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E-Motion Country Intervention Strategy Colombia

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Abbreviations

AC	Air Conditioning
AECID	Spanish Agency for International Development Cooperation
AFD	French Development Agency
AssetCo	Special Purpose Company (SPV / SPE / SPC)
BAU	Business As Usual
BEB	Battery Electric Buses
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CF	Cash Flow
CFF	Cities Finance Facility
DNP	National Planning Department
EIRR	Economic Internal Rate of Return
EV	Electric Vehicle
FA	Financial Assistance
FINDETER	Territorial Development Finance
FIRR	the Financial Internal Rate of Return
GHG	Greenhouse Gases
GIZ	German International Cooperation
ICCT	International Council on Clean Transportation
IDB	Inter-American Development Bank
IDEAM	Institute of Hydrology, Meteorology and Environmental Studies
IEA	International Energy Agency
LABMOB	Sustainable Mobility Lab
LCV	Light Commercial Vehicle
MADS	Ministry of Environment and Sustainable Development
NAMA	Nationally Appropriate Mitigation Action
OEM	Original Equipment Manufacturer
PM	Particulate Matter
PNUD	United Nations Development Programme
P4G	Partnering for Green Growth and the Global Goals 2030
PPP	Public-Private Partnership
PRI	Principles for Responsible Investment
PTO	Public Transport Operator – usually a private company
SETP	Strategic Public Transportation Systems
SITM	Integrated Mass Transit Systems
SPV / SPE / SPC	Special Purpose Vehicle / Special Purpose Entity / Special Purpose Company.
TA	Technical Assistance
TCO	Total cost of ownership
UNEP	United Nations Environment Programme
UPME	Mining and Energy Planning Unit
WACC	Weighted Average Capital Cost
WTW	well-to-wheel
WWF	World Wildlife Fund
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

Colombia has a land surface area of 1,141,748 km^2 (Instituto Geográfico Agustín Codazzi, 2021) and is the second most biodiverse country in the world (Ministry of Environment and Sustainable Development, 2019). In 2019 its population reached 50,339,000 inhabitants, putting it in the 29th most populated country. It is expected that the population reaches 53,417,000 inhabitants in 2030 (United Nations, Department of Economic and Social Affairs, Population Division, 2019). According to the World Bank, GDP per capita in constant 2010 prices for 2019 was US$ 7,800 (World Bank Group, 2020). According to the National Census of Population and Housing - CNPV - 2018 (National Administrative Department of Statistics - DANE, 2019) Bogota, Medellin, Cali and Barranquilla have more than one million inhabitants.

Colombia has an automotive industry dedicated mainly to vehicle assembly, auto parts production and motorcycle assembly. In 2019 it manufactured 127,000 vehicles, occupying the fourth position in manufacturers in the region (PROCOLOMBIA, 2020). According to the National Association of Colombian Businessmen and women (ANDI), the sector generates 25,000 direct jobs; however, the DANE estimated that in 2019, 535,359 people were employed in the activities of trade, maintenance and repair of motor vehicles and motorcycles (National Department of Statistics (DANE), 2020). Busscar, Superpolo and Mountain Kenworth, bodywork manufacturing companies have participated as partners of firms as BYD and Yutong for the assembly electric buses acquired for the operation of the Integrated Transport System (SITP) of Bogota. Mountain Kenworth is also involved in the spare parts supply chain, as operation and maintenance will be carried out by Colombian technical staff trained by the alliance (Martínez, 2020). At the national level, no specific policies have been defined for the electric vehicle industry. However, the country is advancing processes within the framework of the ENME, where the Ministry of Transportation must define the minimum homologation parameters for the import, assembly or manufacturing processes of electric vehicles and the Ministry of Commerce will establish the guidelines to provide guarantees for electric vehicles, as well as promote after-sales service programs with importers of electric vehicles. (Minambiente; Ministry of Environment; Ministry of Mines; Ministry of Transportation; UPME, 2020).

