E-Motion Country Intervention Strategy Brazil

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Abbreviations

ABNT	Brazilian Agency of Technical Standards
ABREVEi	Association of Innovative Electric Vehicle Owners
ABVE	Brazilian Association of Electric Vehicles
AEA	Brazilian Association of Automotive Engineering
ANAC	National Civil Aviation Agency
ANEEL	National Electric Energy Agency
ANP	National Agency of Petroleum, Natural Gas and Biofuels
ANTP	National Association of Public Transportation
ANTT	National Land Transportation Agency
AssetCo	Special Purpose Company (SPV / SPE / SPC)
BA	Bahia State
BNDES	Brazilian National Bank for Economic and Social Development
BRL	Real Brazilian Currency
BYD	Build Your Dreams Company & Industry
CAMEX	Chamber of Foreign Trade
CDFMM	Carine Fund Board of Trustees
CDM	Clean Development Mechanism
CIM	Interministerial Committee on Climate Change
CM	Combined Margin
CO2-eq	Carbon Dioxide Equivalent
CONAC	Civil Aviation Council
CONAERO	National Commission of Airport Authorities
CONAMA	National Environmental Council
CONAPORTOS	National Commission of Port Authorities
CONTRAN	National Transit Council
CPRM	Geological Survey of Brazil
DENATRAN	National Traffic Department
DF	Federal District
DNIT	National Department of Transportation Infrastructure
DSM	Demand Side Management
EPE	Energy Research Company
ES	Espirito Santo State
EV	Electric Vehicle
FNMC	National Fund on Climate Change
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GPS	Global Position System
GWh	Giga Watt Hour
IBGE	Brazilian Institute of Geography and Statistics
ICT	Institution of Science & Technology
IDB	Inter-American Development Bank
INMETRO	National Institute of Metrology, Quality & Technology
IPI	Tax on industrialized products
IPVA	Motor Vehicle Property Tax
KWh	Kilo Watt Hour
LCMR	low-cost/must-run
MA	Maranhão State
MCTI	Ministry of Science, Technology, Innovation & Communication
MDIC	Ministry of Industry, Foreign Trade and Services

MDR	Ministry of Regional Development
MG	Minas Gerais State
MMA	Ministry of Environment
MME	Ministry of Mines and Energy
MS	Mato Grosso do Sul State.
MW	Megawatts
NBR	Brazilian Standards
NDC	Nationally Determined Contribution
NMT	Non-Motorized Transport
NTU	National Association of Urban Transport Companies
OEM	Original Equipment Manufacturer
PE	Pernambuco State
PETROBRAS	Brazilian Petrol Company
PI	Piaui State
PM	Post Meridian
PNE	National Energy Plan
PNEF	National Energy Efficiency Plan
PNMC	National Climate Change Policy
PNME	National Platform for Electric Mobility
PNMU	National Policy on Urban Mobility
PNT	National Transportation Policy
PPP	Public-Private Partnership
PRI	Principles for Responsible Investment
PR	Parana State
PROALCOOL	National Alcohol Program
PROCONVE	Motor Vehicle Air Pollution Control Program
PROMOBE	Program of Electric Mobility and Efficient Propulsion
PRO-TRANSPORT	Program for Infrastructure Transportation and Urban Mobility
PSTM	Transportation and Urban Mobility Sector Plan for Climate Change Mitigation and Adaptation
PT	Public Transportation
R&D	Research and Development (P&D)
RENOVABIO	National Biofuels Program
RJ	Rio de Janeiro State
RN	Rio Grande do Norte State.
RS	Rio Grande do Sul State.
SC	Santa Catarina State
SE	Sergipe State
SIMOB	Urban Mobility Information System
SENAI	National Service of Industrial Learning
SINDITAXIS	Taxi Drivers Union
SP	São Paulo State
SPV / SPE / SPC	Special Purpose Vehicle / Special Purpose Entity / Special Purpose Company.
TI	Individual motorized transport
TTW	Tank-to-wheel
UNFCCC	United Nations Framework Convention on Climate Change
USD	American Dollar
V	Volts
VA	Value Added
WTW	Well-to-wheel
ZEBRA	Zero Emission Bus Rapid-Deployment Accelerator

Contents

1. Introduction

The country intervention strategy summarizes the results of the country diagnostic and the market assessment and adds the components of proposed project interventions (investment projects and technical assistance), proposed instruments and the direct plus indirect potential impact of the program.

2. Country Diagnostic[1]

2.1. General

Brazil has an area of 8,511,965 km^2, making it the largest country in South America and the fifth largest in the world. In terms of population, the Brazilian Institute of Geography and Statistics (IBGE, 2020) estimated that in 2019 there were 210 million inhabitants and projected that by 2030 there will be 224 million inhabitants. In economic terms, Brazil is the ninth largest economy in the world with a GDP of 2.01 trillion dollars at 2018 prices, which makes it the largest in Ibero-America, as well as accounting for 40% of the entire GDP of the region (Ministry of Foreign Affairs, European Union and Cooperation, 2020).

The Brazilian automotive industry is among the ten most important in the world. Consequently, it will have to make significant investments if it decides to produce electric vehicles for the mass market (Geraldo Costa, 2019). Under the government policy INOVAR auto, which promotes the local manufacture of efficient vehicles, "super-credits" are provided to electric vehicle producers, helping them to achieve their consumption goals (Geraldo Costa, 2019).

Brazil launched in 1970 the federal "Proálcool" initiative to promote the use of sugarcane ethanol as fuel. From 1990 to 2011, the cultivated area increased by 45 % and ethanol production increased by an average of 1.5 billion tons per year, generating 1.2 million direct and indirect jobs. Therefore, electric vehicles are expected to face a strong resistance form biofuel (ethanol) in Brazil (Geraldo Costa, 2019).

2.2. Climate and Energy Policies

In Brazil, Law No. 12,187 of December 29, 2009 institutes the National Climate Change Policy (PNMC). This Law establishes principles, objectives, guidelines and instruments of the PNMC, considering adaptation, mitigation to the adverse effects of climate change, emissions, source, greenhouse gases, impact on climate change, vulnerability to climate variability and extreme events.

Brazil's total GHG emissions in 2014 were 1,357 $MtCO_{2e}$. In 2019, emissions from transportation (197 $MtCO_{2e}$) remained stable compared to 2018. These emissions are generated using fuels in freight or passenger vehicles. Trucks and automobiles are the two main sources of emissions in transportation, responsible for 40% and 31%, respectively, of the GHGs emitted in this sector in 2019 (SEEG, 2020).

In its NDC (Nationally Determined Contribution, 2015) Brazil commits to mitigate, adapt and implement measures with the purpose of achieving the ultimate goal of the convention foreseen in the Paris Agreement. The fundamental objective of the NDC is to reduce greenhouse gas emissions by

[1] See Report Grutter Consulting, 2020, Country Diagnostic Brazil for further details.

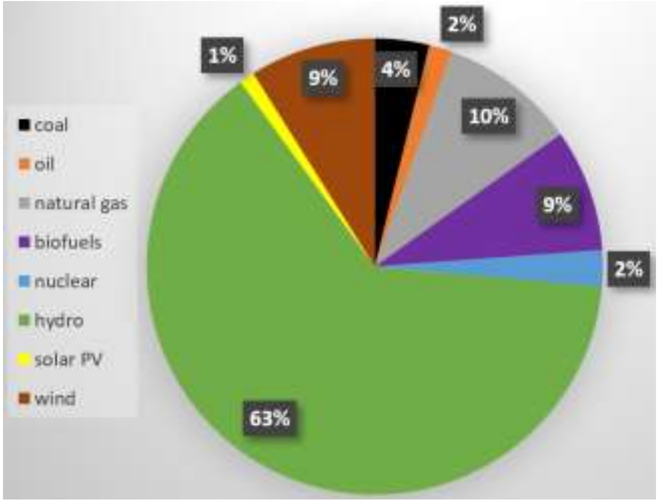
37%, reaching lower level than 2005, by 2030, to help limit the global average temperature growth to 2°C above pre-industrial levels, and to promote the country's long-term sustainable development.

The Transportation and Urban Mobility Sector Plan for Climate Change Mitigation and Adaptation (PSTM) seeks to contribute to the mitigation of GHG emissions in the sector, through initiatives that lead to the expansion of freight transportation infrastructure and greater use of more energy-efficient modes and, in the urban mobility sector, greater use of efficient public passenger transportation systems, contributing to the fulfilment of the commitments voluntarily assumed by Brazil.

The NDC dedicates a paragraph to the transportation sector to state that the government will further promote efficiency measures and improve public transportation infrastructure in urban areas. These include increasing the share of biofuels in the Brazilian energy mix. Brazil has a share of 27% of biofuels in the transportation sector in 2019. The biodiesel content is 4.7% and the bioethanol share 22%.

In 2019 82% of electricity was generated by renewable and 18% by fossil sources (see figure below).

Figure 1: Power Generation by Source in 2019



Source: IEA

The carbon factor of the electricity grid of Brazil is for 2019 0.119 kgCO_2/kWh[2].

2.3. Transport Sector

2020 some 98 million vehicles were operating in Brazil. The country has the vehicle emission standard equivalent to Euro 2 for light vehicles since 1997, and Euro 4 since 2009. Euro 5 has been introduced from 2013-2015[3]. Euro VI standards are expected to be introduced 2022. Diesel fuel sold in the country has 500 ppm sulphur with cities also selling 100ppm sulphur diesel.

Transportation emission costs modelled in this report are close to 18 billion USD for 2019 and 21 billion USD for 2030 with the share of local pollutants being around 20%. Vehicle emission costs represents for 2019 1% of the country's GDP.

[2] Calculation by Grutter Consulting based on data from IEA (Grutter Consulting, 2021)
[3] [Brazil: Light-duty: Emissions | Transport Policy]

Transport GHG emissions of Brazil in 2019 are estimated at 290 million tCO_{2e}[4] based on a bottom-up transport model calibrated with top-down fuel consumption data. Commercial vehicles including taxis, buses and LCVs are responsible for around 40% of GHG emissions and 60-80% of pollutants ($PM_{2.5}$ and NO_x). GHG emission from the transport sector are expected to grow under a BAU scenario by around 16% reaching 336 million tCO_2 by 2030[5] (see table below).

