personnel training

Another important aspect concerning the operation of electric fleets is **staff training**. Although electric buses generally have better internal technology that would optimize their maintenance and, therefore, their availability, the operation, and maintenance of these new vehicles require a staff training process that must be carried out in advance to make the transition as smooth as possible. These are some of the aspects to be considered:

Figure 4-9 – Workforce training key points in the electromobility transition

Aspects to be considered	Training Measures
Decrease in existing jobs due to the change in the business model.	• Training and staff turnover plans. • Training for the change in processes and/or new functions generated. • Work together with unions on mitigation measures for changing activities.
Cautions with the expected useful life of the batteries.	• Training drivers in driving strategies to optimize battery life with the support of vehicle manufacturers.
Increase in traffic accidents due to the low noise levels emitted by vehicles.	• Driver training to raise awareness of other low-noise vehicles, and community awareness campaigns about low-noise technologies on the road.
Change in traditional dispatching practices due to power supply needs.	• Rely on more accurate bus dispatch planning and shift allocation per driver.

Source: Own elaboration based on WRI (2022) [10].

4.1.3.4 Operation of the garages

In operational terms, the **layout of garages and buildings** used for storage and maintenance of conventional vehicles **may not be ideal for an electric operation**. Thus, it is necessary to consider the space required for vehicle charging, transformers, and any associated infrastructure. Only a minor adaptation to the conventional situation may be enough, but including this in the planning is essential, as it may affect the initial cost. Figure 4-10 shows an example of a garage in Bogotá (Colombia) that required civil construction to adapt the space for the electric bus chargers.

Figure 4-10 – **Adequate garage with charging infrastructure in Bogotá'**

Source: El Tiempo (2021) [30].

All aspects mentioned above that imply a transition to electric fleets need to be considered in planning **to minimize the associated risks and costs**. Municipal authorities can conduct a thorough analysis that allows them to identify the main risks, assess whether the benefits outweigh the associated cost, and thus define strategies to make this transition as cost-effective as possible. The alignment process with current or potential operators **is essential to assess the minimum requirements to minimize the transition's impact** on service delivery and the financial parameters described in the following chapter.

4.2 FINANCIAL PARAMETERS

Due to the high capital costs required for implementing electric bus projects, **financial structuring is essential for project feasibility**. The main aspects identified to be considered and defined during the financial structuring process are:

1. **Cost Analysis**
2. **Business Model Definition**
3. **Resource Mobilization**
4. **Financial and profitability indicators**

These aspects are not necessarily developed in chronological order but are evaluated simultaneously in an iterative process since decisions made regarding each one directly impact the others. For example, the **online** platform **Financial Hub, presented in Figure 4-11, is an open tool where Brazilian cities and financial institutions** meet and share interests in structuring and financing projects.

Figure 4-11 – Financial Hub for the electromobility transition in Brazil

Source: Own elaboration.

The ***Financial Hub*** tool was designed to assist in **making decisions** regarding the financial structuring of the project.

With this tool, **transport entities** and **cities** can get an overview of how the aspects discussed in this chapter relate to and affect each other. These parameters are defined in the platform for cities and for financial institutions.

4.2.1 Cost Analysis

While the project's total cost of ownership (TCO) analysis was one of the parameters defined during the pre-feasibility and planning phase, financial structuring is an opportunity to develop an accurate cost analysis with the knowledge gained during operational planning. Aspects such as the **project objectives, the project schedule, and the bus and charger technology chosen by the city for the system, among others, directly affect the TCO of the project**.

It is recommended to perform financial statements or cash flow analyses for the project schedule, detailing capital, operating, and fiscal costs, among others. In addition, it is important to include expected revenue over the project term, which requires knowledge of the system's demand projections and expected tariff increases. This analysis should be very detailed. For example, one can consider the reduction in operating costs resulting from the expansion of the electric bus fleet, the reduction in battery costs and improved battery performance in the future, and even the effect on demand that the modernization and redesign of the bus system could cause.[5]

When conducting the cost analysis, it is important to remember that electric bus projects for public transport are an iterative process. Decisions made regarding the project's business model, financing, and interest rates of the financial products purchased for the project directly affect present value costs.

Performing several analyses on different scenarios of the business model and financing lines is necessary to understand how the TCO of the project relates to the business model and the city's electric bus project or the chosen financing alternative. This issue is discussed in the next chapter.

4.2.2 Business Model Definition

The definition of the business model is one of the most critical aspects in structuring the entire project. It determines the actors that play a role in the electric bus project and, to a large extent, the risk associated with the capital investment. Four main business models are considered for an electric bus project. Figure 4 12 shows the possible operational models for an electric bus operation.

5 The TCO assesses the cost structure associated with the purchase and operation of an electric bus fleet. There are other relevant aspects, such as socio-environmental factors and externalities related to the reduction of pollution, emissions and noise in the public transport sector, and the consequent improvement in the quality of life and health of the population, which positively affects the evaluation of the impact of technological change. These benefits, that should be considered when deciding to invest in the deployment of electric fleets, are discussed in the chapter 4.4 Parâmetros socioambientais

Figure 4-12 – Operational Models

Traditional	Vertically integrated	Shared responsibility	Public Operation
✓ **Operator** is primarily responsible for the **availability of the** bus service ✓ **Operator's own resources** with corporate financial instruments ✓ **Little** public **control** and supervision	✓ **Operator** is primarily responsible for the **availability of the** bus service ✓ **Operator's own resources** with corporate financial instruments ✓ Public transport **concession contract**	✓ **Private** operating **company** is responsible for bus service **operation** and **maintenance** ✓ Another **private company** or the same **public entity** owns the **fleet** and/or the **infrastructure** ✓ **Public Bidding** Process	✓ **Government owns and operates** the entire public transport system ✓ It is possible to **outsource** some minor aspects of the operation, such as **maintenance**

Source: Own elaboration.

Although the possibility of implementing some of these business models may vary depending on the institutional set-up, for electric bus projects, it is preferable to have new players that lower the associated risk compared to **a traditional model in which the operator assumes most of the risk**. In the traditional model, the new partners may be reluctant to participate in a project of electric fleet transition. The presence of these new players **increases the overall debt capacity of** the project and makes it possible to acquire financial products that reduce costs and **increase the project's viability.**

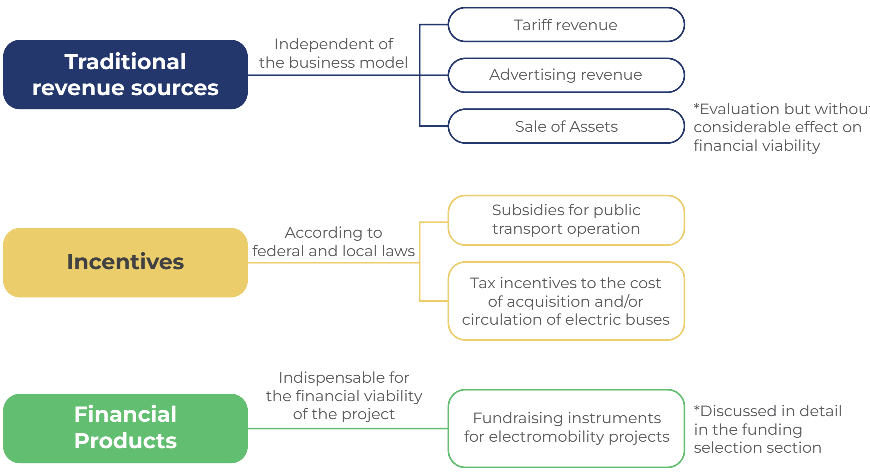
Regardless of the business model chosen by each city, the term defined for the project must correspond as closely as possible to the useful life of the assets (vehicles and batteries). This is **beneficial both for the bidding operators** and **the granting authority** that defines the requirements for assets' disposal at the end of the project and **for the financial agents or companies** that may own the assets and do not need to **purchase new vehicles to meet the technical requirements of the system**. In addition, it may not be necessary to consider the residual value of the assets within the project's profitability analysis.

However, it is also important to define the requirements for the final disposal of batteries and vehicles before the project bidding process to mitigate adverse environmental effects, discussed in more detail in **chapter 4.1.1 Project assets: vehicles and batteries**.

4.2.3 Sources of funds

Regarding traditional revenue sources that should be considered in the cost analysis and financial structuring of the project, regardless of the business model, this section elaborates on existing financing or subsidies, tariff revenues, advertising and other revenues during operation, and even revenues from asset sales. Tariff revenues are typically used to cover operating expenses and not for capital investment in system assets, but this **does not eliminate the need to include them in the financial structuring of the project**. In addition, revenue from advertising on vehicles, bus shelters, and charging stations, coupled with increased interest in innovative electric bus technology, may help reduce potential funding shortages during bus operations. In Figure 4-13 is presented the **summary of possible funding sources for electromobility projects**.

Figure 4-13 – Sources of funding for electromobility projects in public transport



Source: Own elaboration.

Regarding the sale of assets (vehicles and batteries), although it is advisable to analyze scenarios in which revenues equivalent to the residual value of the assets can be generated, the secondary market for used electric vehicles and batteries has not yet been fully explored. Therefore, this type of revenue should not considerably affect the project's financial viability. However, there are increasing cases of battery reuse in other industries and advances in the battery life of electric vehicles, which **represents a potential for future revenue generation for those who purchase the batteries** [24].

For financial structuring, it is also crucial to consider the incentives for sustainable public transport projects, such as electric bus systems. This includes subsidies for the operation of public transport, which are generally the same as for conventional bus systems, and tax incentives applicable to the acquisition cost of electric buses and, to a lesser extent, to the costs associated with operation.

Despite the ability of the system to generate these revenues, the financial viability of an electromobility project depends on financial products' acquisition and the debt capacity of the actors involved in the project. This financing **is provided by multilateral agencies and by Brazilian financial entities interested in** this type of project. The positive evaluation that these entities give to the project's financial viability ensures low-interest rates that reduce the associated costs. For this reason, a detailed financial structure that **considers all the parameters outlined in this section** is essential for accessing adequate financing lines and for the project's successful implementation. In the section **5.1 Funding Sources** are discussed these financing lines available in the Brazilian market.

Political and regulatory aspects also considerably affect the financing alternatives applicable to the project. For example, electromobility projects in a city that has made progress in the institutional organization of transport regulators and has regulatory and contracting frameworks for such projects are well received by the financial institutions evaluating the project. **Chapter 4.3 Regulatory Parameters** elaborates on examples of rules and regulations achieved in Brazil that have a positive impact. In addition, the process for defining the best financing alternative for each specific electromobility project is developed in chapter **5.2 Selecting the best financing option**, detailing the conditions for choosing the financing alternatives.

4.2.4 Financial and profitability indicators

A financial structuring that fits the reality of the project's city depends on access to resources to carry out the project and on an interest rate respecting the payment capacities of the implementer. Therefore, the indicators shown in Figure 4-14 should be considered:

Figure 4-14 – Financial and profitability indicators for project success

Funding Rate

This value is a reference for the municipality or other project guarantor when obtaining grant funding from actors, such as the federal government or multilateral agencies, whose agenda prioritizes this type of project.

Project IRR

Indicates the ratio between the **investment made** and the project's **free cash flow.** This value is useful for analyzing the potential return on investment and generally, it should be higher than the cost of capital of the company or entity that is evaluating the project to decide to undertake it.

Equity IRR

Considers the financial structuring of the project and the existence of debt when **calculating the return on equity-related** cash flows only. If the required amount of equity capital is lower, the project's profitability tends to increase because debt instruments tend to be less expensive than equity instruments.

Debt coverage ratio

It is the ratio between **net operating income** and **total** debt **obligations** in a year. A debt coverage ratio of less than 1 indicates that the debtor cannot cover its obligations with its revenues and would be forced to seek funds from sources other than its operations. Values above 1 indicate that the debtor can cover all its obligations with its income. However, an ideal value ranges between 1.25 and 2, as it evidences a high payment capacity by the debtor and is the minimum debt coverage ratio usually requested by lending institutions.

Source: Own elaboration.

These financial indicators are not the only ones to be considered during the project's life but are the most important in the **initial financial structuring phase**. TIn chapter **6.1 Granting Mechanisms** is developed a set of indicators that need to be monitored during project operation.

The following presents the **regulatory parameters to be revised to award or modify concessions or contracts** applicable to electromobility projects and the federal, state, and municipal taxation structure.

4.3 REGULATORY PARAMETERS

For implementing the proposed financing mechanisms, regulatory instruments, for review or update, in some cases, are presented below.

The development of a specific **legal framework** for the implementation of bus fleet renewal begins with **general guidelines** set at the **national level** and continues with **regulation** at the **municipal** level.