76% of the municipalities with monitoring of the air quality in Colombia register PM10 levels which surpass the annual norm of 50 μgm^3 [2] For $PM_{2.5}$ the results are slightly better considering the norms of 2017 but based on the norms valid as of 2030 the large majority of urban areas have air pollution levels which are above the future norm (CONPES, 2018). Emission inventories of large cities show that around 80% of particle emissions are due to transport and 20% due to industry. The major sources are

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

[2] DNP with information of IDEAM 2016 cited in F. Mejia, DNP, Calidad del aire: Una prioridad de politica publica en Colombia, 02/2018

buses and trucks with 70-80% of all vehicle emissions (larger share for buses in Bogota and larger share for trucks in Valle de Aburrá). Transport is also responsible for around 60% of NO_x emissions (CONPES, 2018). 2018 results of Bogota show that the new transport system has resulted in emission reductions of buses. The major transport source of PM_{10} emissions are now trucks with 40% followed by cars and light commercial vehicles with 17% each and buses with 12%. For NO_x the major source are buses with 24%, followed by cars with 22% and LCVs with 18% (SDA, 2019)[3]. The bad air quality is also perceived by the population: 51% of the population consider the air quality to be an environmental problem (based on survey realized by DNP, 2017 cited in F. Mejia, DNP, *Calidad del aire: Una prioridad de política pública en Colombia*, 02/2018). In 2016 Colombia realized an economic valuation of the costs of air pollution based on the methodology of the World Bank. It was estimated for 2018 that around 8,000 deaths have to be attributed to air pollution. Depending on the methodology chosen the cost of air pollution is estimated at the equivalent of 0.2 to 1.5% of the GDP of Colombia (lowest figure based on cost of insurances and compensation payments; highest value based on statistical value of life).

2.2. Climate and Energy Policies

Colombia's Greenhouse Gas (GHG) emissions for 2014 are estimated at 237 $MtCO_{2e}$. Transportation emissions are estimated at 29 $MtCO_{2e}$ (31% of total emissions) with a growth of 20% since 2010. Land transport contributes the most emissions with an average of 92% (IDEAM; UNDP; MADS; DNP; CHANCELLERY, 2018). Colombia's Nationally Determined Contribution (NDC) Update estimates that according to the reference scenario emissions would reach a value of 346 $MtCO_{2eq.}$ in 2030. Within the mitigation goals Colombia commits to emit a maximum of 169 $MtCO_{2e}$ in 2030 (equivalent to a 51% reduction of emissions). The NDC contemplates for the transportation sector amongst others to achieve 600,000 registered electric taxis, buses, light commercial vehicles including small trucks and official vehicles.

The Green Growth Policy approved through document CONPES 3934, contemplates as a structural axis the efficient use of natural capital and energy in the productive sectors; as a strategy the development of a national program of electrification for transportation whose indicator to 2030 is to reach the goal of 600,000 electric vehicles (Depatamento Nacional de Planeación, 2019).

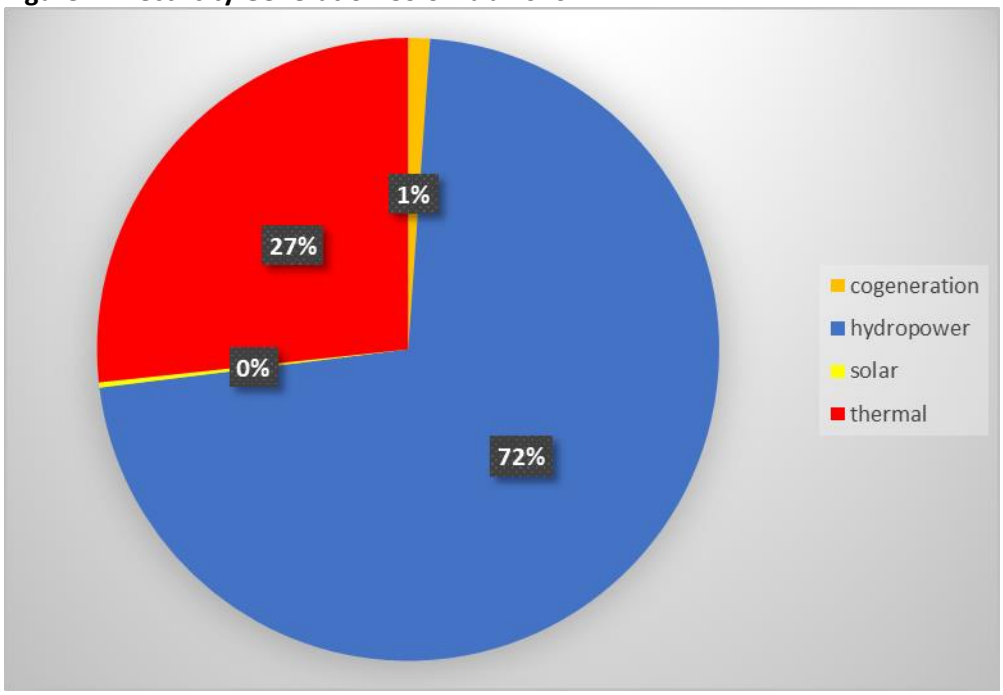
In 2019, around 70% of the installed power capacity (totalling around 17,000 MW including centrally and non-centrally dispatched) is hydropower and 30% thermal power plants (coal, gas, fuel oil and diesel)[4]. In 2020 the share of renewables in total electricity generated was slightly above 70% (see following figure).