Table 1: Projected 2030 Transport Emissions

Vehicle category	NO_x	$PM_{2.5}$	CO_2 TTW	CO_2 WTW	Energy in TJ
Passenger car	41,537	749	137,969,621	164,284,967	1,990,904
Taxi	1,188	21	3,944,911	4,697,336	56,925
Motorcycles	27,028	488	15,397,501	18,432,739	222,186
small bus	135,916	1,068	12,920,674	16,613,117	174,368
standard urban bus	68,213	581	14,891,854	18,709,456	200,970
Coach	132,734	1,040	23,111,427	29,128,753	311,895
LCV	195,826	9,590	64,634,756	86,792,186	876,961
Truck < 7.5t	33,352	216	6,544,739	8,195,539	88,323
Truck 7.5-16t	53,893	327	10,043,907	12,575,016	135,545
Truck 16-32t	77,890	486	13,607,873	17,065,769	183,642
Truck >32t	187,506	1,090	32,529,269	40,746,788	438,991
Total	**955,083**	**15,656**	**335,596,531**	**417,241,667**	**4,680,711**

Source: (Grutter Consulting, 2021)

Urban mobility in the country is considered one of the main challenges today. Cities such as Brasília were designed for automobile commuting, which creates traffic jams and high environmental pollution, common factors in large cities. Public Transportation in Brazil is mainly composed of the following modes of transportation: Buses and Urban Railways (Subway, Train and Light Rail Transit). However, only 12 cities have urban rail services: São Paulo, Rio de Janeiro, Recife, Natal, Porto Alegre, Fortaleza, Brasília, Salvador, Maceió, João Pessoa, Belo Horizonte and Teresina. Thus, buses are the most representative mode of public transportation in the country.

In Brazil, the financing of mobility projects is almost always done through development banks, such as BNDES (Banco Nacional de Desenvolvimento) and Caixa. The Banco Nacional de Fomento - BNDES - offers a line of financing especially for mobility projects (BNDES Finem - Urban Mobility).

In 2017, a survey conducted by the Brazilian Institute of Geography and Statistics (IBGE) revealed that, in 113 municipalities in the country, cabs are the only means of public transport. The Brazilian Chamber of Deputies approved in March 2018 the law 13,640/2018 that regulates transportation apps such as Uber, Cabify or 99, whose drivers will be required a series of conditions to be able to offer their service.

2.4. EV Policies and Activities

In October 2015, the first incentives for the purchase of electric vehicles were adopted. These vehicles were mandated to have a 0 % import tariff rate and there is currently an initiative to reduce to 0 % the Industrialized Products Tax for hybrid, electric, and ethanol vehicles manufactured in the country. At the state and local level, electric vehicles are exempt from paying the annual owner's tax in the states of Pernambuco, Maranhão, Ceará, Piauí, Rio Grande do Norte, Rio Grande do Sul and Sergipe,

[4] Tank-to-wheel approach; taking into account biofuels and assuming (wrongly) that biofuels have no upstream emissions the GHG emissions from the transport sector are 253 Mt CO_{2e}; Using a well-to-wheel approach including Black Carbon emissions are: 361 Mt CO_{2e}.

[5] 291 Mt CO_{2e} based on 0-emission biofuel.

and reduced taxes in Rio de Janeiro, Mato Grosso do Sul and São Paulo. In 2014, the city of São Paulo enacted a law exempting electric and hybrid vehicles from the "Rodizio Veicular," a program that reduces the circulation of vehicles.

The following regulatory measures to foster e-mobility have been realized (Promobe, 2019):

- CAMEX Resolution 97 of October 26, 2015: the import tax rate for automobiles with electric propulsion engine powered by accumulators or fuel cells with a range of at least 80 km was reduced to 0. For hybrids, it reduced the rate from 35% to between 2 and 7% depending on the capacity and efficiency of the engine.
- Normative Resolution No. 819, dated June 19, 2018: The first regulation on the recharging of electric vehicles is found. It is established that the recharging service is a competitive activity and distict from commercialization or supply, so it does not make sense to set rates for this service.
- Decree No. 9,442 of July 4, 2018. This decree reduced the rates of the Indistrualized Products Tax (IPI) to vehicles with hybrid and electric motors. The rate decreased from 25% to a range between 7% and 20%. The more efficient the vehicle, the lower the percentage.

There are 21 bills pending in the Chamber of Deputies on electric mobility that seek greater incentives for electric vehicles (Promobe, 2019).

The following table summarizes enabling factors and barriers towards the deployment of commercial EVs in Brazil.

Table 2: Enabling Factors and Barriers to Commercial EVs in Brazil

Enabling factors	• The Government has passed some initial bills and regulations for EVs. • Brazil manufactures vehicles which can be a barrier or an enabling factor towards e-mobility (barrier if the industrial policy is backwards oriented and trying to preserve existing structures and an enabling factor if the industrial policy is geared towards fostering new technologies and future markets). • Brazil has realized various EV pilots and is thus gaining initial experience. • Brazil has a very low carbon grid factor.
Barriers	• Lack of experience and know-how on creating for commercials EVs an enabling surrounding including regulations, business models and financial support policies which enable their massive uptake. • Commercial EVs are perceived to lack profitability and have much higher upfront costs. • For taxi and LCV deployment an urban public fast charging infrastructure is required. This is not yet available making operations of such vehicles problematic. • Lack of financial support for the purchase or operations of commercial EVs. Kick-starting EV deployment in this area without concessional finance and subsidies covering part of the incremental investment will not be possible. • Brazil focuses its efforts on the promotion of biofuels. This presents a barrier towards a shift to a more sustainable transportation technology

3. Actor Mapping

The **Ministry of Regional Development (MDR)** is the main public funder of transport infrastructure at the municipal level financing BRTs, roads, terminals and other transport infrastructure throughout Brazil. On 17 February 2021, the MDR published the Normative Instruction regulating the reformulation of the Urban Transport and Mobility Infrastructure Programme (Pro-Transporte). The reformulation of Pro-Transport was published on 15 December 2020, through Resolution 989. The objective of Pro-Transport is to promote the improvement of urban mobility, universal accessibility, quality of life and access to basic services and social facilities in Brazilian cities, prioritizing collective public transport and non-motorised modes. Within the MDR, the National Secretariat of Mobility and Regional and Urban Development is the result of the merger of the former National Secretariat of Regional and Urban Development and the National Secretariat of Mobility and Urban Services. The new secretariat oversees promoting regional and urban development by strengthening local and regional innovative productive systems, investments in urban rehabilitation, territorial management, federative capacity building and investments in urban mobility.

The **Ministry of Science, Technology, Innovation & Communication** (MCTI) is responsible for promoting the development of technological solutions for the sustainability of cities, with an impact on reducing social inequalities and the negative effects of urban development on the environment. The MCTI created the Technologies for Sustainable Cities Programme in response to the growing demand for solutions to the challenges faced. Over the past eight years, the Programme has been active in promoting applied research in technologies aimed at supporting projects for the development of technological solutions and demonstration projects in the areas of mobility, environmental sanitation and sustainable energy systems for social development. The MCTI also aims to develop and evaluate prototypes to generate data on the technical and economic feasibility of using solar photovoltaic-powered land and river electric vehicles for passenger and freight transport at scale.

Municipalities with a population of less than 100 thousand inhabitants have technical assistance from the Ministry of Regional Development (MDR) to prepare their Urban Mobility Plans. The Support System for the Preparation of Urban Mobility Plans is a tool that assists municipal managers in the preparation of the Urban Mobility Plan. In the system, managers fill out a preliminary version of the plan, with the minimum content required by the National Policy on Urban Mobility (PNMU), established by Law 12,587/12. The former Ministry of Transporte has been incorporated by the **Ministry of Infrastructure** by 2019.

The **National Department of Transportation Infrastructure** (DNIT) is now linked to the Ministry of Infrastructure and is responsible for the maintenance, expansion, construction, supervision and elaboration of studies related to the road, rail and water systems.

The **National Land Transport Agency** (ANTT) is responsible for regulating, supervising and inspecting transport activities carried out by third parties, preserving the public interest. This entity oversees the formulation of guidelines for the development of the transport sector in the country. The areas of competence of this ministry are national policy on rail, road, river, airport and air transport, national traffic policy and planning the implementation of transport investment programmes.

The objective of the **Ministry of the Environment** (MMA) is to formulate environmental public policies that encourage sustainable development. Its areas of competence are: National environmental policy; Policy for the preservation, conservation and sustainable use of ecosystems, biodiversity and forests; Strategies for improving environmental quality and the sustainable use of natural resources; Environmental and productive integration policies; Environmental policies and programs for the Amazon; Strategies for the promotion of environmental policies; Economic-ecological zoning. The destination of wastes and batteries are under the Ministry of the Environment authorities and control, at the national level.

The **Ministry of Mines and Energy** (MME) has four secretary sections that propose the guidelines in their areas of activity: Secretary of Petroleum, Natural Gas, and Biofuels: proposes guidelines for bidding in areas for the exploitation and production of these components; Geology, Mining and Mineral Processing Secretary: conducts studies and proposes sustainable actions for mining and mineral processing; Secretary of Electric Energy, which seeks access to this resource through society; Energy Planning and Development Secretary, which analyzes the granting of concessions, authorizations and permits for electric power services.

The ANEEL (**National Electrical Energy Agency**), an autarchy under a special regime linked to the Ministry of Mines and Energy, was created to regulate the Brazilian electrical sector, through Law 9427/1996 and Decree 2335/1997. ANEEL aims to (1) Regulate the generation (production), transmission, distribution and commercialization of electric power; (2) inspect, directly or through agreements with state agencies, the concessions, permissions and services of electric power; (3) Implement the policies and directives of the federal government relating to the exploitation of electric power and hydraulic potentials; (4) Establish tariffs; (5) Settle differences, in the administrative sphere, between agents and between these agents and consumers; and (6) promote the granting of concessions, permissions and authorizations for electric power undertakings and services, as delegated by the Federal Government. Recently, ANEEL has invested almost BRL 500 million in mobility projects through innovation and technology programs.

The **Ministry of Economy** integrates functions of the Ministries of Finance, Planning, Development and Management, Industry, Foreign Trade and Services, and Labor. Among its many tasks is the formulation of guidelines for public projects with multilateral organizations and government agencies.

The **National Platform of Electric Mobility** is a joint effort of important players in the government, industry, academia and civil society to build long-term goals, considering the points of view of technological of technological development, governmental public policies and the market. It aims to encouragement and market induction; Growth of insertion in productive activities; Propose public policy and regulatory instruments; and Creation of competencies in research and development (R&D) in Brazil. The Platform is a space for articulation, convergence, and networking. New members and partners are continuously added, ensuring the PNME both flexibility and a constant flow of skills needed to respond to dynamic technological, economic, political, and social challenges.

The **Brazilian National Bank for Economic and Social Development**, BNDES, s a bank financing facility that provides funding for investment projects of public interest aimed at urban mobility with low interest rates for the private sector - mainly bus operating companies in Brazil - but the minimum value of a project is BRL 40 million (aprox. 7.2 MUSD).

In Brazil, the public transport sector each of the 5,570 **municipalities** has the right and the responsibility to legislate on public transportation, as long as federal and state laws are respected. In this context, one can surely find several business models for the concession and granting of public transportation services.