This regulatory framework includes specific goals and deadlines for implementation as well as particular incentives, such as those presented in Figure 4-15:

Figure 4-15 – Incentives from the regulatory framework

01	**"Phased" obligation**	Federal-level obligation for operators to **renew** existing bus **fleets in** phases (percentage per period), and an obligation for **new operators to use** battery **electric buses** (complete or a percentage)
02	**Special Grants**	**Subsidies for electric vehicles** distinguishing and prioritizing technologies that generate fewer emissions, fiscal and tax measures, financial and economic mechanisms (in which the proposed financial models could be included)
03	**Tax benefits**	**Tax benefits for the manufacture and acquisition of electric buses** in the country and their complements, such as batteries and recharging infrastructure
04	**Reduced import cost**	**Temporary reduction of import tariffs** for new, unused buses powered exclusively by a battery electric motor (and its complements) to favor the local production of these technologies

Source: Own elaboration.

4.3.1 Bidding and contracts

Concerning the new bids and contracts composing the financial structuring of the project, the following actions are recommended for two possible scenarios: new bids and already signed contracts that have not yet reached the end of the concession period:

A. **New tenders:** provide in the tender documents: a) clauses requiring electric buses; or b) favor those that include an electric fleet powered by renewable energy sources and/or emission reduction targets; c) promote the integration of consortia in tenders and joint ventures with different entities, e.g., with energy suppliers.

B. **Contracts already signed and based on a regulatory framework:** as provided for in the obligation pointed out above (e.g., imposing a fleet renewal obligation in stages), the possibility of introducing an obligation to renew the fleet currently operated by the operator (or a percentage) should be evaluated in each case, either by agreement of the parties or by a unilateral modification by the operator. Feasibility and consequences (for example, the contract's economic-financial rebalance) depend on analyzing all municipality regulations and specific contract clauses.

To enable the **participation of energy distributors in the financing models**, Article 8 of Law No. 10,848 (Sale of Electricity) would need to be changed, as it does not allow these entities to perform activities outside the scope of the concession, permission or authorization (except in the cases foreseen in the law and the respective concession contracts).

4.3.2 Taxation

In this Step 3 of the parameter formulation, it is essential to **identify the taxes related to the acquisition and operation of the electric buses**. Some of the taxes vary between states, such as IPI or ICMS. Four central taxes focus on importing an electric bus or its components [31]:

Figure 4-16 – Brazilian taxes on electromobility projects

Import Tax (II), levied when the bus enters the national territory and with a rate for the complete (assembled) electric vehicle of 35%.

Tax on Industrial Products (IPI), whose rate is linked to the vehicle's technical specifications and characteristics, ranging from 7% to 25%.

Social Integration Program (PIS) and Contribution for Social Security Financing (COFINS), which added together can reach values higher than 15%.

Value-Added Tax on Goods and Services (ICMS), the only state tax on the list, generated when a good or service circulates within or out of the state, with a rate of up to 20%.

Source: Own elaboration.

There are several examples in Brazil of tax incentives that could be applied for a more affordable electric bus acquisition, given the urgency of the transition. One example at the federal level is **the *Ex-Tarifário* regime**, in which the import tax on components or even the entire vehicle can be reduced. In 2016, for example, the Chamber of Foreign Trade (Camex), which governs the Import Tax, temporarily reduced to 2% the rates on a series of capital goods, including essential components of electric buses.

In addition, a temporary reduction of import duties could be provided for new, unused buses **powered exclusively by an**

electric motor (and its accessories), **also seeking local production** (for example, reducing the rate to 0% if the applicant has a local production plan for these goods).

Next chapter elaborates on the social and environmental benefits that largely justify the realization of the electromobility transition project. In addition, the inclusion of these social and environmental parameters depends on the governance in place at the implementation localization, issue explored in the following chapter.

4.4 SOCIO-ENVIRONMENTAL AND GOVERNANCE PARAMETERS

The social and environmental benefits from the transition to electromobility can trigger medium- and long-term positive impacts on the economy and achieve GHG and local pollutant emission reduction targets. Fleet renewal improves air quality and public health in cities. In addition, Latin American countries with advanced electromobility projects **see the growing market for electric drive technologies as a way to create jobs** through new opportunities in manufacturing, infrastructure, and services. [28].

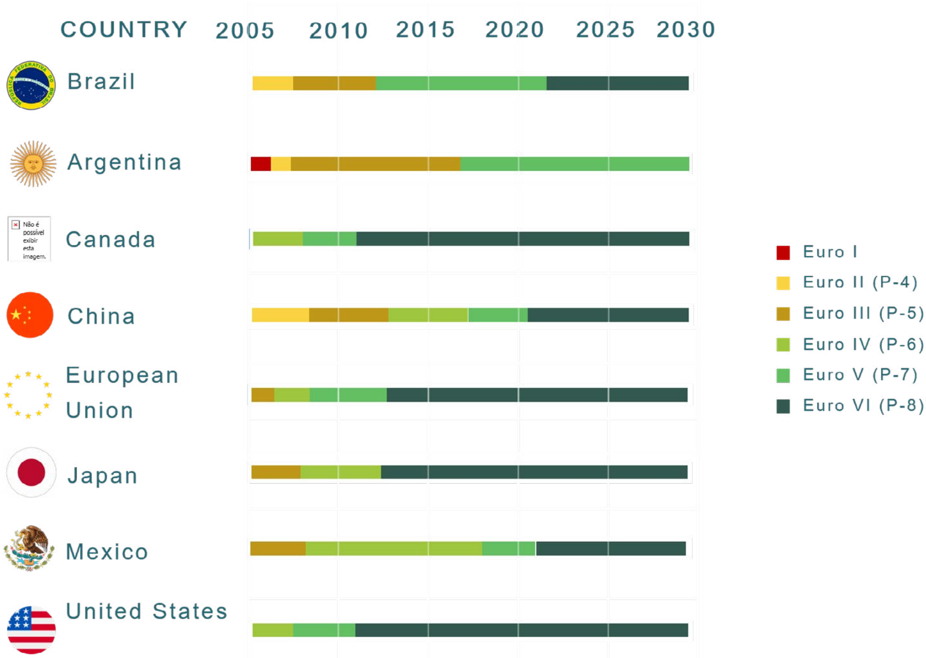
Financial institutions, especially multilateral and development banks, primarily focus on emissions generation and mitigation benefits. Below are presented the main environmental and social benefits and needs in governance to **monitor and secure these benefits**.

4.4.1 Environmental Benefits

The transition to electromobility means cost savings for healthcare systems in cities. In addition, the exchange of polluting diesel buses with combustion P-5 or lower technologies represents a decrease in the concentration of nitrogen oxides and particulate matter in the city air. To quickly achieve these environmental and health goals, **countries ban in stages the purchase of new buses and freight vehicles that do not meet a minimum** engine **emission technology** [3].

Figure 4-17 shows a timeline of heavy vehicle technology legislation in Latin American countries and worldwide. Brazil has planned to purchase buses with at least a P-8 technology since 2022. In Latin America, Brazil is one of the countries that already require the incorporation of Euro VI or P-8 technology in public transport fleets.

Figure 4-17 – **Legislation of engine technology of the bus fleet in Brazil and other countries**



Source: own elaboration based on PNME (2021) [9] and Telles Pascoal et al., 2018 [3].

In addition to the benefits of air quality and the population's quality of life, the transition to electric buses brings a further advantage. Electric buses do not **depend on oil and are, therefore, less susceptible to fuel market price variations and instabilities in** production and distribution [10].

4.4.2 Social benefits

The deployment of electric fleets represents a challenge to ensure the maintenance of current jobs and the social inclusion of all sectors of the population of a growing market and industry. However, the transition to electromobility can encourage the deployment of new factories to supply the vehicles and the charging infrastructure components to provide electric power.[8]

A key aspect in identifying the potential for job creation is initiating workforce adaptation plans by the implementer and the transport operators. These plans are the managing documents that guide the project to integrate workers who participated in the diesel operation.

4.4.3 Governance

The governance aspect of the political and institutional sector is crucial in any region of the world. This element refers to different public and private institutions' presence, involvement and incentives. In addition, there must be a temporal synchronization of interests at the political and regulatory level in the three spheres of government (municipal, state, and federal) and with the market. Aligning agendas across different levels of government and at various institutional, public, and private levels is necessary to overcome constraints parallelly.

The multiplicity of municipalities and organizations **defining different policies**, with divergent objectives, in terms of time or purpose, means that the financial sector can concentrate efforts on particular places or specific projects, leaving aside others with equal impact but less "attractive." To articulate efforts and to make visible the **social and environmental benefits to attract funders to electromobility projects**, the implementer can seek the coordination of the actors that articulate and lead the initiatives of the electric vehicle projects. Figure 4-18 details this identification of the actors that "govern" the transition.

Figure 4-18 – Project governance definition

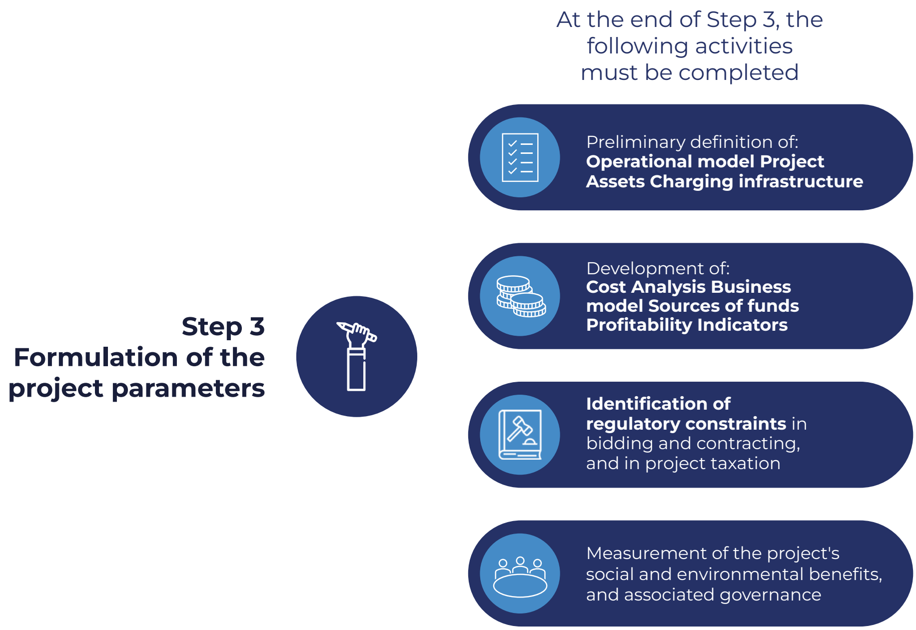
Who governs?	How to govern?
Define, identify, and classify the actors that articulate within the project in the local context	Identify and characterize the instruments created to develop the Project and other electromobility actions
Identify the role of: → The political sector → The Vehicle industry → The electric sector → The innovation sector → The universities → Operators of public transport services	→ Scaling the city's autonomy → Understand the presence or lack of genuine interest of rulers → Identify facilitatinf public policies → Identify laws and strategic plans in the municipality

Source: Own elaboration based on WRI Brasil (2022) [10] and CAF (2019) [13].

For example, the National Platform for Electric Mobility (PNME) articulates actors and transfers knowledge to municipalities and the federal public sector [4]. The PNME serves as an example of an institution that concentrates on the supply and articulates the way of "governing" all the actors shown in Figure 4-18 to establish long-term goals and plans that facilitate the search for funding and project implementation.

Figure 4-19 shows the activities expected to have been implemented by the end of Structuring Step 3.

Figure 4-19 – Design parameter formulation steps, Step 3 summary



Source: Own elaboration.

The next step analyzes the form of evaluation and selection of financing with financial institutions to materialize the electromobility project.

5.

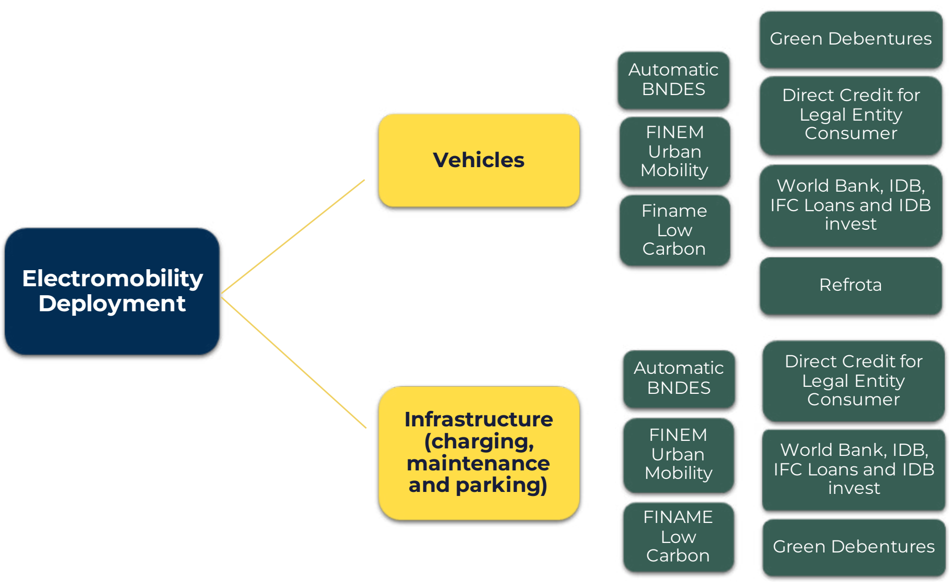
STEP 4: FINANCING EVALUATION AND SELECTION

Step 4 for implementing electromobility in public transport systems consists of searching for funding sources and evaluating and selecting them. **There is a growing list of funding sources in Brazil that** cities and all interested parties can access.