Colombia still has a considerable non-exploited renewable energy capacity in terms of hydroelectric, solar and wind power (Arango, 2019).

[3] See for further air quality details of Colombia Annex 1 report

[4] XM. (2020). *Net effective capacity*. Retrieved from XM: https://informeanual.xm.com.co/demo_3/pages/xm/21-capacidad-efectiva-neta.html

Figure 1: Electricity Generation Colombia 2020



Source: XM (2020), *Generation (kWh) 2020:* http://portalbissrs.xm.com.co/oferta/Paginas/Historicos/Historicos.aspx

2.3. Transport Sector

2018 around 14 million vehicles were officially listed in the statistics of the Ministry of Transport (Ministerio de Transporte, 2020) - however, based on an analysis of vehicle insurance and annual registration the actual number of operating vehicles is only estimated at around 8.5 million units (UPME, 2015). Many vehicles still in the list of the Ministry of Transport are no longer operational - this is well reflected in the age statistics which shows e.g. more than 1.2 million motorcycles (15% of the fleet) older than 16 years - most of these motorcycles are probably out of operations or only used on a very limited base.

Since 2010 the country has the vehicle emission standard Euro 3 for gasoline cars and motorcycles, Euro 4/IV for diesel powered vehicles [5]. Euro 6 standards are under discussions and shall be introduced in 2025 (MinAmbiente, MinMinas, MinTransporte, UPME, 2019). As of 2018 60% of heavy duty vehicles operating in the country comply with Euro II, 15% with Euro IV and 25% with pre-Euro vehicle emission standards (MinAmbiente, MinMinas, MinTransporte, UPME, 2019).

Resolution 90963 of 2014 established a maximum sulfur contents in fuels of 50 ppm. The ethanol share in gasoline is currently 10% and the biodiesel share in diesel also 10% GHG calculations are thus influenced by this biofuel share (MinMinas, 2020).

Road transport GHG emissions of Colombia in 2018 are estimated at 33 million tCO_{2e}[6] based on a bottom-up transport model calibrated with top-down fuel consumption data. Taking into account biofuel usage GHG emissions from the road transport sector are estimated at 30 $MtCO_{2e}$. Commercial vehicles including taxis, buses and LCVs are responsible for around 50% of GHG emissions and 35-50% of pollutants ($PM_{2.5}$ and NO_x). GHG emission from the transport sector are expected to grow under a

[5] Emission Standards: Colombia: On-Road Vehicles and Engines (dieselnet.com)
[6] Tank-to-wheel approach; well-to-wheel approach including Black Carbon: 43 $MtCO_{2e}$

BAU scenario by around 40% reaching 46 million tCO_{2e} by 2030 (see table below). With this growth the NDC target[7] will be difficult to achieve.