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4. EV Deployment Scenarios

3 different EV scenarios have been constructed:

- EV15@30: The moderate EV scenario is based on the "EV new policies scenario" which has as target for 2030 15% instead of 30% EV share. The same approach is used as for EV30@30.
- EV30@30: The EV30@30 scenario of IEA has as target that 30% of all vehicles sold in 2030 are electric. The scenario is built on newly purchased vehicles (and not the stock of vehicles) in

line with IEA scenarios (IEA, 2019). In addition to the IEA also motorcycles and trucks <7.5t are included with the same EV penetration rates.

- EV "high growth" scenario focusing on the potential for commercial vehicles targeted by the E-Motion Program with an EV target of 100% of new registered vehicles for these categories by 2030. The "high growth scenario" shows what would be required to achieve the targets as set by the Paris declaration on e-mobility. In all other vehicle categories the maximum of the 2 other scenarios has been chosen.

The following table shows the results in terms of GHG reduction against a scenario of no EVs as well as the additional electricity consumption due to EVs with the different scenarios.

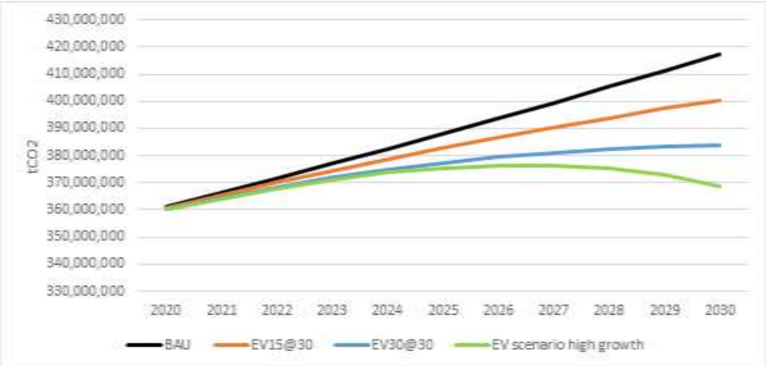
Table 3: Scenario Results

Impact	Scenario	By 2025	By 2030
GHG reduction WTW in tCO_{2e} per annum	IEA 15@30	5,380,000	16,800,000
	IEA30@30	10,760,000	33,500,000
	"High growth" scenario	12,550,000	48,300,000
Electricity demand of EVs in GWh per annum	IEA 15@30	6,240	19,000
	IEA30@30	12,480	39,000
	"High growth" scenario	12,190	46,000

Source: (Grutter Consulting, 2021)

The figure below shows the slow reaction of GHG emission reductions of the sector due to long permanence of vehicles once purchased. The introduction of EVs takes a long time to reduce in absolute terms GHG emissions of the transport sector as vehicle growth still occurs and as vehicle replacement rates are relatively low i.e. it takes time to achieve a large stock and therefore large impact of EVs. This highlights the importance of early actions. Waiting 5-10 years more until the market has evolved without support will result in a 5-10-year time lag of GHG reductions and thus non-attainment of climate targets.

Figure 2: Projected GHG Transport Emissions Brazil under Different Scenarios (WTW)



Source: Grutter Consulting

The 2030 projected electricity demand of EVs represents 4% of same year electricity generation for the EV scenario using the highest growth scenario. The electricity demand increase resulting from EVs is very gradual and thus leaves enough time to the country to plan a potential production expansion.

The grid system of Brazil has had during summer months a peak between 1 and 4PM and in winter an evening peak at 6PM. Electric buses can avoid using these peaks for charging. This is true for overnight charged buses as well as intermediate or opportunity fast charged buses. Taxi fast charging could basically be done outside the peak as well and fast chargers could apply significant differential pricing to avoid peak charging. Passenger cars and LCVs are basically charged overnight which minimises the need for incremental electricity generation capacity and investment in distribution infrastructure upgrades.

5. Market Analysis[6]

5.1. Current EV Market

The current EV market in incipient and based on pilot projects. The country has currently a public and private network of more than 250 charging points. In terms of infrastructure, Plug Share, a site that is responsible for mapping international charging infrastructure, estimates that there are about 150 public / private charging points installed in Brazil, which are concentrated in the south and south-eastern axes of the country.

5.2. Current Commercial EV Financial Viability

5.2.1. Introduction

The financial assessment is made per vehicle type with local data. Following parameters are assessed:

- Total cost of ownership (TCO) per kilometre comparing the fossil with the electric unit: The TCO is calculated in financial and economic terms; values are not discounted for the TCO. The TCO only includes parameters which are different between an EV and a fossil unit i.e. Capital Expenditure (CAPEX), energy costs, maintenance costs and finance costs. Other (important) costs such as for example for bus operators driver, fare system, or management are not included as these are identical between technologies. This needs to be considered when comparing TCOs from different sources.
- Incremental upfront capital investment required and incremental equity capital required with current financing schemes.
- Profitability of investing in an EV instead of a fossil vehicle by calculating the Financial Internal Rate of Return (FIRR) and the Economic Internal Rate of Return (EIRR) of the incremental capital expenditure: the FIRR is compared to the Weighted Average Capital Cost (WACC) for the transport sector calculated at 7.8%[7];
- Differential cash flow;
- Discounted payback time of differential investment (using the WACC as discount rate).

The financial analysis is a comparison of investment options. It does not assess the financial viability of operating the specific vehicle (as example in public transport diesel buses could be operating at a loss and e-buses could continue to be operated at a loss) nor the financial soundness and creditworthiness of an enterprise. For latter other factors need to be contemplated such as revenues, debt and equity levels etc. The financial analysis is a comparison of investing pari passu in electric instead of fossil units. All calculations are performed in constant real 2020 USD.

5.2.2. Electric Buses

The following table summarizes the financial assessment of BEBs (fast as well as overnight charged BEBs were assessed). The standard bus considered in the analysis is a 12m urban bus with AC (see for other characteristics Annex). To comply with operating conditions in Brazil an overnight charged bus

[6] See also for further details (Grutter Consulting, 2021a)
[7] See (Grutter Consulting, 2021a) for details of calculations.

would require a battery set of 420 kWh whilst a fast-charged unit could be equipped with a 200 kWh battery set and 300 kW chargers (on average 1 per 8 buses)[8].

Table 4: Summary Financial Assessment 12m BEBs Brazil

Criteria	Result	Assessment
Financial TCO	0.68 – 0.74 USD/km for BEBs versus 0.76 USD/km for diesel Euro V bus[9]	Non-discounted the cumulated lifetime costs for BEBs are comparable to diesel buses.
Capital investment	300-330,000 USD for BEB incl. chargers, grid connection and bus depot upgrade; 150,000 USD for diesel bus	Significantly higher capital requirement incl. higher loan demand; negative impact on debt to equity ratio
Equity investment	10,000 for BEB[10] versus 30,000 for diesel bus	Significantly higher equity demand which might overstretch the capabilities of enterprises
Profitability[11]	FIRR of 8-13%	Investment in e-buses is profitable
Discounted Payback	Incremental investment is not recovered with savings during asset lifetime (16yrs)	The investment in e-buses is not profitable and the payback time is extremely long, even going beyond the asset lifetime. This indicates a high risk profile of the investment.
Cash Flow (CF)	Negative cumulative CF until year 6 and again from year 8 (due to investments for battery replacement in year 8 and charger replacement in year 10)	The investment in BEBs will affect the liquidity position of the companies in a negative manner and will a}impact negatively the solvency ratio and at least for the loan period the working capital ratio.

Source: (Grutter Consulting, 2021a); see Annex for details including assumptions

The investment in BEBs with the current financial conditions and business models is marginally profitable, but with a high risk. The TCO does give the indication that e-buses are potentially an interesting alternative. However, BEBs will require a different financial structuring and financial incentives to be a viable business proposal in Brazil.

5.2.3. Electric Taxis

The following table summarizes the financial assessment of e-taxis. The comparison is based on a Chevrolet Onix with gasoline engine versus a Jac e40 e-taxi with a 40kWh battery set.

Table 5: Summary Financial Assessment E-Taxis Brazil

Criteria	Result	Assessment
TCO[12]	0.13 USD/km for e-taxis versus 0.11 USD for gasoline unit	Non-discounted the cumulated lifetime costs for e-taxis are higher than for gasoline units.
Capital investment	41,000 USD for e-taxi including homer charger versus 12,000 USD for gasoline unit	Significantly higher capital requirement incl. higher loan demand
Equity investment	10,000 USD for e-taxi versus 2,000 USD for gasoline unit	Significantly higher equity demand which might overstretch the capabilities of taxi owners

[8] For details see Annex

[9] TCO includes only CAPEX (including battery replacement, including bus, charging infrastructure, grid connection, bus depot upgrades), energy, maintenance, and financial cost but not driver or management overhead. Calculated for 16-year lifespan.

[10] Banks only finance 80% of BEB but not of charging infrastructure, grid connection and depot upgrades due to not being collateral.

[11] FIRR of incremental investment compared to diesel bus.

[12] Includes CAPEX, energy, maintenance and finance costs; does not include other costs such as the driver which are independent of the technology chosen.

Profitability[13]	FIRR of -3%	Investment in e-taxis is not profitable.
Discounted Payback	Incremental investment is not recovered during the 10 years savings	The payback time is too long. This indicates a high risk profile of the investment.
Cash Flow	Negative cumulative CF until year 10	The investment in e-taxis will affect the liquidity position of the taxi owner in a negative manner and will affect negatively the solvency ratio and at least for the loan period the working capital ratio.

Source: (Grutter Consulting, 2021a); see Annex for details including assumptions

The investment in e-taxis with current financial conditions and business models is a loss business with a considerable risk and high owner capital requirements. One of the major risks is that revenues will be lower when using an e-taxi. Taxis are often driven with 2 shifts especially during weekends (Friday to Sunday) or on special days with double shifts or 24 hours as this is the most profitable period. During such days the driving range of the e-taxi will be insufficient without re-charging. Home-charging takes 6-8 hours and is too slow. Also public chargers available are in general too slow. A fast-charging urban network of 100-150kW chargers is a necessity to ensure that e-taxi owners do not lose a significant part of their revenues. Therefore currently e-taxis cannot be considered a financially viable investment except for special cases such as luxury taxis or low-mileage units with very regular schedules.

5.2.4. Electric LCVs

The following table summarizes the financial assessment of e-LCVs. The comparison is based on a Volkswagen Delivery diesel versus ea JAC iEV1200T with a GVWR of 7.5t.

Table 6: Summary Financial Assessment e-LCVs Brazil

Criteria	Result	Assessment
TCO[14]	0.25 USD/km for e-LCVs versus 0.23 USD/km for diesel unit	Non-discounted the cumulated lifetime costs for e-LCVs is higher than for fossil units
Capital investment	66,000 USD for e-LCV including home chargers versus 37,000 USD for fossil unit	Higher capital requirement incl. higher loan demand
Equity investment	15,000 USD for e-LCV versus 7,000 USD for fossil unit	Double equity demand
Profitability[15]	FIRR of -1%	Investment in e-LCVs is not profitable
Discounted Payback	Incremental investment is not recovered in lifetime of vehicles with savings	The payback time is very long. This indicates a high risk profile of the investment. This is also due to investment for replacement battery in year 7/8
Cash Flow	Cumulative negative entire lifespan	The investment in e-LCVs has a cumulative negative liquidity impact during the lifespan also due to investments for battery replacement in year 8

Source: (Grutter Consulting, 2021a); see Annex for details including assumptions

The investment in e-LCVs with current financial conditions and business models is not profitable, has a high risk and a very long payback time. Also electric LCVs are not common in the market.