5.1 FUNDING SOURCES

There are lines of credit for financing infrastructure and the purchase of vehicles. However, purchasing batteries does not have specific lines and requires other modalities besides the traditional credit offered by development banks (see Figure 5-1).

Figure 5-1 – **Summary of financing lines**



Source: Own elaboration based on BNDES, IDB, World Bank, MDR, IFC [1, 32] and interviews with banks.

The resources from the existing lines can be combined for a better risk-return commitment and respective economic-financial viability (see details in Table 5). However, whatever the combination, the **risk of operator non-compliance needs to be minimized or mitigated**. This represents a point of attention. The limitation to access credit lines or financing comes from the conditions of **financial sustainability of** the operators and, therefore, from the capacity of indebtedness and cash generation (which ultimately relates to the tariff policy of the public transport concession).

Table 5 – Financing lines available for the implementation of electromobility projects: total purchase of vehicles or charging infrastructure and maintenance

Funding Sources	Financing object	Financing Conditions	Guarantees and Counterparts	Financed Amounts	Interest Rates	Deadli-nes	Grace period
BNDES Automatic	Vehicle acquisition or infrastructure implementation (requires CNAE activity classification)	Up to 100% of the value	Free negotiation between the accredited financial institution and the beneficiary of the financing. Possibility of using the BNDES FGI (Investment Guarantee Fund) to complement the guarantees offered by the company.	Up to R$150 million for business investment projects	0.95% per year + Selic Rate or TLP or TLB + financial agent's rate	Up to 20 years	Up to 3 years

Funding Sources	Financing object	Financing Conditions	Guarantees and Counterparts	Financed Amounts	Interest Rates	Deadlines	Grace period
FINEM Urban Mobility	Studies and projects; civil works; assemblies and installations; vehicles and tools; training; pre-operating expenses; new domestic machinery and equipment credited to the BNDES; and imported machinery and equipment without similar national equipment	For micro, small, and medium-sized enterprises (MSMEs), up to 100% of the financial items. For states and municipalities, up to 90% of the project's total value, limited to 100% of the bankable items. For other clients, up to 80% of the project's total value, limited to 100% of the bankable items.	For direct support: real guarantees (such as a mortgage, pledge, fiduciary property, receivables, etc.) or personal guarantees (such as surety or guarantee), defined in the analysis of the operation. For indirect support: negotiated between the accredited financial institution and the customer. The BNDES can underwrite up to 50% of the value of the Bonds issued by the beneficiary for the execution of the project. In this case, the sum of the financed amount and the subscribed Bonds, which corresponds to the BNDES' total support, cannot exceed 80% of the total value of the bankable items.	Minimum of R$ 40 million	Direct support (TLP + 1.3% per year + variable credit risk rate according to the client's risk and financing terms) Indirect support (TLP + 1.45% per year + Financial Agent Rate negotiated between the institution and the client)	Up to 34 years old.	Up to 6 months after the project is put into operation

Funding Sources	Financing object	Financing Conditions	Guarantees and Counterparts	Financed Amounts	Interest Rates	Deadlines	Grace period
FINAME Low Carbon	Financing for the acquisition and commercialization of solar and wind power generation systems, solar water heaters, electric and hybrid buses and trucks, and those powered exclusively by biofuels and other machinery and equipment with higher energy efficiency indices or that contribute to the reduction of greenhouse gas emissions. All the products must be new, of national manufacture, and accredited in the Finame Accreditation (CFI) of the BNDES System.	Up to 100% of the value	Free negotiation between the accredited financial institution and the beneficiary of the financing. Possibility of using the BNDES FGI (Investment Guarantee Fund) to complement the guarantees offered by the company.	Not Informed	TFB, TLP or Selic + 0,95% p.a. + Financial Agent Rate (up to 3,5% p.a.)	Up to 10 years	Up to 2 years. In BNDES Fixed Rate financing (TFB), the grace period is up to 1 year.

Funding Sources	Financing object	Financing Conditions	Guarantees and Counterparts	Financed Amounts	Interest Rates	Deadlines	Grace period
Refrota	Public and private sector financing for the implementation and upgrading of systems and improvements in urban mobility for people – types of bus transport system vehicles: 1: Minibuses, Minibuses, Mini-buses, and basic buses; 2: Padron Bus, Articulated Bus, and Biarticulated Bus.	Up to 95% of the investment value	Minimum counterpart of 5% of the investment value	Not Informed	6% per year + Interest differential rate up to 2% + Credit risk rate up to 1% + Credit risk rate up to 1%.	Up to 20 years	Up to 48 months
Green Bonds	Projects providing relevant environmental benefits in urban mobility, public transport, and sanitation.	Variables	Guarantee backed by receivables, but with mitigation of the operator's risk through additional guarantees (real or with third-party endorsement)	Depending on the guarantees offered	Dependence on market conditions (For 2022, between 6.9% and 7.4% per year)	Depends on the market	Depends on the market

Funding Sources	Financing object	Financing Conditions	Guarantees and Counterparts	Financed Amounts	Interest Rates	Deadlines	Grace period
Commercial Banks CDC-PJ (Direct Credit to Legal Entity Consumer)	Intended for purchasing durable goods and services or even without a specific purpose.	Depending on the borrower's risk profile and the specific characteristics of the projects	In rem guarantees and third-party endorsement guarantees	Depending on the guarantees offered	Dependence on market conditions and guarantees offered (For 2022, equal to or above 9.8% per year)	Depends on the market	Depends on the market
IFC Loans	Loans to the private sector for the acquisition of durable goods such as vehicles, machinery, equipment, and civil works associated with the projects	Depending on the borrower's risk profile and the specific characteristics of the projects	In rem guarantees and third-party endorsement guarantees	Depending on the guarantees offered	Dependence on market conditions and guarantees offered (For 2022, between 8.5% and 9.8% per year)	Depends on the market	Depends on the market
World B ank	Loans to the public sector for the purchase of durable goods, such as vehicles, machinery, equipment, and civil works associated with the projects	Depending on the municipality's risk profile, the country's risk level, and the specific characteristics of the projects	Sovereign Guarantees	Depending on the guarantees offered	Dependence on market conditions and guarantees offered (For 2022, between 8.5% and 9.8% per year)	Depends on the market	Depends on the market

Funding Sources	Financing object	Financing Conditions	Guarantees and Counterparts	Financed Amounts	Interest Rates	Deadlines	Grace period
IDB Invest	Loans to the private sector to purchase durable goods such as vehicles, machinery, equipment, and civil works associated with clean energy projects	Depending on the borrower's risk profile and the specific characteristics of the projects	In rem guarantees and third-party endorsement guarantees	Depending on the guarantees offered	Dependent on market conditions and guarantees offered (For 2022, between 8.5% and 9.8% per year)	Depends on the market	Depends on the market
IDB	Loans to the public sector for the purchase of durable goods, such as vehicles, machinery, equipment, and civil works associated with the projects	Depending on the municipality's risk profile, the country's risk level, and the specific characteristics of the projects	Sovereign Guarantees	Depending on the guarantees offered	Dependence on market conditions and guarantees offered (For 2022, between 8.5% and 9.8% per year)	Depends on the market	Depends on the market

Source: Own elaboration based on BNDES, IDB, World Bank, MDR, IFC, and interviews.

Most of the incentivized financing is made available by BNDES. Only Refrota is offered by Caixa Econômica Federal (with resources from the Ministry of Regional Development).

The CDC-PJ modality is the most common among commercial banks. They require real guarantees and/or third-party endorsement. The vehicle manufacturers' banks adopt the CDC-PJ for financing fleet acquisitions made by urban transport operators.

On the other hand, Green Bonds are treated as "incentivized infrastructure Bonds" regulated by Federal Law 12,431/2011, as amended by Law 12,715/2012, which defines the forms of access to tax benefits. Thus, these debt securities can constitute attractive assets in investment portfolios of the "green finance" or ESG type (funds that value private actions in favor of the environment and social and corporate governance directed to minority shareholders).

The potential for **green bonds associated with electromobility projects to be purchased with resources from the European Union (EU)** through the new LAGREEN fund stands out. In 2020, the European Union Investment Center for Latin America (LAIF), the German Ministry of Cooperation (BMZ), and the German Development Bank (KfW) signed an agreement for a €15 million EU contribution to the Latin American Green Bond Fund, known as LAGREEN.

LAGREEN covers especially **first-time issuers** and those committed to transparency and the environmental quality of the underlying assets. In addition, all sectors defined in the **Green Bond Principles** that meet targets for greenhouse gas emissions reduction, climate change adaptation, and biodiversity conservation are eligible investment targets. That is, the eventual green Bonds of electromobility projects are eligible.

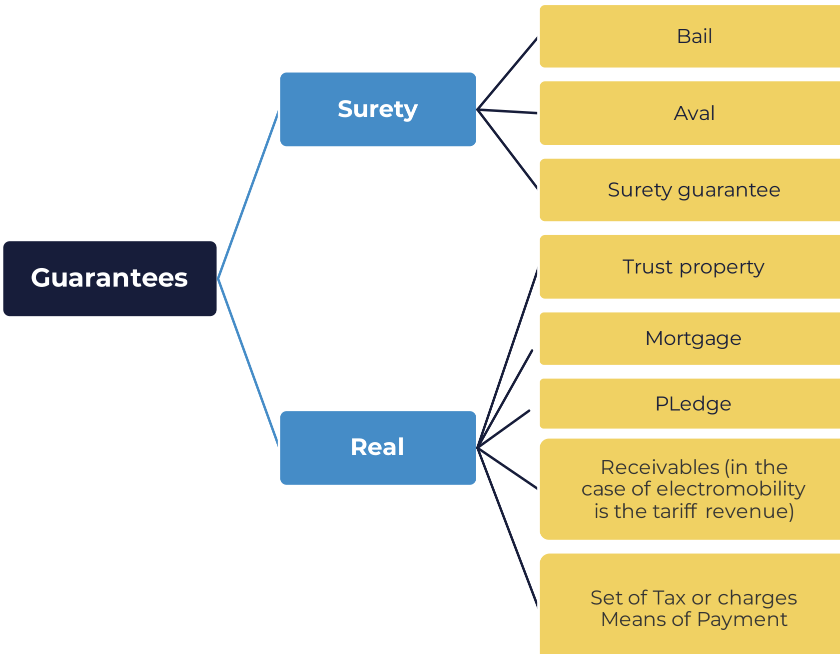
This initiative is complemented by another already underway in Brazil. The German Development Bank (KfW) has chosen five Brazilian cities to finance sustainable urban mobility projects (Curitiba, Fortaleza, Recife, Salvador, and Guarulhos). The initiative is part of a cooperation agreement between the European institution, BNDES, and the Ministry of Regional Development. The contribution of 450 thousand Euros includes the five projects. The resources for the pre-feasibility studies of these projects come from the German government (Ministry for Economic Cooperation and Development - BMZ), and the contracts are carried out directly by KfW.

Multilateral institutions, in turn, can be divided into two blocks: public-sector financing and private-sector financing. The World Bank (WB) and the Inter-American Development Bank (IDB) provide public-sector financing. They can offer financing to municipal administrations to implement infrastructure and acquire vehicles.

The advantage lies in the possibility of acquiring imported machinery and vehicles - BNDES preferentially finances equipment produced in Brazil (although there is a list of "exceptions"). On the other hand, the financing needs the approval of the Executive and the Federal Senate since sovereign guarantees are required. **On the other hand, the IFC and IDB Invest finance private companies - however, the companies must comply with the requirements for granting credit and guarantee offer** - in addition to the exchange rate risk represented by loans in foreign currency. Therefore, during this evaluation process, cities need to consider the **limitations of the type of company to be financed**.

Regardless of the type of loan contracted, all require guarantees. The guarantees can be of two types: real or fiduciary (third party) – see Figure 5 2 summarizing the typical guarantees for financing the acquisition of vehicles, machinery, and equipment. The biggest challenge is to build a **combination of guarantees** that make the financing of vehicle and infrastructure acquisitions viable and reduce the associated risk.

Figure 5-2 – Overview of the possible guarantees



Source: Own elaboration based on BNDES requirements.

Warranty is crucial in any financing, and it is no different in the case of electromobility. However, the vehicles do not yet have a secondary market with resale liquidity, the batteries have a relatively short life span, and the other equipment for charging are application-specific assets. These characteristics imply that the real assets are not sufficient warranties in granting loans and additional warranties - surety - have to be added.