Table 1: Projected 2030 Transport Emissions

Vehicle category	NO_x	$PM_{2.5}$	CO_2 TTW	CO_2 WTW	Energy in TJ
Passenger car	4,697	103	12,140,534	14,646,224	176,296
Taxi	732	14	2,237,562	2,881,207	33,952
Motorcycles	13,704	247	4,337,127	5,216,808	62,585
small bus	25,221	198	2,397,554	3,082,723	32,356
standard urban bus	28,714	245	6,268,774	7,875,806	84,599
LCV	5,104	180	8,383,530	10,127,381	120,152
Truck < 7.5t	8,263	53	1,621,373	2,030,337	21,881
Truck 7.5-16t	15,020	91	2,799,276	3,504,706	37,777
Truck 16-32t	10,773	67	1,882,050	2,360,298	25,399
Truck >32t	20,220	118	3,507,854	4,394,005	47,339
Total	**132,447**	**1,316**	**45,575,633**	**56,119,494**	**642,335**

Source: (Grutter Consulting, 2021)

The National Government sanctioned Law 105 of 1993 and Law 336 of 1996, with the objective of reducing the problem of urban passenger transportation, which was made up of individual under-capitalized operators, an obsolete vehicle fleet, deficient regulation, inadequate routes and operations, among others. It was proposed that cities with more than 600,000 inhabitants develop an Integrated Mass Transportation System (SITM) with exclusive corridors served by Bus Rapid Transit (BRT) (National Planning Department, 2002). For cities with a population between 250,000 and 600,000 inhabitants, Strategic Public Transportation Systems (SETP) are proposed to meet 100% of the demand for urban public transportation (Government of Colombia, 2009). Some of these systems are in operation while the Government is making progress in the implementation of others.

The reference model for concessions in Colombia is Transmilenio. Initially, the concession for the provision and operation of the fleet was granted to the same actor. However, this model has migrated to a scheme of separation of ownership and operation, which allows guaranteeing the availability of the fleet, regardless of the continuation of the operator. The duration of the concessions is 10 years for diesel buses and 15 years for electric vehicles in both components. The remuneration is, in the case of fleet provision, $/bus and depends on the type and technology of the vehicle and, in operations, the payment is divided into component of $/km (depending again on the type and technology of the bus) and $/bus associated to the operational cost of the vehicle by type and technology (FDN & TMSA, 2017). The fleet is active during the term of the concession contract - once the contract is terminated, the operator must deliver the buses to Transmilenio for their respective scrapping by the fleet supplier.

In Colombia, Decree 172 of 2001 (MinTransport, 2001) regulates the individual passenger transportation service in cab vehicles. This decree was in turn compiled by the Single Decree 1079 of 2015 (MinTransport, 2015) and this establishes that the competent transport authorities are the Ministry of Transport and the Mobility secretary of the Municipality under the Municipal or District Mayor's Office. In order for a company to provide the individual motorized land transportation service of passengers in cab vehicles, they must request and obtain a permit to operate. According to the

[7] Nationally Determined Contributions (NDC) are non-binding national plans highlighting climate actions, including climate related targets, policies and measures governments aim to implement in response to climate change and as a contribution to achieve the global targets set out in the Paris Agreement.

Fenalco Bogotá study, 24% drive their own cab, 67% of drivers drive someone else's cab and 9% work under contract (Fenalco Bogotá, 2016).

2.4. EV Policies and Activities

Colombia has recognized the importance of the electrification of the transportation sector and its importance in reducing environmental impacts. The national government has published a set of laws, strategies and mechanisms that seek to promote electromobility in the country. The local governments have joined this effort and have shown their interest by joining different initiatives. Although the political framework regarding electric vehicles is broad, with the aim of strengthening it, especially in public transportation systems where different government departments have been working on policies, regulations and financing schemes.

The Electric Mobility Law has managed to provide for measures in public transportation services such as compliance with a minimum quota of 30% of EVs in new acquisitions or contracts, taking into account the commercial offer in Colombia. According to the same law, the goals for the incorporation of electric vehicles in the acquisition of the fleet of zero-emission mass transportation systems must follow the scheme of minimum proportions of 10% in 2025, 20% in 2027, 40% in 2029, 60% in 2031, 80% in 2033 and 100% in 2035 (Congress of Colombia, 2019).