[13] FIRR of incremental investment compared to gasoline taxi.
[14] Includes CAPEX, energy, maintenance and finance costs; does not include other costs such as the driver which are independent of the technology chosen.
[15] FIRR of incremental investment compared to gasoline LCV.

5.3. Sensitivity of Commercial EVs to Change of Finance Conditions

5.3.1. Introduction

Variations have been conducted by using concessional loan conditions and investment subsidies to assess their impact on the core financial parameters. The following table lists the base assumptions used for calculations. All values are tentative and used as modelling assumptions. Project specific conditions will depend on a variety of factors such as risk rate or borrower status.

Table 7: Assumed Concessional Conditions for USD Loan

Parameter	Value	Source
GCF loan conditions	1.25% annual (0.75% commitment fee + 0.5% service fee)[16]	GCF conditions public sector non-vulnerable countries; GCF/B09/08
AFD/CAF loan conditions non-sovereign public sector	4.8%	AFD
Assumed shares	30% GCF and 70% CAF	
Bank spread for on-lending	2%	Assumed
Resultant minimum loan rate for buses if based on project finance with public lender e.g. municipality	3.7%	Calculated based on above data
Resultant minimum loan rate for LCVs and taxis based on lending through public banks	5.7%	
Lending rates for buses, LCVs and taxis	80% maximum	
Loan tenure	14 years buses 9 years taxis & LCVs	

5.3.2. E-Buses

Concessional finance would result in an interest rate of 3.7% instead of 7.5%. The level of concessionallity would be dependent if the recipient is a public body e.g. municipality or public bank. The loan tenure is already currently for BEBs 14 years. An 80% lending rate on the total CAPEX and not only on buses is also assumed. Following impacts can be observed:

1. The TCO reduces considerably is now clearly below that of diesel buses.
2. The concessional loan does not change the FIRR but reduces the WACC making the investment more feasible.
3. Owners capital requirements are reduced with the concessional loan (due to not only financing the bus but all investment components).
4. The risk and the capital exposure of the entrepreneur can be reduced significantly. With fast-charged BEBs the investment can be recovered within 13 years.

The TCO is reduced significantly and the dynamic repayment period is now much shorter than the asset lifetime. It can be concluded that concessional loans are nearly sufficient to make investments in e-buses profitable in Brazil. Only a small grant financing of 5% of CAPEX for investments is thus required in Brazil. With a grant finance of 5% of CAPEX, a loan with 20% equity and 75% loan rate (100%-20% equity minus 5% grant) and an average 2.5% interest rate (based on 30% loan by

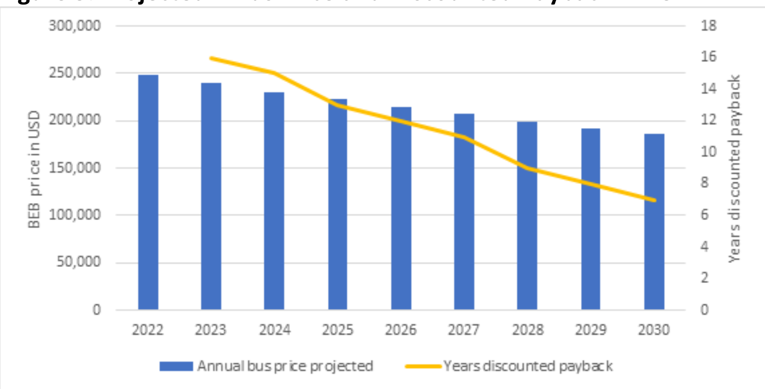
[16] In the GCF/B09/08 contract, in addition to the interest rate, the GFC consider an annual service fee of 0.50% on disbursed balances and a commitment fee set at a maximum of 0.75% of the undisbursed balance to encourage disbursements.

GCF@1.25% and 45% loan share AFD and co-financiers @ 4.8%) at 14 years tenure the WACC results in 3.8%. With these conditions:

- The BEB TCO is between 0.55 and 0.60 USD/km which is significantly lower than that of dieel buses;
- The FIRR is for the differential investment in BEBs compared to diesel buses between 10% and 15% which is above the WACC of 3.8%.
- The discounted payback period is 7-8 years which is lower than the commercial lifespan of 16 years and the concession period.

The following graph shows how under decreasing e-bus costs the dynamic payback will also reduce (see chapter 5.4. for expected BAU deployment in absence of the Program). Until 2030 e-buses are expected to have a payback period of around 7 years with commercial and non-concessional finance conditions instead of more than 16 years currently.

Figure 3: Projected E-Bus Price and Discounted Payback Time



Source: Grutter Consulting; annual decrease of BEB projected at 4% based on decreasing battery price projections of BNEF[17]; graph valid for fast-charged BEBs

5.3.3. E-Taxis

For taxis the assumption is that a fast charging infrastructure would be established to eliminate the barrier of reduced revenues. The charging infrastructure would be managed by a 3rd party (e.g. electric utility) and would be partially grant and concessional loan financed (see chapter 6 for a possible project). Taxis would thus just pay the price charged for usage of public chargers (time/power/consumption relative prices possible). Taxis are privately owned and managed.

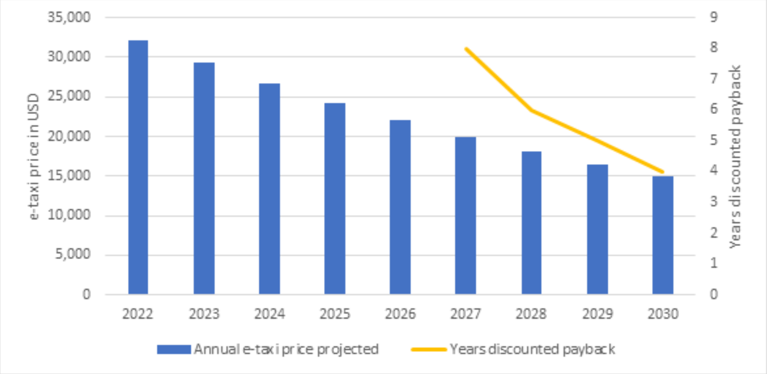
Modelling concessional loans plus a 20% grant does not resolve the lack of commercial viability of e-taxis. This is to a certain extent due to the very low cost of locally manufactured gasoline units and the limited market and high price of EVs. Without national production of cost competitive EVs this will remain a market without large potential.

The figure below shows the trend of decreasing dynamic paybacks of e-taxis. Clearly with decreasing prices they get more attractive. The project trend price decreases only applies if national manufacturers start producing low-cost EVs such as used for taxis. Also, the graph below does not

[17] https://www.sustainable-bus.com/news/electric-vehicle-outlook-2020-bnef-electric-buses/#:~:text=With%20regards%20to%20electric%20bus,needed%20to%20keep%20prices%20falling%C2%BB.&text=But%20by%202030%20demand%20grows%20almost%2014%2Dfold%20to%201%2C755GWh.

take into account the reduced revenues but only cost impacts i.e. as long as the charging issue is not resolved the investment in e-taxis remains commercially a risky undertaking.

Figure 4: Dynamic Payback versus Projected e-Taxi Price Decrease



Source: Grutter Consulting; annual decrease of e-taxi prices projected at 8% based on price parity expected by 2030 (see Electric vehicle trends | Deloitte Insights)

The conclusion for e-taxis is that it is not feasible, even with significant financial incentives, to achieve in the medium run a sustainable EV market in this segment. Therefore the recommendation is given to not enter with e-taxis in Brazil.

5.3.4. E-LCVs

LCVs are privately owned and managed. The assumed business model is that finance is provided through loans managed by public banks which would receive the concessional conditions of the Program. A concessional loan improves the liquidity situation and the TCOs without however having a major impact in other areas i.e. grants would be required. The interest of public entities in entering this area with EVs is however limited. Therefore this vehicle category is not further considered.

5.4. BAU versus Project EV Market Deployment

5.4.1. Approach

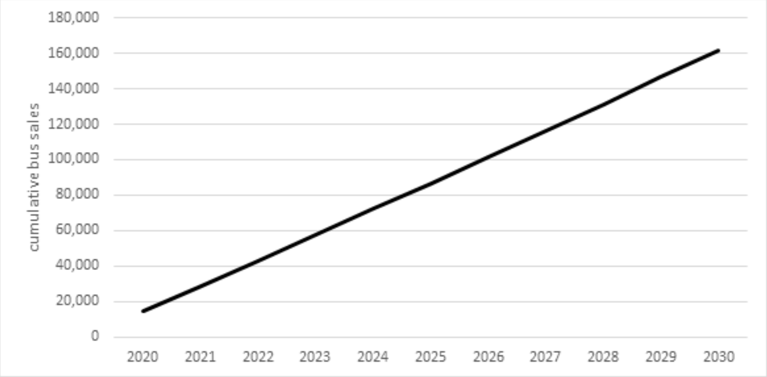
Under a BAU scenario EVs will pick up without commercial support. The question is when and how much. The following chapters will model the BAU deployment expected for the different commercial EV technologies due to decreasing EV prices and therefore increasing financial profitability of latter and the scenario of commercial EV deployment with program activities. This allows to model a scenario with and without program and the potential impact of the program beyond the singular fleet investments.

5.4.2. E-Buses

Market Demand for Urban Buses

The initial graph shows the total projected cumulative demand for urban buses in Brazil based on vehicle replacement and market growth rates.