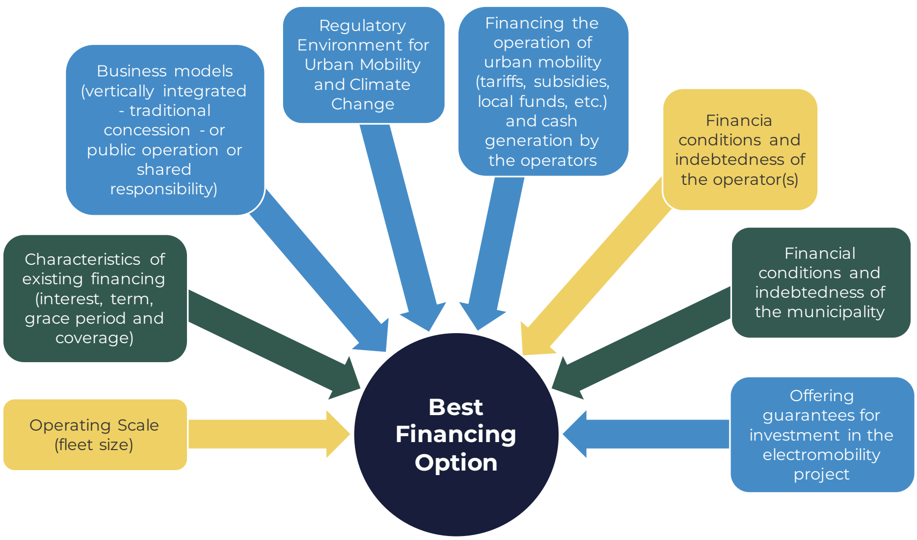
One possibility is for the municipality to act as a guarantor when there is no interest or financial viability on the part of the specialized private sector companies. Thus, the municipal government would provide part of the third-party surety guarantees. However, the combination with public sector guarantees to ensure amortization conditions by the concessionaires and the operating conditions of the system can also present complications since they depend on the fiscal conditions of the municipalities and their respective legal frameworks and budget provisions (such as the existence of funds or resources previously allocated for this purpose).

The conditions of local public finances also deserve attention due to **budgetary constraints**, whether for the **viability of resources for** the local counterpart of financing and investments, to guarantee resources for the public consideration in cases of PPP, or the programming of resources aimed at the subsidies needed for the provision of services by concessionaires (exposed in Part B of this document).

5.2 SELECTING THE BEST FINANCING OPTION

Due to Brazilian cities' specificity, no single business and financing model meets their specific needs and conditions. Private actors and municipalities must adopt or develop a business model more adequate to the local reality and choose the best financing option [2]. The **Brazilian reality is too diverse to think of a "Brazilian model"** in the same way that one speaks of a "Chilean model" or a "Colombian model." The "Brazilian model" under development may not have a specific financing pattern but a portfolio of alternatives that fit the different sizes of municipalities and their respective scales and capacities, as illustrated in Figure 5-3.

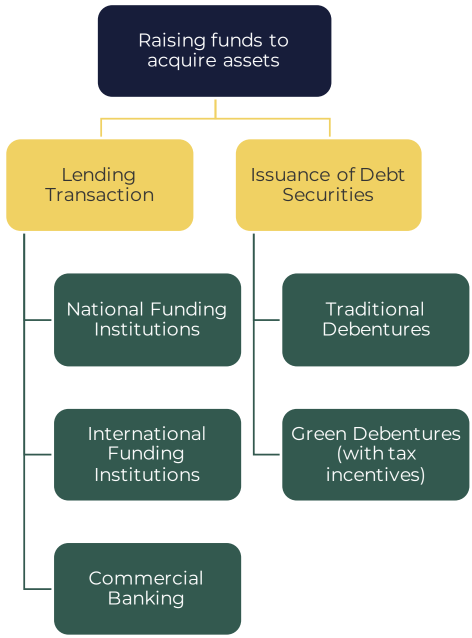
Figure 5-3 – Constraints for selecting the best financing option



Source: Own elaboration.

The **Financial Hub** tool developed by the Ministry of Regional Development takes into account these different possibilities for selecting the best financing according to the business model, the municipality's regulatory framework ("regulatory feasibility"), the project's guarantees, the municipality's credit rating, and the beneficiary of the vehicle financing (municipality, PPP, operator, etc.).

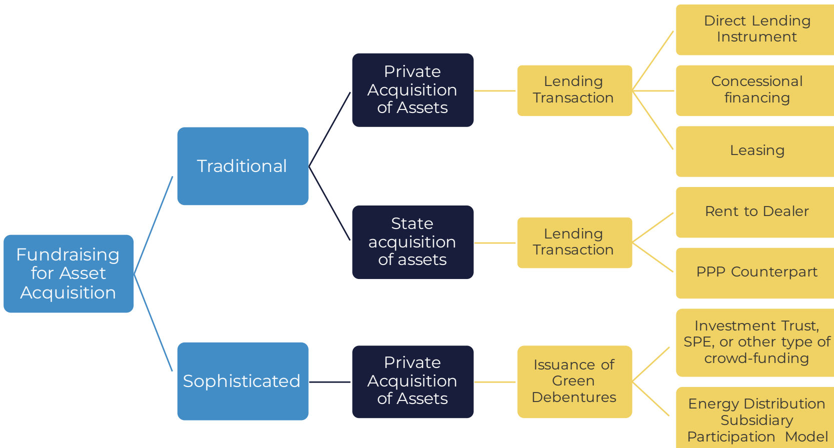
Figure 5-4 – Alternatives from fundraising



Source: Elaborated by the author.

Situations with larger fleets and a public transport regulatory structure that allows for other contractual arrangements - other than **just traditional concessions** - **can access alternative funding sources** (as shown in Figure 5-4) and not rely solely on loan agreements. In this case, mechanisms with the participation of energy subsidiaries or the creation of Special Purpose Entity (SPEs) may be feasible - as illustrated in Figure 5-5.

Figure 5-5 – Funding options for fundraising



Source: Own elaboration.

Among the elements presented in the systematizations above, there is a set of conditions of high complexity for most municipalities. In addition to the technical management and governance conditions for, for example, the establishment of **Special Purpose Entities (SPE)**, there are numerous difficulties related to risk and guarantee management.

The SPE, however, may represent the alternative with the lowest financing interest rate. This is because there are other additional guarantee instruments, such as the so-called **covenants**, which are "obligations to do or not to do," whose purpose is to monitor the cash flow of the project or the company. The lender imposes these obligations and restrictions on the financing contract (or debenture indenture) on the borrower (project) and, in some instances, its shareholders [33].

Covenants, in the specific case of SPEs [34], are mechanisms of control and intervention in the electromobility project that aim at:

- Ensuring that the SPE builds and operates the electromobility project according to the expected technical and economic premises.

- Alerting creditors in advance about potential problems or deviations; and

- Protecting the guarantees pledged. So they go beyond the borrower's obligation to pay interest and notional, comply with legislation, and build, operate and maintain the project.

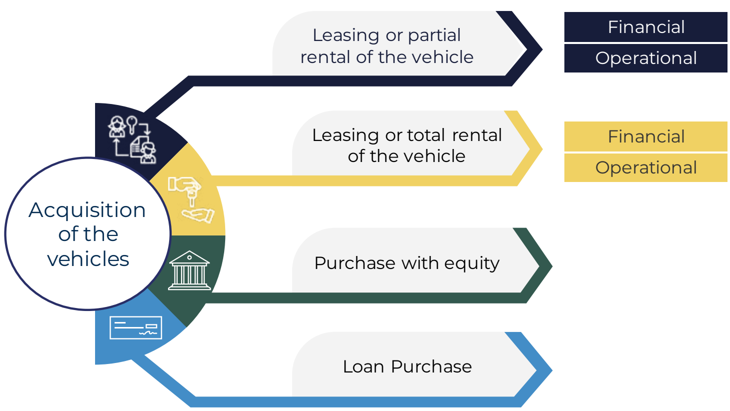
Some of these obligations and restrictions are in effect until **completion** (physical or financial). Others are in force until the financing is fully liquidated. Their non-compliance, when not consented to by the **waiver**, brings specific contractual penalties.

Precisely because they have additional guarantee mechanisms and allow the investor more control over the investment project and its management, the business models involving PPP resulting in an **SPE** are associated with **lower interest rates** than traditional or vertically integrated models.

In turn, **leasing** (total or partial) is an attractive possibility for requiring less complexity from the parties involved and presenting more attractive interest rates. Therefore, **leasing** operations in Brazil are characterized as **lease operations**, a financial modality that involves the fiduciary alienation of the asset, and are regulated by the Central Bank of Brazil (Bacen) and can only be carried out through a financial institution or a company authorized explicitly for this purpose. This is established in Bacen Resolution no. 2309, article 1 [35].

However, due to the financial and indebtedness conditions of the operators or the requirement of guarantees for a set of municipalities, the feasibility of introducing electromobility can take the form of rent - as in the cases of São José dos Campos, Salvador, or even São Paulo. The vehicles' acquisition (and other assets) can be made by the municipality (responsible for contracting the loans) and leased to the operators under a contract in which they are responsible for their maintenance. In other cases, the vehicles can be acquired by the private sector. Figure 5-6 presents the forms of acquisition of the vehicles in general.

Figure 5-6 – Vehicle acquisition possibilities



Source: Own elaboration based on WRI Brasil [10].

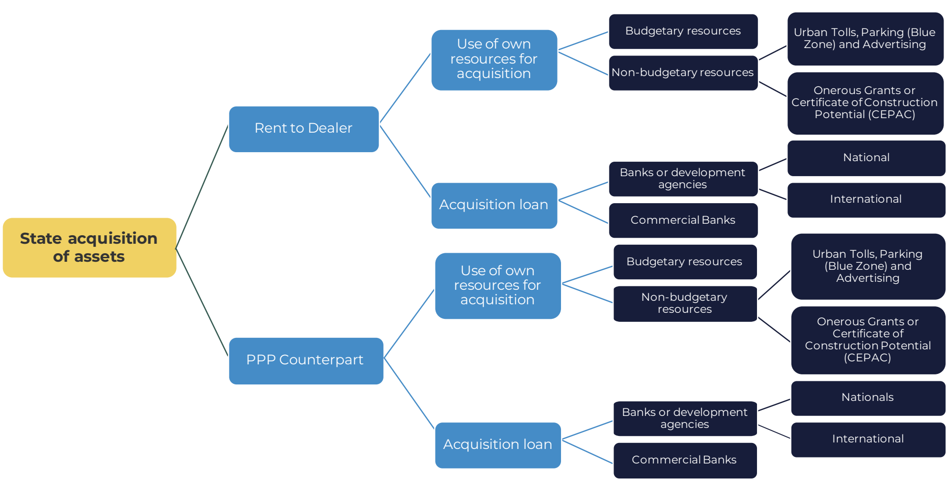
If the **beneficiary of the funding is a public entity**, the "lease" of the buses and the charging infrastructure cannot be through leasing but through renting. This type of lease agreement may have some limitations, such as the maximum term for leasing the goods, which is 5 years, and the contract renewal at the end of the term.

In the case of public administration, the municipality would be the owner and lessor of the buses and equipment, and the concessionaires would be their lessees. In this condition, the lease contract is governed by Private Law (articles 565 to 578 from the Civil Code), and the municipal government stipulates its validity term. This term may even coincide with the concession term.

The city of Sao Paulo is an example of renting, with the public sector as the lessor. The current concession contracts defined in Clause 3.48 the **possibility of use by the concessionaire of the municipal fleet, with the latter being responsible for payment of rent and maintenance**. Thus, there may be variations of the lessee, commonly the City Hall or the transport operator.

The acquisition of assets by the public authority **requires better financial conditions for the municipality**, debt capacity and the proper a**uthorizations under the Fiscal Responsibility Law** (such as the approval of operations by the Federal Senate), and the ability to manage and obtain resources that are not exclusively budgetary. Figure 5-7 **illustrates the possible resources that can be used to acquire** electromobility assets.

Figure 5-7 – **Resources for state acquisition of electromobility assets**



Source: Own elaboration.

Figure 5-8 summarizes the activities of Stage 4 for the implementation of the project. By the end of this stage, the City has identified the best financing option that is adequate with the predefined business model.

Figure 5-8 – Steps of the assessment and selection of the best financing option, summary of Step 4

Source: Own elaboration.

At the end of Stage 4, the city completes all steps for selecting the best financing option based on the diagnosis of the current situation, understanding the interests of all stakeholders, and the pre-selection of the business model best suited to the reality of the project's city. Next, PART B of this TRM evaluates the monitoring indicators suggested for the city to measure in the operation phase once the electric buses and the charging infrastructure are acquired.

PART B:

GUIDE FOR FINANCING IN THE OPERATION PHASE OF THE ELECTRIC FLEET

6.

STEP 5: IMPLEMENTATION AND MONITORING

This chapter describes how to evaluate and monitor the different financial indicators that ensure the fleet's payment and availability during the project's life. Best practices are presented for monitoring operators, manufacturers, and investing companies in electromobility projects in public transport for granting mechanisms and expected remuneration for service provision.

6.1 GRANTING MECHANISMS

The granting authority, whether under direct or indirect administration, seeks to characterize as **accurately as possible the operating costs and the technical tariff** as a basis for the expected remuneration of operators, obtaining the value per paying passenger to determine **the projections for the system costing by the tariff paid by the user**, the needs for ancillary revenues, and the need for subsidies from the municipal budget. In this last case, it **is essential to cross-reference with the municipal budget availability**, that is, the **projection of subsidies needed to maintain the system and its weight in the Net Current Revenue** - RCL in the medium and long term.