Figure 5: Total Projected Cumulative Market Demand Urban Buses Brazil



Source: (Grutter Consulting, 2021)

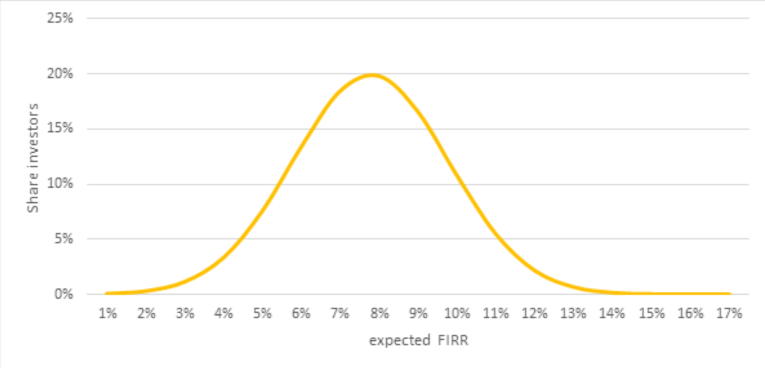
Projected BAU Demand for E-Buses

The BAU e-bus demand is based on comparing the FIRR with the WACC taking the decision rule that the investment is realized if the FIRR is higher than the WACC. The required WACC is adjusted for a risk rate based on being a new technology using the following criteria:

- Performance risk of BEBs with higher than expected energy costs (due to increasing electricity prices, more charging during high cost periods and/or higher than expected energy consumption of buses). The medium risk rate is modelled around 40% as buses might consume more energy or electricity prices might increase respectively costs depend on consumption pattern.
- Performance risk of e-bus maintenance costs. Whilst e-buses do require less maintenance of liquids and engine, their tyre usage is higher and spare parts are more expensive. Also maintenance savings might not materialize except for large fleets as only latter will allow for re-structuring the maintenance department and reducing for example workforce in this area. The medium risk rate is modelled around BEBs having equal maintenance costs as diesel units (observed by multiple smaller Chinese operators).
- Risk of battery costs not decreasing as fast as expected. Whilst the standard model assumes battery prices to decrease by 50% the risk-model assumes a decrease of on average only 10%. This is also based on the fact that cell prices are decreasing fast but battery package prices not as much. Also, BEBs might require new battery management systems with an additional investment in 8 years.

Not all investors have the same risk appetite. The modelling assumes normal distributed risk propensities i.e. we have the same share of persons being risk averse and risk takers. The risk propensity distribution is used to calculate a normal distribution of risk factors, which is added to the WACC and allows to determine for each year the share of investors which are willing to invest at e-buses at the given CAPEX of that year. The figure below shows the assumed distribution of investors based on a normal distribution of investors around the base risk-free WACC of 7.8%.

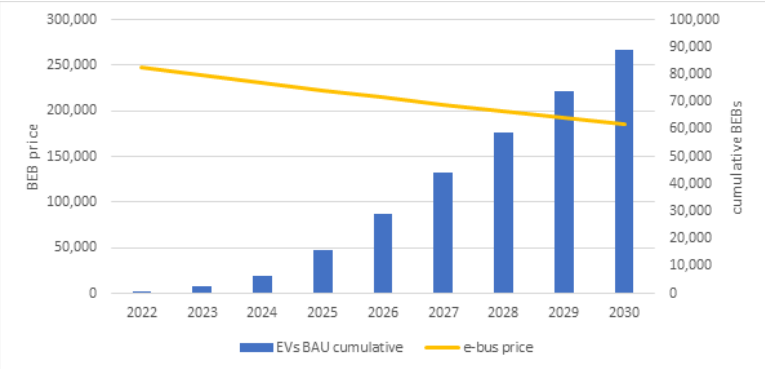
Figure 6: Expected FIRR of Investors



Source Grutter Consulting

The following curve shows the trend projection of decreasing bus prices and the BAU projection of uptake of e-buses without project intervention in Brazil.

Figure 7: BAU Projected E-Bus Uptake in Brazil and Price Trend of E-Buses



Source: Grutter Consulting; based on constant real USD without real price changes except for BEBs

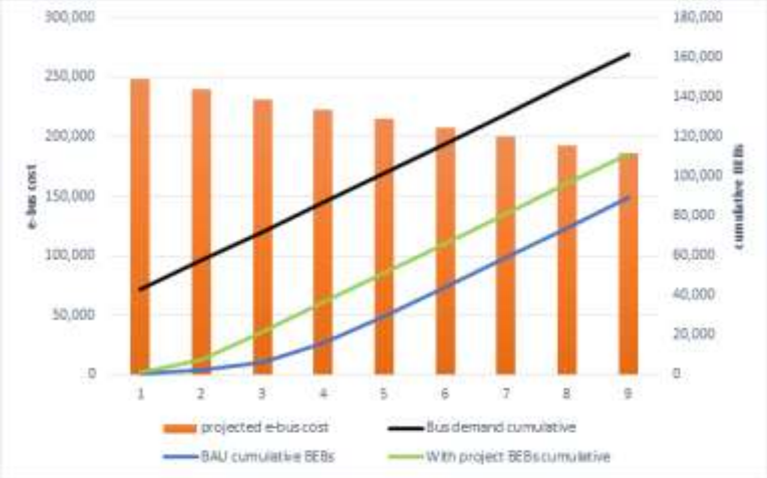
Under a BAU scenario BEBs in Brazil start to get commercially viable around 2024/2025 and then increase rapidly. With the BAU scenario the market share of electric buses by 2030 would be around 40%.

Estimated with-Project Demand for E-Buses

The EV project has as basic function to accelerate EV deployment. It uses financial assistance (FA) to deploy an initial at-scale fleet. This initial fleet is used to reduce the performance risk perception of future investors by having actual performance data of large-scale fleet application, by reducing risks and costs of new market entrants, by having appropriate maintenance facilities in place and by having new business models in place (if so required). Technical assistance (TA) is used to reduce entry barriers e.g. the length of concessions for e-buses, asset turn-over contracts and new business models e.g. based on leasing. At the same time capacity building and training reduce the performance risks.

The projected BEB demand with project is therefore based on reduced risk rates due to the initial fleet financed by the program and due to reduced performance risks. Even with this, risks are not assumed to be reduced to 0 immediately. A gradual risk rate reduction relative to BAU from 2023 to 2025 is assumed (it is assumed that a fleet of e-buses financed by the project enters operations in 2022). The projected EV demand is then modelled with the changed risk rates, whilst taking the same BAU EV price development. The figure below shows the e-bus market deployment with and without project i.e. under a BAU and with the case of a project intervention.

Figure 8: BAU and with-Project Projected E-Bus Uptake in Brazil and Price Trend of E-Buses



Source: Grutter Consulting; based on fast-charged BEBs

Comparing the with and without project scenario we can state an increase of the uptake speed (slope of the function). The e-bus fleet reaches by 2030 111,000 instead of 89,000 units with a BEB market share of 53% instead of 42% by 2030 i.e. the “high growth scenario” can be achieved. Thus the project has a decisive impact on accelerating climate friendly technologies. Compared with the BAU scenario this results by 2030 in the following impact (based on lifetime impact of cumulative incremental fleet operating by 2030):

- Additional 44 million tons of CO_2 reduced.
- Additional 1,090 tons of $PM_{2.5}$ avoided.
- Additional 128,000 tons of NO_x avoided.
- Additional economic savings of 2,180 MUSD.

Taxis and LCVs are not modelled as the program will not make interventions in this vehicle segment in Brazil.

6. Potential Investment Projects

6.1. Urban Buses

6.1.1. Barriers and Interventions Options

The major barrier towards massive e-bus deployment in Brazil that the initial investment is very high and combined with the risks of e-buses this results in an investment which is not profitable. In the case of private operators business models which tend towards asset and operation separation or leasing would be beneficial. E-buses have major environmental and societal advantages expressed in large positive environmental and health impacts. Whilst the TCO of e-buses is comparable to diesel units, the capital exposure, risks and lack of profitability make it a non-attractive investment.

Concessional loans are critical to de-risk the investment and to create an attractive financial framework. This includes longer loan tenures, concessional interest rates, and higher lending rate. No upfront investment subsidies are required.

6.1.2. Possible Business Models

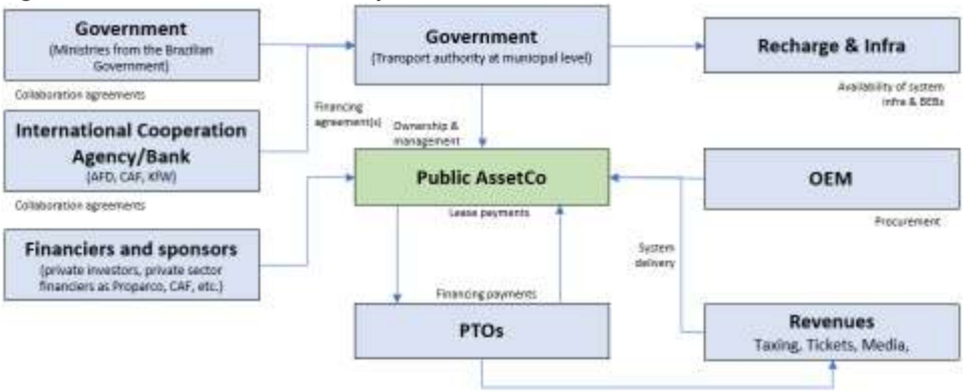
The typical structures that could be followed in the case of Brazil are:

- Public sector-led;
- Private sector-led (“PPP”); and
- Public Transport Operator (PTO)-led delivery.

Option 1: Public Sector-led Delivery

Public sector-led delivery is highlighted in the figure below.

Figure 9: Public Sector-led Delivery



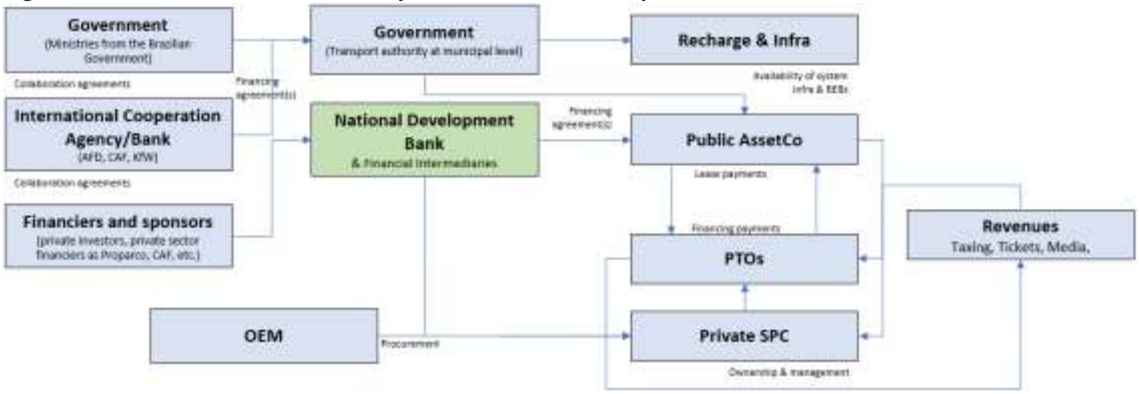
Source: Grutter Consulting based on Grutter Consulting / RebelGroup report for IFC, 2021

In this proposed model:

- The centrality lies in public undertakings - which can rely on private resources.
- These institutions receive resources from the financiers for the acquisition of the cameras and purchase the vehicles.
- Subsequently, they hire the PTOs that operate the transportation system.
- This model separates the responsibility for the fraction, from the responsibility for the operation of the public transportation system. In this case, the sources of funds come from banks, agencies, governments, and other forms of partnership for fleet acquisition, such as PROPARCO and AFD are directed to local public agents, BRT, etc.
- The Federal Government ministries, agencies, and international cooperation programs make on-lending to municipal transportation authorities in local governments, who in turn provide the charging and other necessary structures.
- The financiers and other partners are responsible for providing resources to the public agents that make the acquisition of fleets possible, directly from the manufacturers.
- The PTOs, contracted by the public agents, provide the electric mobility that generates revenue, fees, publication, ticketing, and other means of resources that are also passed on to the Trust Fund for management.