6.1.1 Systematizing the operational elements

Regardless of the characteristics of the tariff policy - whether it is a public tariff paid by the user as the only source of revenue for the system; or a subsidized tariff through cross-subsidies or transfers from the municipal budget - it is crucial to detail the operating costs and the conditions of demand for public transport. Only then will it be possible to dimension the conditions of the balance of the system, either for the calculation of tariff adjustments or for the determination of budgetary and extra-budgetary resources necessary to maintain the services with the expected quality and cost.

6.1.1.1 Equivalent passengers

The value of the public tariff results from dividing the total cost of services by the number of paying passengers. On the other hand, from l**ocal social policies** or **constitutional determinations** (free transport for the elderly, the unemployed, half tariffs for students, and others), **there is a volume of cross-subsidies** or subsidies from budgetary resources.

The transported passengers represent a fundamental variable for the service's dimensioning, and their characterization depends on the tariff category - **Common Fare, Transport voucher, Student, and Free, among others**. This characterization allows the projection of the possibilities of expansion of subsidies and their volume for revenue. The number of equivalent passengers is given by the weighting of the number of users benefited by the different discount categories added to the paying users, thus constituting the volume of passengers who effectively pay for the cost of the transport systems.

The concept of equivalent passenger makes it possible to determine cross-subsidy mechanisms insofar as paying users are charged the equivalent value of the discounts and gratuities granted. However, given the social and economic conditions, such a way of financing the system is complex. Therefore, the concept of equivalent passengers must also be considered to dimension the volume of subsidies assumed by public authorities for budgetary resources, its weight in the budget composition, and the conditions of its implementation under the fiscal framework of the municipality.

6.1.1.2 Fixed and variable costs

The operating and maintenance costs (OPEX) **are evaluated in R$/km**, representing the variable costs directly related to the mileage traveled. These are cost elements such as **Fuel, Lubricants, Road Costs, Parts, and Accessories, with fuel - diesel oil being the most expensive item**. This operational cost is evaluated in km/l and, in the case of electric buses, km/kWh. Therefore, by establishing the price of these inputs in R$/l or R$/kWh, it is possible to determine the variable costs R$/year, per km traveled, and per passenger.

In the technical note **Technical-Economic Evaluation of Electric Buses in Brazil**, the Energy Research Company (EPE) presents the following estimate [36]:

"**A battery electric bus has a maintenance cost 24% lower** than a P7 diesel model, regardless of whether recharging is done at the fueling point or along the route (MDIC, 2018b). Operational tests conducted in the city of Salvador (BA), identified that the **maintenance value of electric buses can be up to 25% lower**, if compared to diesel similar ones. According to the manufacturer of such vehicles, the reduction is due to the engine composition by only three major components that require periodic maintenance."

Other indicators are presented in the Study of economic-financial feasibility for transport services of the Secretariat of Mobility - SEMOB, Salvador - BA [37] , which presents the variable costs of public transport for diesel and electric buses. Based on the ANTP methodology, the variable costs are related to the basic consumption coefficients, varying according to the mileage of the system.

The following expression was used to calculate the fuel cost for diesel-powered vehicles:

$$CC = CCCP \times PLC \times PQA$$

CC – Fuel Cost (R$)

CCCP – Weighted fuel consumption coefficient (liters/km)

PLC – Diesel oil liter price (R$/liter)

PQA – Annual Mileage Production (km)

To calculate this cost for electric vehicles, we considered kilowatts as opposed to liters:

$$CC = CCCP \times PEE \times PQA$$

Fuel Cost (R$)

CCCP - Weighted fuel consumption coefficient (kWh/km)

PEE - Electric Energy Price (R$/kWh)

AQP - Annual Mileage Production (km)

The same procedures are adopted for the costs related to lubricants and parts and accessories, being that for electric vehicles, in these items, the coefficient equivalent to two-thirds of the value used for Diesel vehicles was considered.

As for fixed costs, these have no direct relationship with the mileage performed. These costs are classified as Depreciation (Vehicles, Garages, Equipment); Personnel Expenses

(Operation, Maintenance, Inspection); Administrative Expenses; Marketing Expenses; Capital Compensation; Lease of Garages, Vehicles, and Equipment. As for variable costs, the ANTP method details how these fixed cost elements are calculated.

Among these elements, the Remuneration of Fixed Capital stands out for determining the system's cash flow. This is the remuneration of the capital in vehicles, land, buildings and garage equipment, warehouses, equipment, support vehicles, and infrastructure. This highlight is presented since such costs for the business models that involve the acquisition and infrastructure for electric vehicles are higher than their diesel equivalents. Thus, these costs must be reflected in the operation's cash flow to ensure the conditions of economic and financial balance in the concession contracts and for the dimensioning of the volume of subsidies required for the fair remuneration of operators.

6.1.2 Expected remuneration for the provision of services

Public passenger transport services provision seeks to reflect in the concession contracts the coverage of all fixed and variable costs, a profit margin that ensures the entrepreneurs and investors, as in any economic activity, the adequate return for the services provided. This expected remuneration is inserted in the calls for bids and defines the tariff prices for users and the public sector's participation in the system's maintenance. In Table 6 is shown an example of a detailed breakdown of the São Paulo transport system costs, with the operators' remuneration and the cost of operating the infrastructure.

Table 6 – Costs of the urban public passenger transport system in the city of São Paulo

HOW MUCH DOES THE TRANSPORT SYSTEM COST (R$)			
DISCRIMINATION	R$ / month	BY PASSENGER	
		TOTAL	EQUIVALENT
1 - TRANSPORT SYSTEM COST (1.1 + 1.2) [1]	**748.200.283**	**3,42**	**7,26**
1.1 TRANSPORT OPERATING COST (operator remuneration)	**682.360.485**	**3,12**	**6,62**
1.1.1 - Operating Cost (Concession + Permit)	638.582.885	2,92	6,20
1.1.1.1 Fixed costs (operating, maintenance and inspection personnel, equipment maintenance, and administrative expenses)	*368.312.844*	*1,68*	*3,57*
1.1.1.2 Depreciation (vehicles, garages, and equipment)	*56.984.513*	*0,26*	*0,55*
1.1.1.3 - Variable costs (diesel, running costs, lubricants, parts, and accessories)	*199.638.318*	*0,91*	*1,94*
1.1.1.4 - Contribution on Revenues (2% as per Federal Law 12,546/11)	*13.647.210*	*0,06*	*0,13*
1.1.2. Gross profit from operation (1.1 - 1.1.1)	43.777.600	0,20	0,42
1.1.2.1 Income tax and CSSL (1.1.2- x 34%)	*14.884.384*	*0,07*	*0,14*
1.1.2.2 - Operator profit (1.1.2 - 1.1.2.1)	*28.893.216*	*0,13*	*0,28*
1.2. INFRASTRUCTURE OPERATING COSTS	**65.839.798**	**0,30**	**0,64**
1.2.1 - Terminals (operation, security, cleaning, and terminal maintenance)	18.932.167	0,09	0,18
1.2.2 - Commercialization of Single Ticket Credits (Municipality's share in recharge fees and commercialization structure)	11.649.475	0,05	0,11
1.2.3 - Management (supervision and system management)	32.158.157	0,15	0,31
1.2.4 - Operation of terminal ticket offices	3.100.000	0,01	0,03

Source: São Paulo City Hall [38].

6.1.3 Tariff policy and subsidy

In the first place, one can indicate that the public tariff - that is, the public price defined by the granting authority, charged to the system's users, added to other revenues, such as advertising in the vehicles and terminals, and the leasing of commercial and service spaces - covers all the operation costs, including the concessionaire's remuneration.

However, not all passengers transported are paying, and there are payment exemptions and discounts due to constitutional determinations or local social policies. Moreover, in particular social and economic circumstances, it is not always possible for the government to transfer to paying users the total cost of the system to keep it at levels satisfactory to the population and, at the same time, ensure the quality and regularity of services. For this reason, the public tariff charged to these users in most Brazilian cities is lower than the remuneration tariff, effectively compensating the concessionaire for providing the services.

Thus, the remuneration tariff seeks to preserve the economic-financial balance of the concession contracts, establishing in them the criteria for review and readjustment. However, it is not always that the value of the remuneration tariff is associated with the value of the public tariff, and the government must clearly define this differentiation.

If, in conventional business models, this equation is already challenging to balance, in cases of higher initial costs derived from a process of transition to electromobility, more relevant participation of the local government is required with significant investments in the acquisition of vehicles, equipment, and infrastructure or increased direct subsidies during the concession period.

This explains the importance of a clear and precise tariff policy, defining the actual costs of passengers carried and equivalent paying passengers, alternative sources of funding, possible cross-subsidy alternatives, and especially the volume of direct subsidies from the municipal budget and their weight in the overall revenue. The following table, extracted from the fare calculation spreadsheet in São Paulo, even without the impacts of the introduction of electromobility, provides an example of detailed costs, allowing the dimensioning of the sources and subsidies required for the maintenance of the system.

Table 7 – **Summary tariff spreadsheet of the urban passenger transport system in the city of São Paulo**

1. WHAT IS THE TRANSPORT SYSTEM	
1.1. PROPOSED TARIFF FOR JAN/20 (R$)	4,40
1.2 PASSENGERS TRANSPORTED (includes all tariff payment modalities) - million/month	218,7
1.3 EQUIVALENT PASSENGERS (excludes gratuities, bus-bus integration and considers each paying student equal to 0,5 paying and each common rail integration equal to 0,82 paying) - million/month	103,1
1.4 Fleet (including technical operational reserve) Vehicle units	14.077

DISCRIMINATION	relative %	R$ million/ month	R$ per equivalent passenger	R$ million/ year
2. WHAT IS THE TRANSPORT SYSTEM'S COST	**100%**	**748,2**	**7,26**	**8.978,4**
2.1 OPERATING COST OF TRANSPORT (bus, personnel, diesel, operator profit, etc.)	91%	682,4	6,62	**8.188,3**
2.2 INFRASTRUCTURE OPERATING COSTS (commercialization of Single Ticket credits, terminals, management)	9%	65,8	0,64	**790,1**
3. WHO PAYS THE TRANSPORT BILL	**100%**	**748,2**	**7,26**	**8.978,4**
3.1. USER + EMPLOYER	64%	476,0	4,62	5.711,7
3.1.1. Paying user	49%	368,9	3,58	4.426,7
3.1.2 Employer (participation in the cost of transport vouchers)	14%	107,1	1,04	1.284,9

DISCRIMINATION	relative %	R$ million/ month	R$ per equivalent passenger	R$ million/ year
3.2. MUNICIPALITY (budgetary resources of the Municipality of São Paulo)	35%	259,7	2,52	3.116,6
3.2.1 Direct user subsidy	28%	209,3	2,03	2.512,0
3.2.1.1 Public transport policy (bus-bus and bus-train integration)	5%	35,6	0,35	426,9
3.2.1.2 Educational policy (cost of gratuity and half-tariff for students)	8%	61,4	0,60	736,7
3.2.1.3 Social policies (elderly and disabled)	15%	112,4	1,09	1.348,4
3.2.2 Municipal public resources for infrastructure	7%	50,4	0,49	604,6
3.3 OTHER SOURCES (fines, advertising, recharge fees, rentals)	2%	12,5	0,12	150,1

Source: São Paulo City Hall [38].

In this case, 35% of the costs of the transport system go under the municipal budget resources, 7% for infrastructure, and 28% in direct subsidies to the user, distributed among integration, half-tariff for students, and gratuities resulting from social policies, such as the elderly and people with disabilities. Considering the Net Current Revenue of the Municipality of São Paulo for the year 2019, 35% of the transport costs are equivalent to 5.75% of the Net Current Revenue. Given the conditions and specificities of each location, such estimates and projections determine the maintenance and balance system conditions in the medium and long term.

It is necessary to consider the various risks that may increase the need for transfers and municipal subsidies or deepen the precariousness of services. These risks can be summarized as the possibility of a drop in demand; the increase in operational costs, such as diesel, lubricants, parts, and accessories; an increase in the price of assets; difficulty in implementing new technologies; loss of public revenue and fiscal unbalance, incurring in default by local governments, among others.

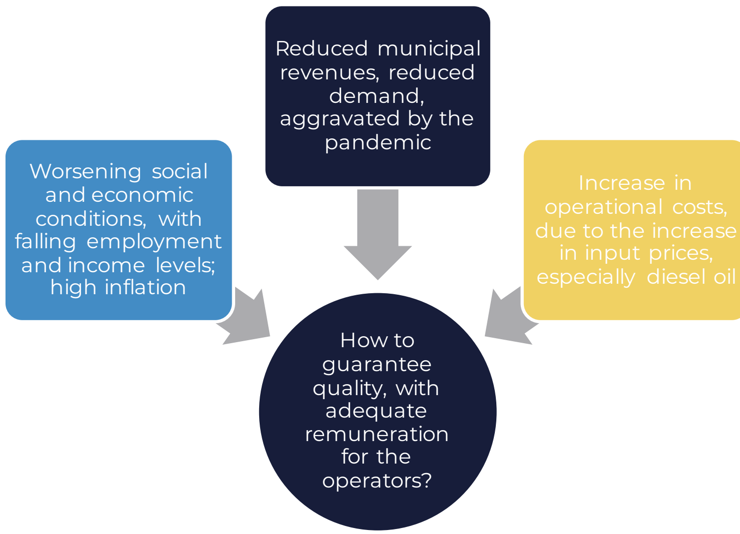
In the case of electric buses powered by battery, as already pointed out, the operation and maintenance costs are lower than those of buses powered by diesel oil, showing that this transition may result, in addition to environmental gains, in favorable conditions of the economic balance of the system in the long term. However, when the amortization of investments in the necessary infrastructure and electric vehicles adds to such costs, reviewing the transfers and subsidies is necessary to ensure the operation balance.

Next chapter elaborates on the steps to evaluate the financing for the operation of the public transport system in Brazilian cities.

6.2 FINANCING FOR PUBLIC TRANSPORT SYSTEM OPERATION

The sustainability of the urban public transport system, in the medium and long term, depends on conditions that ensure the economic and financial balance of the concession contracts. Therefore, the question of how to guarantee urban public passenger transport services with quantity and quality, with reduced costs and accessible tariffs, and, at the same time, with fair remuneration for the operating companies imposes quite complex challenges to local public management.

Figure 6-1 – **Complexity of transport systems in the current context**



Source: Own elaboration.

The current context makes it practically unfeasible to maintain quality services and, on the other hand, adequate remuneration to the concession companies based exclusively on revenues from tariffs paid by users. Besides, the perspectives for the near future of worsening social and economic conditions, given falling income levels, high inflation, reduced municipal revenues, and reduced demand, aggravated by the pandemic, in addition to the increase in the system's operating costs due to the rise in input prices, especially diesel oil, complicates, even more, the situation,

In the case of the transition to battery-powered buses, the lower operating cost compared to diesel buses is mainly due to the high operating costs associated with diesel oil, lubricant, and moving parts and accessories. Thus, in the medium and long term, it is possible to project economic advantages to users, the public sector, and operators offsetting the higher fixed costs (see Costs and Emissions Appraisal Tool for Transit Buses - CEA Tool - developed by WRI [37].

In addition to the conditions for financing investments, guarantee conditions, access to resources from various funding sources, and the risks associated with these operations, topics already addressed in the stages of the project developed so far, the conditions for financing the system's operating costs are also on the agenda. It is not a detailed modeling of the operational cost calculation processes since there are practical guides and spreadsheet models, such as those made available by the National Association of Public Transport = ANTP[6]. Instead, this document seeks to point out the elements observed when structuring the business model and the transition program for electromobility to ensure the conditions in the short, medium, and long term to ensure the economic-financial balance of the new concession contracts.

6.3 MONITORING OF FINANCIAL INDICATORS AND PROJECT EVALUATION

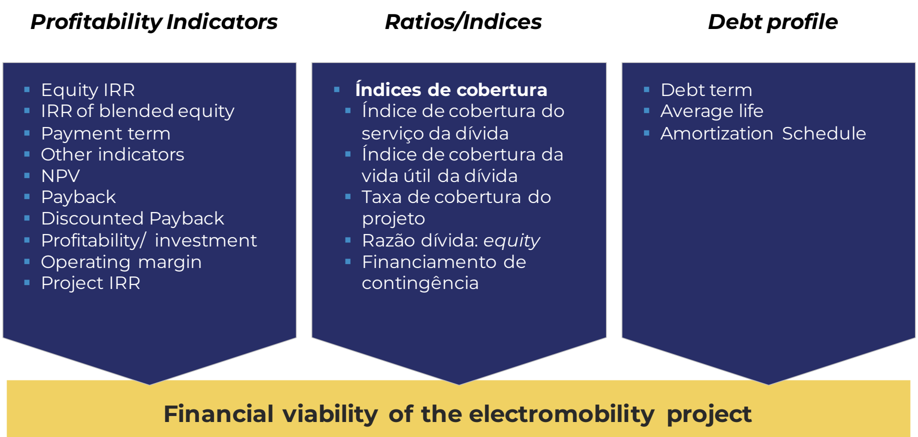
This section describes profitability indicators that analyze the electromobility project's ability to convert revenues into profits; ratios that are essential for the bank to determine whether the cash flow generated is sufficient to pay down debt; and the debt profile, which explains the elements that make up the debt, such as the term, average life, and amortization schedule that are critical for electric bus projects.

Figure 6-2 shows the financial indicators suggested in Step 5 of implementing and monitoring the electric bus project.

6 NATIONAL ASSOCIATION OF COLLECTIVE TRANSPORT - ANTP. **Costs of public bus transport services**: calculation method. 2017

Each indicator is explained in a general way. Their impact on the project and the differences compared to diesel operation are also analyzed. At the strategic level of this TRM, the behavior and expected values of financial indicators are defined by the financial institution and conditions and the beneficiary (the municipality, a private entity, or a company through a bidding process).

Figure 6-2 – Financial indicators for the structuring of the electromobility project



Source: Own elaboration.

6.3.1 Profitability Indicators

What are the profitability indicators?

- These are the indicators that the bank analyzes to evaluate the management of the project, its viability, and how the revenues from the operation of the electric buses turn into profits for the shareholder and for the project as a whole.
- It is necessary to perform an analysis of the assumptions of the financial model so that the indicators reflect the reality of the renewable energy project by understanding the industry and the development region.

6.3.1.1 Equity IRR

What is the Internal Rate of Return (IRR) of Equity?

- It is the measure of the rate of return expected by investors on their capital investment in the project. The calculation of this indicator should be based on the cash return on the capital investment. For the calculation, only cash flows intended for payment to the shareholders of the SPE should be considered.
- This is the most important indicator for investors, as it allows them to check whether the investment in the project is acceptable based on the expected return. Investors decide whether the investment in the project is acceptable by comparing the Equity IRR with a hurdle rate.

The MARR is determined based on the following elements:

- Investors' weighted average cost of capital of electromobility assets;
- Additional return over the cost of capital required for a specific risk;
- Market competitiveness;
- Project feasibility.

Interval of a project IRR

In Brazil, the case of São Paulo has a project IRR for renewable energy projects within a range of 9% and 14% p.a.

Source: Analysis of the deployment of zero-emission buses in the fleet of a bus operator in the city of São Paulo, ICCT& C40, 2022 [23].

6.3.1.2 Blended Equity IRR

The junior debt is a fixed-income instrument whose collection by the holder follows the payment to the other joint creditors. Due to the high CAPEX, it is a mechanism that can be used to finance electromobility assets. Characteristics of junior debt are:

- The holder is last in the order of priority for debt collection;
- The holder assumes a greater risk of loss in the event of liquidation;
- It offers a higher return.

6.3.1.3 Other profitability indicators

In addition to calculating the Internal Rate of Return (IRR), it is also important to analyze other indicators presented below. The indicator, logic, and calculation method are described in Table 8.

What is the IRR of Blended Equity?

- It is a measure of return that considers both Equity and subordinated debt. It is the same discount rate, including the cash flows from the equity of the investor who will be the beneficiary of financing and the subordinated debt. It is usually calculated after taxes paid for the operation of the buses.
- Investors can also invest in the form of subordinated debt. Usually, Equity is minimal compared to subordinated debt.

Table 8 – Key profitability indicators

Measure	Description	Goal	Calculation
Net Present Value (NPV)	Discounted future cash flows of the project (the discount rate can be the MARR).	It shows whether the net profit of the project is positive or negative, evaluated at present value.	$NPV=\sum C_i/(1+r)^t$ C_i=Cash flow at period i r = discount rate for period i t = total number of periods
Payback period	Expected time for the project to recover the investment. For electromobility projects, the payback periods vary from 10 to 15 years depending on the rate of return and total CAPEX, among other variables [36]	It indicates the time required for the project to generate a positive margin given the initial investment.	Payback=number or years
Discounted Refund Period	Payback period, valuing cash flows at present value.	It shows the time required for the project to recover the investment, considering the time value of money.	Discounted Payback=number of years
Rate of return on investment	Future cash flows compared to the value of the investment	Allows you to evaluate the profit margin for the initial investment	Profitability Index-investment=NPV/investment
Operating margin	Profit margin in the normal business activities of the project company	It allows you to determine the project's profitability from its primary activities.	Operation Margin=operation profit/revenues
Project IRR	IRR calculated from the project's cash flows before debt service and contributions.	It allows you to evaluate the rate of return on the project's cash flows.	IRR=r such that VPL=0

6.3.2 Indicators financial

Banks need to establish the minimum required ratios for granting debt, which reduces the credit risk to make electromobility projects viable. If the established ratio is not generated in any period, it is necessary to evaluate modifications in the debt repayment conditions. Therefore, during the execution of the electromobility project, the financial institution carries out periodic monitoring to ensure compliance with the minimum ratios established during the payment term for the electric fleet and the charging infrastructure.

6.3.2.1 Coverage Ratios

Coverage ratios determine the level of protection a bank has to receive debt service payments. Higher ratios may be required to provide financing depending on the project's risk level. From the bank's point of view, the analysis that reduces credit risk is the coverage ratios that cover the importance of financing assets entering the banks' new financing lines, such as buses and recharging infrastructure.

The ratios that should be monitored during the implementation of the funding are:

- Debt Service Coverage Ratio (DSCR)
- Debt Life Coverage Ratio (DLCR)
- Project Life Coverage Ratio (PLCR)

It is worth mentioning that the DSCR (Debt Service Coverage Ratio) allows banks to define the main conditions of the financing, such as the maximum amount of the project to be financed, the total Equity required for the first year and following years, and the distribution of dividends to their investors.

Table 9 presents the three main indicators. These indicators are monitored by financial institutions during the life of the loans and are particularly important in financing electromobility assets gaining visibility on the Brazilian market.

Table 9 – Coverage Ratios

Indicator	Debt Service Coverage Ratio (DSCR)	Debt Life Coverage Ratio (DLCR)	Project Life Coverage Ratio (PLCR)
Definition	It is the bank's most important indicator, showing whether the project's cash flow is sufficient to pay off the debt. It is used to determine the degree of leverage approved for a project.	The number of times the project's cash flows over the life of the debt can pay off the balance. It is like the DSCR, but it considers the loan's entire life to pay off the electromobility assets.	Ability to pay the debt after its original maturity if it could not be paid on time.
Formula	DSCR= $\frac{\text{free cash flow during the year}}{\text{debt service during the year}}$	DLCR= $\frac{\text{free cash flow from the beginning of the operation until debt maturity brought to present value}}{\text{resting debt or balance}}$	PLCR= $\frac{\text{free cash flow from the beginning of the operation until project's end brought to present value}}{\text{resting debt or balance}}$

It is worth mentioning that the DSCR is the most relevant indicator for banks when granting financing and allows them to define the main terms of the financing, such as the maximum amount of the project to be financed (total CAPEX of the electromobility assets) and the required

Equity for the first and following years and the distribution of dividends to its investors. The bank should set the minimum of the DSCR depending on the risk of the project. The type of financing that most likely ensures compliance with the DSR is structured financing, the financing modality in which the project's cash flows are the only source of debt repayment. The modality of structured financing or "project financing" is commonly done by the private sector with the active participation of the operator to monitor compliance with the indicators.

The banks must ensure that the project financed through structured finance generates sufficient cash flow to cover debt service in all periods. The riskier the project, the higher the ratio set so that there is more certainty of correct debt repayment according to the stipulated conditions. If the initially required minimum DSR is not met in any period, modifications can be made to the amortization amounts to remedy the situation, which is common in the amortization periods of electromobility assets.

Coverage ratios are crucial to determining the amount of debt to be provided by the bank. Therefore, instead of pre-setted values, banks should calculate these indices (in particular, the DSCR) to establish the amount of debt for acquiring electromobility assets.

6.3.2.2 Debt/equity ratio

Coverage ratios are crucial to determining the amount of debt to be granted by the bank. Instead of pre-setted values, banks should calculate these ratios (in particular, the SCR) to establish the amount of debt. The Debt to Equity ratio reflects the risk of the project. High-risk projects, such as electromobility projects, have a low Debt to Equity ratio. In electromobility projects, the Debt to Equity ratio of the beneficiary of the financing should be 20/80 or 30/70, showing the financial muscle needed to enter into this loan. This ratio is more common since the Debt to Equity ratio changes as principal repayments are made, and it should decrease until it reaches zero at the beginning of the debt tail period. In electromobility projects, it is expected that the debt-to-equity ratio

The project can be supported by contingency funds, either equity or debt, such as the following examples:

- **Debt**: Contingency funding: Projects must have contingency funding to cover additional project costs during execution.

- **100% contingency capital**: after execution, the SPE applies for a "bridge loan," which is equal to the Equity (Equity bridge loan), which are short-term loans that temporarily cover the capital costs of the project investors.