This option presents a variant focusing on a National Development Bank in this form:

Figure 10: Private sector-led delivery centered in a development bank



Source: Grutter Consulting based on Grutter Consulting / RebelGroup report for IFC, 2021

In this model alternative:

- The centrality is in the "National Development Bank", they receive resources from the financiers and they pass it on to public or private agents, who contract the PTOs.
- The acquisition of fleets is made by private individuals directly with the manufacturers.
- Public agents and private agents hire PTOs that operate the transport system.
- This model separates the responsibility for the fleet from the responsibility for the operation of the public transport system, in which case the sources of funds come from banks, agencies, governments and others forms of partnership for fleet acquisition, such as PROPARCO and AFD, are directed to private and public agents.
- Federal Government Ministries, international cooperation agencies and programs, which transfer funds to municipal transport authorities in local governments that, in turn, provide the recharge structure and other necessary structures. irons are responsible for providing resources to private and public agents.
- The PTOs, hired by public and private agents to provide the electric mobility that generates revenue, fees, publication, billing and other means of resources that are also passed on to the Trust Fund for management.

Option 2: Private Sector-led Delivery

Public Transport Operator (PTO)-led delivery is highlighted in the figure below.

Figure 11: Private sector-led delivery centered in a private SPC

Source: Grutter Consulting based on Grutter Consulting / RebelGroup report for IFC, 2021

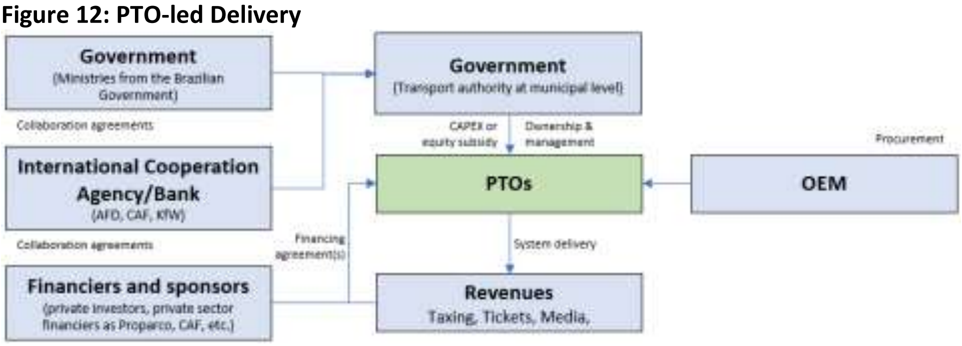
In this model proposal:

- The centrality is in the "Private SPC" which are private enterprises.
- These institutions receive funds from financiers for the acquisition of fleets and purchase vehicles. Subsequently, they hire the PTOs that operate the transport system.
- This model separates the responsibility for the fleet from the responsibility for the operation of the public transport system. In this case, the sources of funds come from banks, agencies, governments and other forms of partnership for the acquisition of the fleet, such as PROPARCO and AFD are directed to private agents.
- Ministries of the Federal Government, agencies and international cooperation programs, which transfer funds to municipal transport authorities in local governments, which in turn provide the charging structure and other necessary structures.
- Financiers and other partners are responsible for providing resources to private agents that enable the acquisition of fleets, directly from manufacturers.
- The PTOs, hired by public agents, provide the electric mobility that generates revenue, fees, publication, ticketing and other means of resources that are also passed on to the Trust Fund for management.

Option 3: Public Transport Operator (PTO)-led delivery.

Public Transport Operator (PTO)-led delivery is highlighted in the figure below.

Figure 12: PTO-led Delivery



Source: Grutter Consulting based on Grutter Consulting / RebelGroup report for IFC, 2021

In this model proposal:

- The centrality is in the PTOs.
- The model is similar to the business model as we normally know it today: centralized in an entity or organization (usually private) that provides both fleet and operators.
- In this case, the sources of funds come from banks, agencies, governments, and other forms of partnership for fleet acquisition, such as PROPARCO and AFD.
- Federal government ministries, agencies, and international cooperation programs, which make transfers of funds to municipal transportation authorities in local governments, which, in turn, contract through competitive bidding.
- Financiers and other partners are responsible for providing resources that enable the acquisition of fleets, directly from manufacturers.
- The PTOs provide the electric mobility that generates revenue, fees, publishing, ticketing, and other means of resources that are also passed on to the Trust Fund for management.

6.1.3. Potential Investment Project

Six potential e-bus investment projects in Curitiba, Teresina, Florianopolis, Niteroi and Belo Horizonte have been identified. Only projects which can be implemented between 2023 and 2025 are included. The buses to be financed through the Program has been limited per city due to funding limitations. The following table summarizes core characteristics of BEB investment projects.

Table 8: Potential E-Bus Investment Project

Item	Description
Project contents	560 urban electric buses of different size[18]
Project owner	Municipalities / City Governments
Total investment	260 MUSD including buses, charging infrastructure, grid connections and bus depot upgrades
Loan components	208 MUSD loan for 75% of the total CAPEX @ 2.5% interest rate for 14 years of which GCF 78 MUSD
Grant component	5% of total CAPEX from the GCF equivalent to 13 MUSD
Environmental impact (cumulative lifespan units)	Reduction of 1,230,000 tCO_{2e}, 28 tons $PM_{2.5}$ and 3,200 tons of NO_x avoided cumulative over the lifespan of units (16 years)

Source: Grutter Consulting

The proposed projects are an important intervention to kick start the process. Under a Business-as-Usual Development (BAU) e-bus barriers will not be resolved and fleets of e-buses will only start to operate in Brazil at a later stage as the market conditions are not conducive towards adoption of e-buses. Market conditions are not yet given in Brazil for a mass deployment of e-buses. Next to this the pandemic has hit public transport operators hard. However, latter is also an opportunity to re-structure and consolidate the sector.

7. Proposed Financial and Technical Assistance

7.1. Financial Assistance Instruments

The following table summarizes financial intervention instruments proposed for commercial EV deployment in Brazil.

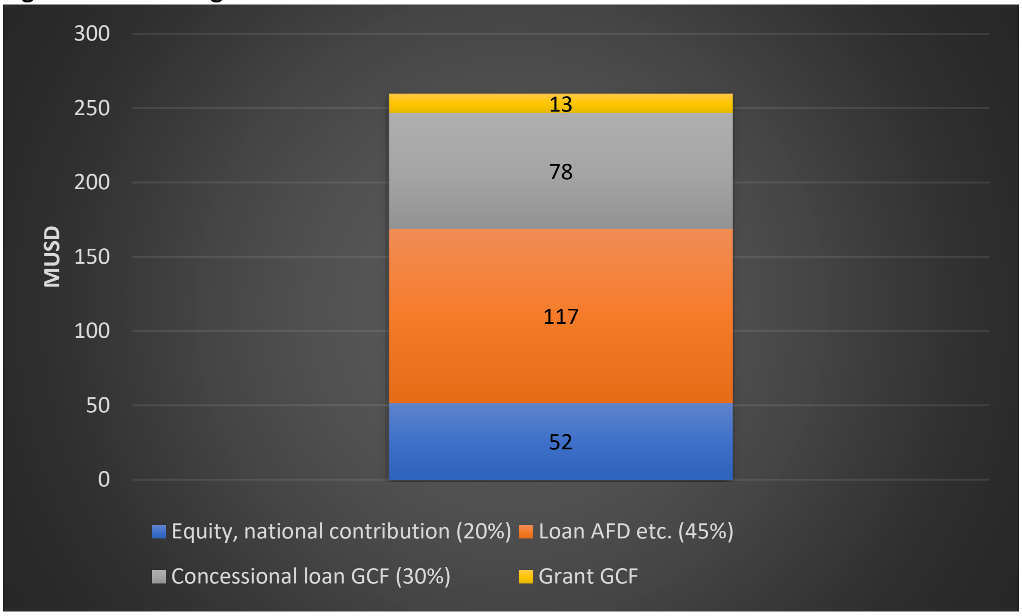
Table 9: Financial Assistance GCF

Instrument	e-buses
Loans	30% of total loan
Grants	5% of CAPEX

Concessional loans from the GCF are blended with ADF and co-finance and have a long tenure (14 years or longer). GCF loan conditions have been estimated at 0.75% annual interest rate.

[18] for split up between cities see Excel sheet annexed and (Grutter Consulting, 2021a)

Figure 13: Financing Structure e-Buses



Note: Numbers are indicative based on 560 e-buses including bus, charger, grid connection, depot upgrade
Source: Grutter Consulting

Six projects for FA have been initially identified:

- Curitiba bus-only lane project with 70 26m buses;
- Curitiba line extensions with 30 12m and 50 18m buses;
- Teresina with 20 12m buses;
- Florianopolis 358 buses of which 3 8m, 312 12m and 43 18m units with GCF support for 40% of units;
- Niteroi with 400 12m buses of which with GCF support 100 units;
- Belo Horizonte with 980 buses of which 90 8m, 700 12m and 190 18m units of which 15% with GCF support.

The following table summarizes the FA proposed for these projects. Only a share of buses is financed in projects with more than 100 units due to funding limitations of the GCF.

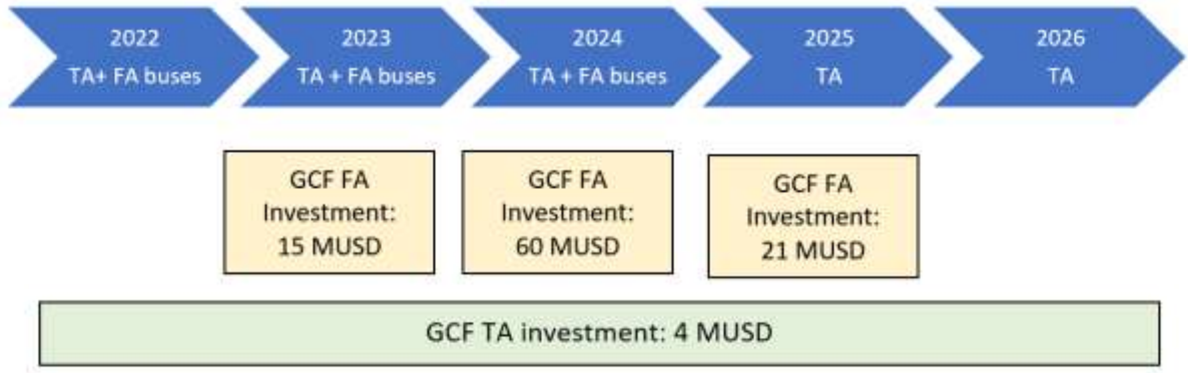
Table 10: FA Potential Projects Brazil (MUSD)

Parameter	e-buses
Total CAPEX	260
Total loan	208
Co-finance loan	*117*
GCF loan	*78*
GCF grant	13
Equity and other co-finance	52

The delivery channel or business models for buses are described in 6.1.2. The delivery channel could be with a public sovereign loan for all projects which is passed-on to the municipalities.