- **Non-Equity Projects**: Projects structured to protect their revenue risk with an Offtake agreement providing greater certainty of cash flow generation.

From the financial institution's point of view, capital projects are preferable because they transfer a certain percentage of the risk to the investors. Also, since the investors' capital is committed, they are more interested in the project's success. On the other hand, it is in the banks' interest that the SPE has contingency funds to cover additional costs during the execution phase, allowing the project to be sustainable.

6.3.3 Profile of debt service

The debt service profile comprises maturity, average life, debt flexibility, and repayment schedule. Each of these elements affects the return for investors and banks. The elements of debt vary depending on the company's profile that needs financing. The following describes the key points that determine the possible variations in the elements that define the debt service profile.

Figure 6-3 – Debt service profile: debt maturity

Source: Own elaboration.

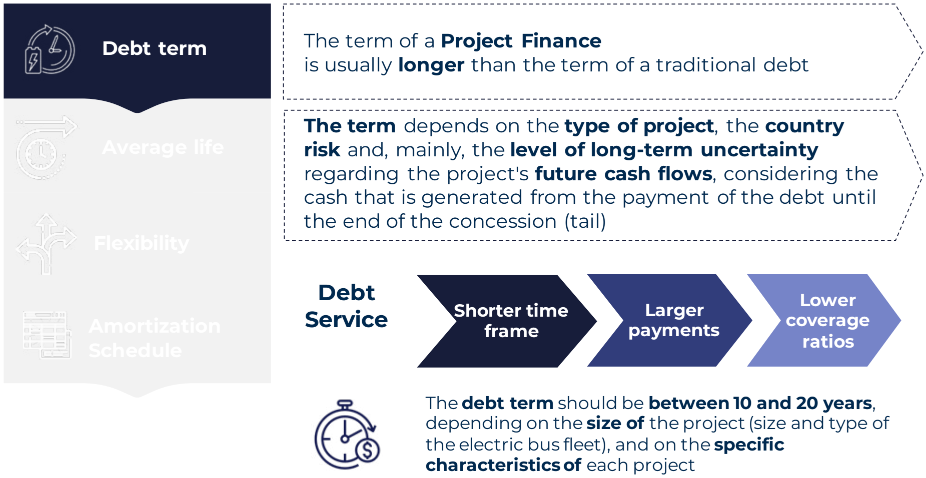
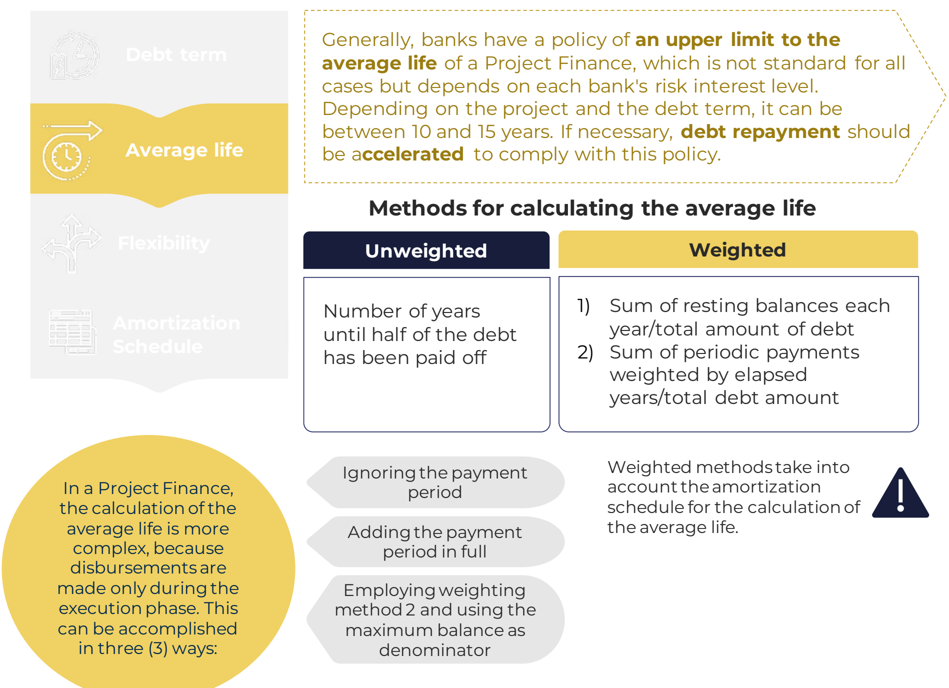
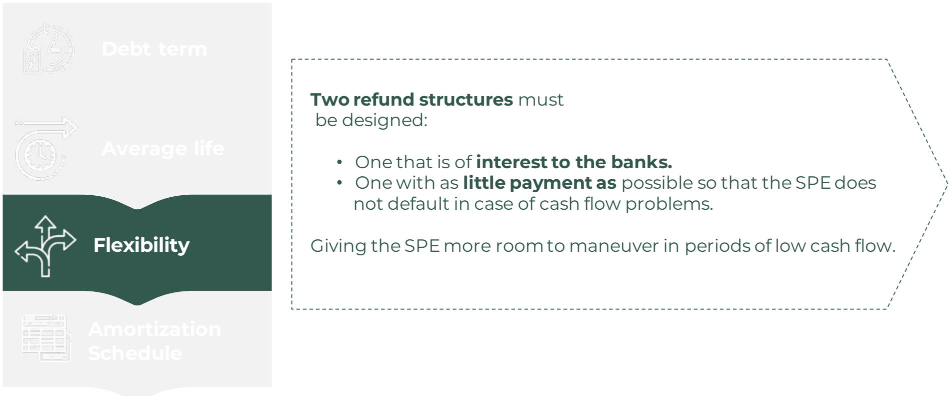


Figure 6-4 – Debt service profile: average life



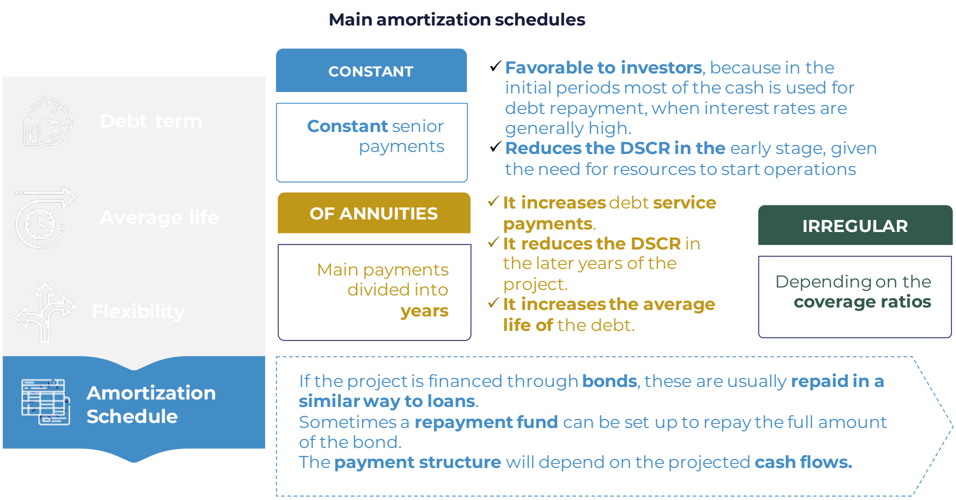
Source: Own elaboration.

Figure 6-5 – Debt service profile: flexibility



Source: Own elaboration.

Figure 6-6 – Debt service profile: amortization schedule



Source: Own elaboration.

The debt service profile defines the sustainability of the financing and the need for a subsidy. Once a deficit is identified in the operation phase to cover the expenses of the financing and operation, mechanisms for providing a subsidy can be evaluated as follows.

6.4 IMPLEMENTATION OF SUBSIDY POLICY IN THE MUNICIPAL BUDGET

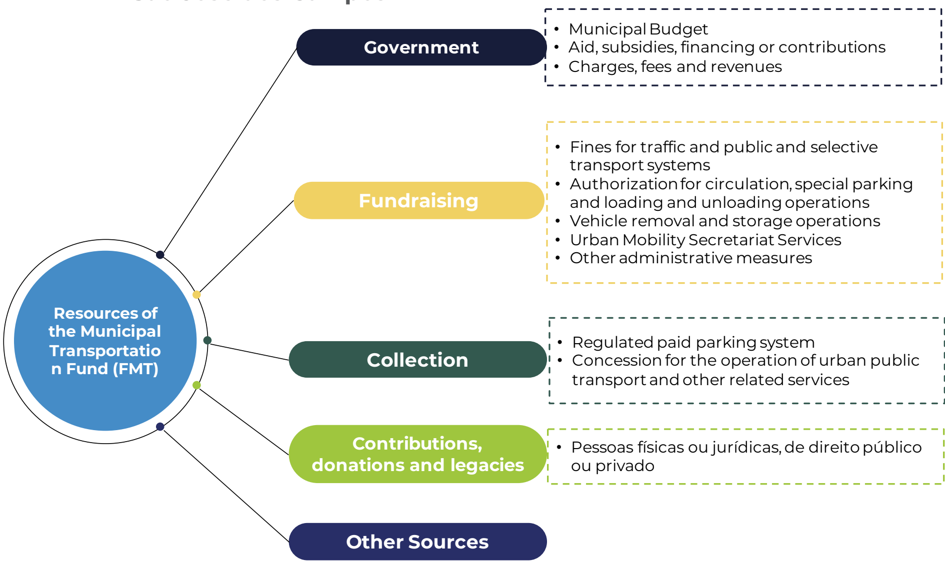
In summary, the resources aimed at investments (Capital Expenditures) can come from capital revenues - credit operations and capital transfers, and in most cases, are complemented by current revenues - Tax Revenues and Current Transfers. On the other hand, the resources destined for subsidies come from current revenues, necessarily having as sources, in some cases, Municipal Funds combined with resources from the Municipal Treasury. For example, municipal budget subsidy expenses can be classified under the following headings.

Body - Municipal Secretariat of Mobility and Transport - SMT
Transport Function
Subfunction Urban Collective Transport
Program - Improving universal urban mobility
Activity - Bus system tariff compensations
Contributions
Other Current Expenses

Whether through investments in acquisition or installation (capital expenses), or contributions to tariff compensations (subsidies), characterized as current expenses of a continuous nature, they must be foreseen in the Multi-Year Plan - PPA and presented in detail in the Annual Budget Law - LOA.

Concerning the sources of resources linked to the Funds destined for the transport system, a very comprehensive example comes from the Municipal Transport Fund of São José dos Campos, established by Law n 5,185 of April 1, 1998, changed by Law n 10,312 of May 04, 2021, establishing in its article 3, the sources of resources that compose the Fund.

Figure 6-7 Resources of the Municipal Transport Fund of São José dos Campos



Source: Own elaboration based on the City Hall of São José dos Campos (1998) [40]

These resources from the São José dos Campos Transport Fund are intended for the development, implementation, incentive, investment, and funding of projects related to [40] :

- Planning, management, and operation support systems for public and selective transport urban[7];
- Infrastructure of collective and selective urban transport;

7 The selective or special transportation is that intended to serve exclusively the server, individually, with no relationship with the collective and ordinary service. It is also understood as regular selective road transport the service that uses vehicles equipped with reclining, upholstered, numbered seats, with external luggage racks and package carriers inside, with only one door, not being allowed to carry standing passengers.

- Traffic engineering;
- Systems, equipment, and devices related to road signs; and
- Systems, equipment, and devices to support traffic planning, operation, and enforcement.

In Brazil, aiming at the maintenance of quality services and, on the other hand, adequate remuneration to the concessionaires, capitals such as Brasilia, São Paulo, Belo Horizonte, and Curitiba, among other capitals and large cities, have operation subsidy policies of different natures and origins.

The following are some case studies of cities that have implemented electric fleets and the financing solutions adopted.

6.4.1 Case Studies of Financing Models

The experiences of cities that have already implemented electric buses allow evaluating of the financing models adopted in different contexts. In the following, electric fleets' deployment cases demonstrate the strategies selected, financing solutions, and the timeframes required for implementation.

Shenzhen, China

The process of electrification of the bus fleet in Shenzhen (China) lasted eight years, from 2009, when the local government drew up a plan to renew the fleet with cleaner vehicles, until 2017, when 100% of the fleet was electrified. Pilot testing began in 2011, with gradual incorporation yearly, until it exceeded 16,000 electric buses in 2017. Achieving this goal required significant subsidies from local and national governments, which by 2016 covered more than half of the initial cost for the incorporation of electric vehicles.

Source: Own elaboration. Photo: Xataka (2018) [41].

London

In 2016, Go-Ahead became the first operator in the City of London to carry out a fleet conversion to electric buses after overcoming several logistical hurdles to adapt its facilities to the new infrastructure required, as well as adopting new practices to streamline and optimize the provision of services in line with charging requirements. In parallel, TfL (Transport for London) has been conducting pilot tests to introduce electric and low-emission vehicles on selected bus corridors, as well as the adaptation of new facilities for the electric operation to have all buses emission-neutral by 2034.