The total GCF contribution for Brazil from the GCF is estimated at 95 MUSD of which 78 MUSD concessional loan, 13 MUSD grant for FA, and 4 MUSD TA grant of which 3 MUSD for project preparation and 1 MUSD for TA managed by GIZ. The following chart shows when investments are expected.

Figure 14: Expected Implementation of Projects



Source: Grutter Consulting

7.2. Technical Assistance Instruments

The areas of intervention in electromobility are mainly focused on financing, charging infrastructure and knowledge of the technology. Considering the projects and with the objective of facilitating the structure of electromobility in the country, the following are defined as focal points[19]:

- Support on electric vehicle procurement policies and public charging infrastructure. Promote the visibility of electric mobility in Brazil[20].
- Technical support on new business models[21], financial models and sector re-structuring for the bus sector including new business models separating bus ownership and bus operations[22], integration of other players with stronger financial background in the public bus sector, and adaptation of bus concession contracts and bus tariff structures. The collection should be handled by a different actor than the operator and the fleet owner, in Brazil the whole business is handled centrally.
- Support for the structuring of a national policy for the proper disposal, recycling and elimination of batteries, in order to minimise the pollution of natural resources.
- Support state and municipal governments to prepare bids that consider the conditions for electric mobility in Brazilian cities. ZEBRA and CAF emphasized to encourage investors and manufacturers in the field of electric mobility. Additionally, The WB and WRI proposes the dissemination of information and support for the review of current concession contracts and guidance to cities on how to modify them to allow electric buses.
- With money tight and the aim of promoting electric mobility, support for feasibility studies is needed[23].
- Support for further institutional arrangements for metropolitan regions to integrate electric mobility between cities[24].

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[19] Meeting with GIZ scheduled for 08 mar 21st.
[20] AFD.
[21] CAF, KfW, Ministry of Science, Technology, Innovation & Communication, Curitiba, Salvador, BNDES, C40, WRI.
[22] CAPEX and OPEX
[23] Rio de Janeiro
[24] Florianópolis and Sao Paulo

- Technical assistance in preventive and corrective maintenance and on training on the characteristics of the EBs for both civil servants and fleet operators.[25]

TA for due diligence / feasibility assessment of the projects worth 3.0 MUSD is managed and paid directly by the financing agent whilst the other TA activities worth 1.3 MUSD are executed by GIZ.

The Annex includes a detailed TA for the policy and capacity building areas.

8. Impact Assessment

The impact of the proposed FA and TA is assessed at 2 levels:

- Direct impact based on the emission reductions of the vehicles financed by the FA of the program.
- Indirect impact based of the program due to the kick-start of mass deployment of EVs initiated through the investment projects combined with the barrier reduction and the reduced performance risk of EV investments. This is reflected in the incremental amount of deployed EVs until 2030 versus the BAU development as shown in chapter 5. The lifetime impact of the incremental number of EVs is the base of calculations of the indirect program impact.

The following table shows the core indicators and the estimated direct and indirect impact in Brazil of the EV program.

Table 11: Program Impact

Parameter	Direct impact	Total impact
GHG reduction lifetime vehicles cumulative in tons	1,230,000	43,500,000
$PM_{2.5}$ reduction lifetime vehicles cumulative in tons	28	1,090
NO_x reduction lifetime vehicles cumulative in tons	3,200	127,000
Energy savings cumulative lifetime vehicles in TJ	10,100	410,000
Fossil fuel savings cumulative lifetime vehicles in Ml	350	13,800
Economic savings cumulative in MUSD	60	2,170

The following table shows the main financial indicators related to the GCF investment.

Table 12: GCF Financial Indicators

Parameter	Direct impact	Total Impact
Total CAPEX investment	260 MUSD	
GCF Loan	78 MUSD	
GCF grant FA	13 MUSD	
GCF Grant TA	4 MUSD	
Total GCF	**95 MUSD**	
Co-finance ration	**64%**	
GCF investment cost per tCO_2 reduced	**77 USD/tCO_2**	**2 USD/tCO_2**
Total investment cost per tCO_2 reduced	**214 USD/tCO_2**	**6 USD/tCO_2**

[25] Train the trainers

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Annex 1: TA Project for Brazil

Brazil has been timidly advancing in the promotion of electric mobility, partly due to the management of the actors involved in the issues related to biofuel production. The material contained in this document indicates that the entry of commercial electric vehicles has some barriers that must be overcome to make this equipment economically and financially attractive in this country.

However, the meetings held in the diagnostic phase with key public and private actors reveal that there is an increasing interest, especially from the private sector, in investing in EV companies. To capitalize on the momentum of e-mobility, a TA project is envisaged to support initiatives to boost the EV mobility with the following outputs and activities.

OUTPUT 1: Establishment of an e-mobility conducive national ecosystem

- Develop a binding roadmap for the deployment of e-buses that includes concrete targets, steps and responsibilities of each of the public entities and, collaterally, private companies. The roadmap shall be elaborated together with the Ministry of Regional Development (MDR) under the Urban Transport and Mobility Infrastructure Programme (Pro-Transporte) guidelines.
- Identify possible business and finance models for e-taxis including the participation of leasing and 3rd party investment funds.
- Develop a roadmap for e-LCV deployment and last mile logistics including public incentives for switching to electric units. This includes assessing the possibilities of establishing low emission zones and differentiated access conditions together with local governments, trade, the delivery company and the general public.
- Have mechanisms in place to reduce the difference between the purchase price of electric vehicles compared to the internal combustion alternative.
- Develop needs assessment on training of bus drivers, maintenance personnel, first response staff and insurance companies on how to cope with EV-related hazards with SENAI, NTU and other associations and stakeholders. Later on, develop a pilot training, train-the-trainers and material and prepare nation-wide rollout.
- Capacity building to develop a strategy for managing battery disposal (second life and recycling). This includes identification of best practices and updating of hazardous waste regulations. Identified stakeholders should be involved, e.g. hazardous waste recyclers.
- Capacity building for:
  - Insurance companies to properly assess the risk and costs of insuring an EV.
  - Drivers oriented towards eco-driving of EVs.
  - Engineers, mechanics and depot managers to maintain and advise on the preventive and corrective maintenance of EV components.
- Design a charging infrastructure, protocol and interoperability for e-taxis and private vehicles accompanied by policies to encourage off-peak charging.
- Support to governance and coordination mechanisms

OUTPUT 2: Establishment of an e-mobility conducive local ecosystem

- Structure, together with municipalities, appropriate concession contracts and concession conditions conducive to electric bus deployment, including concession duration, fare structuring, guarantees, etc. The activities of the TUMI E-Bus Mission will be taken up as far as possible to consider financing under the program.
- Capacity building for municipalities about the benefits of electric garbage and cleaning trucks, and further special vehicles.
- Leverage outcomes of national R&D programs (P&D ANEEL, Rota 2030) for bi-directional chargers in Brazil. This activity includes an analysis of the grid, costs-benefits, technical feasibility etc.
- Support development of deployment of E-Taxis in Sao Paolo.
- Implementation of a pilot project for bi-directional chargers in Brazil. This activity includes an analysis of the grid, costs-benefits, technical feasibility etc.

OUTPUT 3: Establishment of an e-mobility conducive regional ecosystem:

- Information and outreach events in the areas of buses, taxis and LCVs to inform about advantages of EVs
- Dissemination focused on successful models implemented
- Preparation of knowledge materials including publications, webinars, benchmark and best-practice studies
- MRV Guidelines & Training
- Preparation of Capacity Building guidelines
- Dialogue with EV suppliers

Project Preparation TA

Apart from the general TA activities, the lenders will conduct project specific TA in order to prepare the investment projects.

The project preparation includes the following activities:

- Assistance with the tendering process (define technical specifications for the e-buses, e-taxis or e-LCVs, charging stations, battery size, after sales service etc.)
- Assistance with the selection of the vehicle type to be purchased
- Assistance with the supervision of the contract with the OEM.
- Removal of barriers during the import process (make sure the vehicles are exempt from taxes according to the current la for EV incentives)
- Assistance with the supervision of the contract between owner and operators.
- Assistance with communication and PR work (press releases, events etc.)
- Conduct a legal due diligence with the operators or stakeholders involved
- Assess grid conditions in the places where the vehicles will recharge and conduct the necessary assistance to upgrade the grid.

Annex 2: List of Interviewed Persons and Institutions

Organization	Name	Last name	Department	E-Mail
Programa Nacional de Movilidad Eléctrica / GIZ	Jens	Giersdorf	TUMI Volt / PROMOBe	jens.giersdorf@giz.de
AFD - Agencia Francesa de Desarrollo	Guillermo	Madrid	Mobilidad	madridg@afd.fr
CAF - Banco de Desenvolvimento da América Latina	Andres	Alcala	Sector de préstamos no soberanos	aalcala@caf.com
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	Edgar	Salinas	Cambio Climatico, Sustenibilidad & Proyectos	ESALINAS@caf.com
Programa Nacional de Movilidad Eléctrica / GIZ	Jens	Giersdorf	TUMI Volt / PROMOBe	jens.giersdorf@giz.de
KFW - Banco de Desarrollo Estatal Alemán	Vinicius	Ragghianti	Mobilidad	Vinicius.Ragghianti@kfw.de
	Dirk	Heinrick	Urban and Social Development Latin America	Dirk.Heinrichs@kfw.de
AND - Autoridad Nacional Designada	Raquel	Breda	Para el Fundo Verde para el Clima	raquel.breda@mma.gov.br
AFD - Agencia Francesa de Desarrollo	Guillermo	Madrid	Mobilidad	madridg@afd.fr
	Suzanne	Spooner	División de transporte	spooners@afd.fr
CAF - Banco de Desenvolvimento de Américas Latina	Marcelo	Dos Santos	Ejecutivo de la CAF	mdossantos@caf.com
Ministério da Economia	Gustavo	Motta	Mobilidad	gustavolsmotta@gmail.com
Ministério da Economia	Juliana	Oliveira Santini	Mobilidad	juliana.santini@economia.gov.br
ZEBRA	Thomas	Maltese	Mobilidad	tmaltese@c40.org
Ministério da Economia	Margarete Maria	Gandini	Automotivo	margarete.gandini@economia.gov.br
	Ricardo	Zomer	Automotivo	ricardo.zomer@economia.gov.br
	Sandro Eli	Alencar	Agenda E-mobilidad	sandro.eli@economia.gov.br