Source: Own elaboration. Photo: Electrive (2019) [42].

Paris

In Paris (France), the deployment of electric buses is still ongoing. The goal of the authorities and the public transport service provider (RATP, Regie Autonome des Transports Parisiens) is to renew all nearly 5,000 vehicles by 2025, of which at least 3,000 are electric. The first milestone under this plan was the launch of a public tender in 2018 aimed at purchasing 800 electric buses. The process involves encouraging the development of local suppliers and creating a partnership between RATP and local power companies to assess the project's feasibility.

Source: Own elaboration. Photo: Via Trolebus (2019) [43].

Santiago

The process of gradually incorporating electric fleets into the metropolitan transport system in Santiago (Chile) began in 2016 when a consortium was formed between the operator MetBus and ENEL X. This led to the development of feasibility studies and the first pilot tests to verify the suitability of this technology for the routes in operation.

In 2017, energy transition goals were set, establishing that by 2050, all public transport vehicles in the country must be electric (in Santiago, the goal is to be achieved by 2035). In late 2018 and early 2019, the first 100 electric buses went into operation, with the federal government contributing to the operation with public funds. From this experience, the model implemented was replicated in other corridors, with approximately 800 electric vehicles operating in the city since 2021.

Source: Own elaboration based on [17]. Photo: Recargados (2020) [44].

In summary, identifying the critical and regular monitoring of financial indicators is an essential step before the final implementation of the project. The subsidy and the revenue mechanisms define those more critical indicators. Monitoring these indicators transparently between all the actors involved is essential to the project's success throughout the concession. This monitoring is part of the main points of attention, possible advances, and future gains noted in Figure 6-8.

Figure 6-8 – Points of attention, possible advances, and future gains

Key Points

- Amortization of the necessary infrastructure investments
- Acquisition costs of electric vehicles and battery life
- Business Model and Financing Conditions under development

Possible Advances

- Legal framework and regulatory framework
- Structuring of financing and guarantee conditions
- Public Funds
- Tariff policy and subsidy

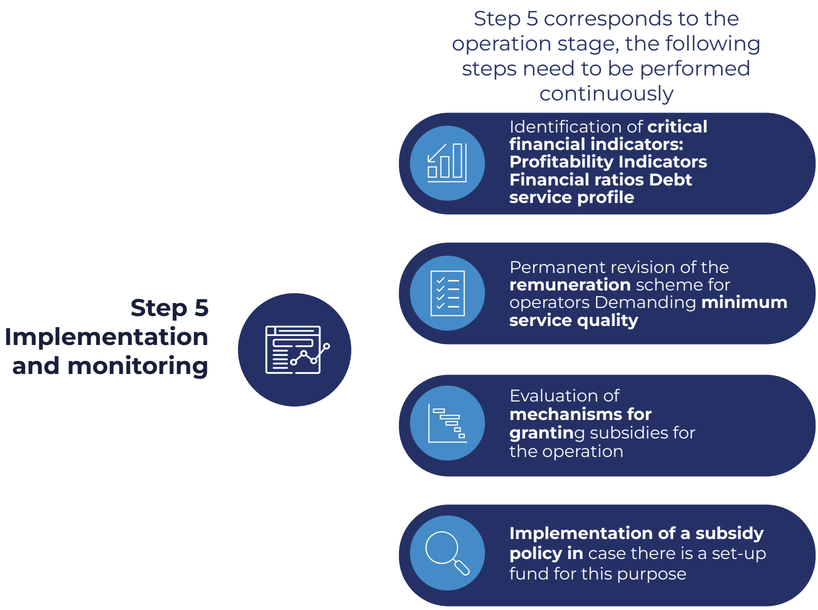
Future Gains

- Lower bus operating and maintenance costs
- Environmental and social gains: GHG reduction and improved health conditions
- Economic balance of the system in the long run

Source: Own elaboration.

Figure 6-9 summarizes the activities to guide the cities or project implementers to achieve sustainable financial conditions during the operation stage.

Figure 6-9 – Steps of project implementation and monitoring, a summary of Step 5 activities



Source: Own elaboration.

Step 5 is a process that should be iterative over the project's lifetime to ensure continuity of service with electric buses and to open up the possibility of attracting further investment interest to expand the city's electric fleet. Presenting healthy finances at the first scale project in the city can demonstrate to all stakeholders the financial and economic attractiveness of electromobility projects. Even if subsidies cannot be obtained in the early phases of the project, monitoring the profitability indicators presented here can ensure continued operation while revenue sources are diversified.

7.

REFERENCES

[1] ZEBRA. **Investing in electric bus deployment in Latin America**, 2020.

[2] C40 CITIES FINANCE FACILITY. **Modelos y Fuentes de financiación para proyectos de movilidad de cero emisiones en México**. Ciudad de México, 2021.

[3] Pascoal, E. T.; FURTADO, A. E.; FERREIRA FILHO, V. S. **Eletromobilidade no Brasil:** iniciativas, oportunidades e desafios, 2018.

[4] PLATAFORMA NACIONAL DE MOBILIDADE ELÉTRICA. **Mapeamento e diagnóstico das iniciativas sobre mobilidade elétrica no Brasil**, 2018.

[5] MOBILITAS. **Avanços dos ônibus elétricos na América Latina**, 2021.

[6] ICCT. **Avaliação Internacional de Políticas Públicas para Eletromobilidade em Frotas Urbanas**, 2018.

[7] BLOOMBERG NEW ENERGY FINANCE. **Electric Buses in Cities Driving Towards Cleaner Air and Lower CO2**, 2018.

[8] ICCT; C40 CITIES. **Accelerating a market transition in Latin America:** new business models for electric bus deployment, 2020.

[9] PLATAFORMA NACIONAL DE MOBILIDADE ELÉTRICA. **1º Anuário Brasileiro da Mobilidade**, 2021.

[10] WRI BRASIL. Guia de Eletromobilidade: orientações para a estruturação de projetos no transporte coletivo por ônibus. **Mobilidade Urbana de Baixo Carbono**, 2022.

[11] ICCT. **International Evaluation of Public Policies for Electromobility in Urban Fleets**, 2018. [Online].

[12] SUBSECRETARÍA DE PLANIFICACIÓN DE LA MOVILIDAD. **Buses Eléctricos.** Prueba Piloto de Buses de Combustibles Alternativos. Buenos Aires, 2021.

[13] ROLIM, F.; BRASILEIRO, A.; SANTOS, E. **Competition in Brazilian bus and coach services:** the results of recent competitive tendering processes. 2010. [Online].

[14] ARAGÃO. J.; BRASILEIRO, A. **The Brazilian Urban Bus Industry:** present challenges and future perspectives, 1999. [Online]. Disponível em: http://hdl.handle.net/2123/6585.

[15] THE WORLD BANK. **Lessons from Chile:** experience with e-mobility, 2019.

[16] BANCO INTERAMERICANO DE DESARROLLO. **Reporte:** Costos y tarifas de remuneración por vehículo y por kilómetro, para vehículos eléctricos de la flota Troncal y No troncal de la Fase III del Sistema Integrado de Transporte Publico SITP, 2019.

[17] BANCO INTERAMERICANO DE DESARROLLO. **Análisis y diseño de modelos de negocio y mecanismos de financiación para buses eléctricos en Lima**, Perú. 2020.

[18] WRI. **How to Enable Electric Bus Adoption in Cities Worldwide**, 2020.

[19] EMPRESA DE PESQUISA ENERGÉTICA. **Avaliação Técnico-Econômica de Ônibus Elétrico no Brasil**, 2020.

[20] SLOWIK, P. *et al*. **Avaliação Internacional de Políticas Públicas para Eletromobilidade em Frotas Urbanas**. PROMOB-e, 2018.

[21] ALBUQUERQUE, C. *et al*. **Eletromobilidade no transporte coletivo:** o caso da cidade de São Paulo. PROMOB-e, 2019.

[22] WRI BRASIL. **Guia de eletromobilidade:** orientações para estruturação de projetos no transporte coletivo por ônibus, 2022.

[23] ICCT; C40. **Análise da implantação de ônibus zero emissão na frota de um operador de ônibus da cidade de São Paulo**, 2022.

[24] GLÜCKER, P. *et al*. Prolongation of Battery Lifetime for Electric Buses through Flywheel Integration. **Energies**, v. 14, n. 4, 2021.

[25] ITDP. **Operationalizing E-bus Fleets:** lessons learned from China ITDP, 2020.

[26] AAMODT, A.; CORY, K.; CONEY, K. **Electrifying Transit:** a guidebook for implementing battery electric buses. National Renewable Energy Lab. (NREL), 2021.

[27] MAIO, P. *et al*. **Resultados del piloto de buses eléctricos en Buenos Aires**. Tecnologías alternativas en el transporte público, CAF, 2021.

[28] CAF. **La electromovilidad en el transporte público de América Latina**, 2019.

[29] ITDP. **From Santiago to Shenzhen:** how electric buses are moving cities, 2021.

[30] EL TIEMPO. **Bogotá toma un nuevo aire con los patios de recarga de Enel X**, 03-2021. [Online]. Disponível em: https://www.eltiempo.com/contenido-comercial/bogota-toma-un-nuevo-aire-con-los-patios-de-recarga-de-enel-x-572113.

[31] WRI BRASIL. **Incentivos tributários podem fomentar transição para ônibus elétricos a bateria no Brasil**, 10-05-2021. [Online]. Disponível em: https://wribrasil.org.br/pt/blog/cidades/incentivos-tributarios-podem-fomentar-transicao-para-onibus-eletricos-bateria-no-brasil.

[32] WORLD BANK. **Green your bus ride clean buses in Latin America**, 2019.

[33] BORGES, L. F.; BORGES, X. Covenants: instrumento de garantia em project finance. **Revista do BNDES**, v. 6, n. 11, p. 117-136, 199.

[34] HOFFMAN, S. L. **The law and business of international project finance**. Ardsley: 3. ed. Cambridge, 2008.

[35] BANCO CENTRAL DO BRASIL. **Resolução N. 2.309**, 1-05-2022. [Online]. Disponível em: https://www.bcb.gov.br/pre/normativos/res/1996/pdf/res_2309_v2_L.pdf.

[36] BRASIL. Ministério de Minas e Energia. Empresa de Pesquisa Energética. 09-2020. [Online]. Disponível em: http://shinyepe.brazilsouth.cloudapp.azure.com:3838/simulador_onibus/Onibusv3/.

[37] C40 CITIES. **Estudo de viabilidade econômico-financeira para os serviços de transporte da Secre-taria de Mobilidade** – Semob, Salvador – BA, Sal-va-dor, Bahia, 2021.

[38] SÃO PAULO (Cidade). **Valores das Tarifas Vigentes a partir de 01/01/2020, 04-2022**. [Online]. Disponível em: https://www.prefeitura.sp.gov.br/cidade/secretarias/mobilidade/institucional/sptrans/acesso_a_informacao/index.php?p=227887.

[39] WRI BRASIL. **Ônibus elétricos valem a pena? Nova ferramenta ajuda cidades a entender custos e benefícios, 17-09-2019**. [Online]. Disponível em: https://wribrasil.org.br/pt/blog/2019/09/onibus-elet-ricos-valem-pena-nova-ferramenta-ajuda-ci-dades-entender-os-custos-e-beneficios. Acesso em: 24 abr. 2022.

[40] SÃO JOSÉ DOS CAMPOS. Secretaria Municipal de Transportes. São José dos Campos, **Lei 5.185, de abril de 1998**, 1/04/1998. [Online]. Disponível em: https://servicos2.sjc.sp.gov.br/legislacao/Leis/1998/5185.pdf. Acesso em: 01 maio 2022.

[41] ÁLVAREZ, R. **Los 16.359 autobuses públicos de Shenzhen ahora son eléctricos:** China se sigue esforzando por ser un país verde, 01-2018. [Online]. Disponível em: https://www.xataka.com/energia/los-16-359-autobuses-publicos-de-shenzhen-ahora-son-electricos-china-se-sigue-esforzando-por-ser-un-pais-verde.

[42] ELECTRIVE. **22 more BYD-ADL electric buses for London**, 10-2019. [Online]. Disponível em: https://www.electrive.com/2019/10/14/22-more-byd-adl-electric-buses-for-london/.

[43] VIA TROLEBUS. **Paris escolhe três fabricantes para fornecerem até 800 ônibus elétricos**, 05-2019. [Online]. Disponível em: https://viatrolebus.com.br/2019/05/paris-escolhe-tres-fabricantes-para-fornecer-ate-800-onibus-eletricos/. Acesso em: 04 abr. 2022.

[44] RECARGADOS. **Santiago de Chile ya suma 776 buses eléctricos en su red de transporte público**, 06-2020. [Online]. Disponível em: https://recargados.net/santiago-de-chile-ya-suma-776-buses-electricos-en-su-red-de-transporte-publico/.

Executor

IABS

Realização

CIF CLIMATE INVESTMENT FUNDS

BANCO MUNDIAL
BIRD • AID | GRUPO BANCO MUNDIAL

MINISTÉRIO DO
DESENVOLVIMENTO REGIONAL