Organization	Name	Last name	Department	E-Mail
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	Rodolfo	Gomes Benevenuto	Proyectos & Monitoreo	rodolfo.benevenuto@economia.gov.br
	Paulo	Avila	Sub-Secretaria Nacional para Sensibilização de Projetos (incluso de Mobilidade)	
Ministério da Economia	Pedro	Maciel Capeluppi	Secretaria de Desenvolvimento da Infraestrutura da Secretaria Especial de Produtividade, Emprego e Competitividade	sdi@economia.gov.br; pedro.capeluppi@economia.gov.br
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	Régis	Hathmann	Secretaria de Pesquisa e Formação Científica	regis.rathmann@mctic.gov.br
	Sônia	Bittencour	Secretaria de Pesquisa e Formação Científica	sregina@mctic.gov.br
Secretaria de Transporte de Curitiba	Ana Cristina	Wollmann Zornig Jayme	Instituto de Investigación y Planificación Urbana de Curitiba	ajayme@ippuc.org.br
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Secretaría Municipal de Planificación y Coordinación	Cintia	Bartz	Planificacion	cintiabartz@gmail.com
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BHTrans	Rogerio	Carvalho	Mobilidad urbana	contacto por telemobil
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Annex 3: Details Financial Calculations

Brazil Bus Parameters 12m Bus

Parameter	Value	Unit	Source
Distance driven per bus per annum	66,000	km	PROMOB-E
Workday distance driven daily	221	km	Default
Specific electicity usage	1.1	kWh/km	Chinese average; ADB, 2018; includes AC but not heating
Diesel usage	59	l/100km	Euro V bus; based on WRI cited in PROMOB-e for mid 2018 in table 7
Maintenance cost diesel bus incl. labor and tyres	0.15	USD/km	PROMOB-E
Lifespan bus diesel	15	years	default 1 million km
Lifespan bus electric	16	years	max based on battery age; can be 20% more than diesel
Lifespan battery @ 80% SOC	8	years	current guarantee levels

Financial defaults

Parameter	Value	Unit	Source
CAPEX diesel bus	150,000	USD	Euro V bus; based on WRI cited in PROMOB-e for mid 2018 in table 7
CAPEX overnight charged e-bus	284,000	USD	Based on bus with 350 kWh battery set and sur-cost for battery size
CAPEX slow-charged batteries	200	USD/kWh	LFP batteries
CAPEX fast-charged BEB	250,000	USD	Based on standard fast-charged bus
CAPEX batteries fast-charged	250	USD/kWh	NMC batteries
Reduction battery cost in 8 years	50%		US DOE projections, 2017 have a decrease of 12% per annum; applied to 5 years; https://energy.gov/sites/prod/files/2017/02/f34/67089%20EERE%20LIB%20cost%20vs%20price%20m
CAPEX charger excl. Installation per kW	120	USD/kW	Standard chinese chargers, 2 nozzles
CAPEX charger installations civil works	2,500	USD/bus	Civil works for chargers; 2 buses per charger; 5,000 USD per unit
Cost per bus depot upgrade	7,500	USD/bus	Coverage of bus and chargers with roof, no paving, includes labour (20m2 per bus, 250 USD/m2 material and 125 USD/m2 labour)
Cost grid connection of chargers	30,000	USD/bus	Compact sub-stations for groups of chargers; 20kV cables from connection substation to the compact substation, 400V cables from compact substation to chagers; costs not born by electric utility
Maintenance & repair cost of e-buses relative to diesel incl. labour	70%		Based on experience in PR China; ADB, 2018; 10% higher tyre costs; 75% lower maintenance staff and general maintenance; 20% lower repair and spare parts
Maintenance & repair cost of CNG buses relative to diesel incl. labour	120%		Based on CNG and diesel bus operators
Lifetime chargers	10	years	standard value
Lifetime bus depot upgrades	20	years	standard value
Lifetime grid connection	20	years	standard value
Maintenance chargers, grid connection, depot	2%		of investment

Option A: Overnight Charging

Battery Size Determination overnight charging

Parameter	Unit	Value
Daily range workday (max)	km	221
Energy usage day	kWh	243
Risk ratio (higher energy consumption)		10%
Reserve ratio		20%
SOC loss year 8		20%
Battery size required year 8	**kWh**	**420**

Charging required at bus depot overnight

Parameter	Unit	Value
Battery capacity	kWh	420
Average daily consumption workday	kWh	243
Time available at depot night	hours	6
Power conversion efficiency of chargers		90%
Charging power required (incl. 1h reserve for slower charging last 20%)	kW	50

Option B: Fast Charging

Parameter	Unit	Value
Battery size	kWh	200
C-rate		0.65
Charging in 30 minutes	kWh	65
Average re-charge during day required with 20% reserve ratio	kWh	83
Average share of day electricity		34%
Fast-charger	kW	300
Power conversion efficiency of chargers		90%
Average required re-charge day with 300 kW charger	minutes	18
Number of buses per fast-charger	buses / charger	8
Night charger power		40

Other options are possible e.g. smaller battery and higher C-rate, buses per fast-charger based on max 12 units or time*2 for charging and 3 hour slot

Finance Costs

Parameter	Value	Unit
Loan term fossil	9	years
Commercial interest rate	9.9%	
loan term ebus	14	years
concessional interest rate	9.4%	

in USD

PROMOBE, p.30

WACC

Cost equity	12.8%		UNFCCC, CDM Methodological Tool Investment Analysis Version 10.0, 2019; value for transport sector
Share equity	20%		offers banks
Cost bank loan EV	9.4%		see above
Cost bank loan fossil	9.9%		see above
Share bank loan	80%		offers banks
Corporate tax rate	34%		Deloitte, 2020
WACC EV	7.5%		calculated
WACC fossil	7.8%		calculated

Brazil Buses Financial Feasibility

12m standard bus, USD 2019

Parameter	Diesel	BEB overnight	BEB fast
CAPEX bus	150,000	284,000	250,000
CAPEX charging infrastructure	0	8,500	12,113
CAPEX grid connection	0	30,000	30,000
CAPEX depot upgrade	0	7,500	7,500
Total CAPEX	150,000	330,000	299,613
Battery replacement yr 8	0	42,000	25,000
Energy cost yr 1	25,700	6,534	6,534
Maintenance cost bus yr 1	9,900	6,930	6,930
Maintenance cost infra yr 1	0	920	992
Finance cost average per year	6,862	13,011	11,453
Economic costs yr 1	6,450	345	345
TCO financial per km	0.76	0.74	0.68
TCO economic per km	0.87	0.75	0.68

timespan of calculation: lifespan of e-buses with replacement investment for fossil buses; end of life value proportional to remaining lifespan

Impact of concessional finance

New finance rate for e-buses	2.54%
GCF rate	1.25%
AFD rate	4.80%
grant share	5%
Loan share	75%
AFD loan share	45%
GCF loan share	30%
Loan tenure in years	14
WACC and discount factor new BEB	3.8%

Impact concessional finance

	overnight charged	fast charged
TCO financial old	0.75	0.68
TCO financial new	0.60	0.55
Discounted Payback in years old	never	never
Discounted Payback in years new	8	7

TCO Taxis

Parameter	Value	Unit	Source
Average battery size	40	kWh	Jac e40; https://www.jacmotors.com.br/veiculos/eletricos-detalhes/iev40
Battery lifespan	10	years	idem to vehicle lifespan
Vehicle lifespan	10	years	e-janeiro/noticia/2020/03/27/prefeitura-do-rio-anuncia-que-vida-util-de-taxis-passara-de-8-para-10-an
Annual mileage	51,810	km	
Daily mileage	157	km	TRANSPORTE EM NÚMEROS Indicadores Anuais do Transporte Público: Modal taxi
Charging at home average	70%		Assumption; only re-charge if above-average mileage or night shifts
Charging fast-chargers	30%		
CAPEX gasoline taxis	12,000		Chevrolet Onix, 2021; https://www.noticiasautomotivas.com.br/onix/
CAPEX e-taxi	39,000		Jac 40; https://www.jacmotors.com.br/veiculos/eletricos-detalhes/iev40
Capex home charger 7.4kW	2,000	USD	wallbox
Gasoline consumption	7.8	l/100km	urban gasoline; https://www.noticiasautomotivas.com.br/onix/
Electricity consumption	0.13	kWh/km	https://www.jacmotors.com.br/veiculos/eletricos-detalhes/iev40
Charger lifespan	10	years	
Maintenance cost gasoline excl. tyres and repairs	0.0093	USD/km	https://www.noticiasautomotivas.com.br/onix/
Maintenance cost total e-taxi	0.00558	USD/km	40% lower

gasoline versus e-taxi

Parameter	gasoline	e-taxi
CAPEX vehicle	12,000	39,000
CAPEX charger	0	2,000
Total CAPEX	12,000	41,000
Energy cost	3,334	983
Maintenance cost	482	289
Finance cost average per loan year	549	1,784
Economic costs yr 1	451	32
Lifespan in years	10	10
TCO financial per km	0.11	0.13
TCO economic per km	0.12	0.14

LCVs

1. Petrol Van

Parameter	Value	Unit	explanation
CAPEX van	37,000	USD	Volkswagen delivery
diesel fuel consumption	15.7	l/100km	https://www.fueleconomy.gov/feg/Find.do?action=sbs&id=39452
Maintenance cost	0.02	USD/km	excludes tyres and repairs; stnadard values
Lifespan	15	years	Based on annual mileage
Daily distance driven	106	km	typical of LCV
Annual distance	35,000	km	95% usage

2. E-Van

Parameter	Value	Unit	explanation
CAPEX e-van	64,000	USD	JAC iEV1200T; 7.5tGVWR; 4t cargo max
Range WLTP	200	km	https://www.biodieselbr.com/noticias/qualidade/motor/caminhoes-com-tecnologias-alternativas-ao-diesel-irao-
Battery size	97	kWh	ganhar-mais-espaco-no-pais-041120; https://www.uol.com.br/carros/noticias/redacao/2020/09/24/jac-iev1200t-
Cost battery	19,400	USD	Based on 200 USD/kWh per battery
electricity consumption	0.44	kWh/km	https://www.uol.com.br/carros/noticias/redacao/2020/09/24/jac-iev1200t-como-e-andar-no-unico-caminhao-eletr
Maintenance cost	0.01	USD/m	50% of fossil (as only engine maintenance is included; no tyres, no repairs)
Lifespan van	15	years	assumed same as fossil
Lifespan battery	8	years	
Capex home charger 7.4kW	2,000	USD	
Lifespan charger	10	years	
Charging at home average	90%		Assumption
Charging fast-chargers	10%		Exceptional if long distances were made

fossil versus e-van

Parameter	diesel	e-van
CAPEX vehicle	37,000	64,000
CAPEX charger	0	2,000
Total CAPEX	37,000	66,000
Battery replacement		19,400
Energy cost	3,620	1,558
Maintenance cost	850	425
Finance cost average per year	1,693	2,928
Economic costs yr 1	1,115	73
Lifespan in years	15	15
TCO financial per km	0.23	0.25
TCO economic per km	0.26	0.26