As a complement to the Law, the National Government has developed the National Strategy for Electric Mobility (ENME), which aims to promote the electrification of the transportation sector. Among its actions are the definition of minimum energy efficiency standards for vehicle technologies; the regulation of both electricity tariffs, infrastructure for vehicle charging, according to their interaction with the vehicle to grid (V2G) network, the promotion of charging infrastructure to guarantee the supply of energy to electric vehicles and the assessment of incentives and economic benefits for electric technology as well as disincentives for more polluting transport. On the other hand, and in addition to the above, the National Energy Plan (PEN) 2020-2050 presents projections for the incorporation of electric vehicles, under the scenario of meeting the GHG reduction commitments (20% by 2030) (UPME, 2019). Projections for 2030 include 630,000 electric motorcycles, 370,000 electric light vehicles, 40,000 e-taxis and 20,000 electric urban freight vehicles.

Regarding economic incentives, Decrees 116 of 2017 and 2051 of 2019 exempted electric chargers until 2027 and vehicles with electric motors, respectively, from the tariff levy. Law 1819 of 2016 establishes that, legal entities that directly make investments in control, conservation and improvement of the environment, will be entitled to deduct from their income tax payable 25% of the investments they have made in the respective taxable year, upon accreditation made by the respective environmental authority, in which the direct environmental benefits associated with such investments must be taken into account.

Metroplus in Medellin purchased in 2019, 64 with a 13.5 m length electric buses for services as feeder buses for its BRT system. The buses were purchased and financed by the Municipality. The Municipality used for this purchase a surplus available through the sale of a public enterprise in 2019 i.e. it is considered an exceptional case that funds are available for purchasing buses with a significant additional cost. A private operator in Medellin purchased additional 12 e-buses with 8 m length in 2019 based on receiving concessional loans with an interest rate 2-3% points below standard market rates and tax incentives including a 25% lower income tax for environmental investment and no payment of VAT.

In Bogota TransMilenio (TM) opted to separate fleet provision and fleet operations including bus depots. In 2019, 483 electric buses were acquired of which 73 with 9 m length units and 392 with a 12 m length units. 133 out of the 483 units are already in operations since end 2020 and the remaining units will enter operations before end of March 2021. For the Phase III tender issued in 2020 (6 zones) therefore the tender conditions were adjusted so that e-buses would be competitive or would win. Electric buses had a strong advantage and all contracts awarded were in Phase III for electric buses. The tender resulted in the award of 1,003 electric buses of which 672 are 9 m length units and the rest 12 m length units. These buses will enter operations between November 2021 and April 2022 thus extending the electric bus fleet of Bogota to 1,485 units. Only medium (9 m) and standard (12 m) size buses have been electrified to the moment. Bogota also wants to electrify articulated and bi-articulated trunk buses for which tenders will be floated in 2023. However, this will require a technology analysis to identify the most appropriate technological approach. This might also result in different business models e.g. in case of using ultra-fast charging systems a separation might be made in provision of charging infrastructure and provision and operation of buses.

Another city that has electric units is Cali, which by 2020 had 35 electric buses.

Currently, only two cities have implemented pilot projects for the deployment of electric cabs in the country; Bogota and Medellin. The program in Bogota with 45 e-cabs revealed some barriers to electromobility, such as the difficulty for operators to acquire credits, the lack of promotion of electromobility, the system and the pilot's entry into operation, the need for functional recharging infrastructure, among others. The Medellin program has not yet taken off.

In 2019, TCC incorporated to its last mile parcel delivery fleet 16 electric vehicles (TCC, 2020). These vehicles were incorporated through the Renting model offered by the company Renting Colombia. Bavaria in alliance with Renting Colombia, announced in 2019 the commitment to incorporate 200 electric trucks to its distribution fleet by 2021, equivalent to 20% of its fleet. They started with 12 Stärk electric trucks with 4-ton capacity that are used in Bogota and Medellin (Bavaria, 2019). In Colombia, DHL has a fleet of 144 vehicles, of which 7 are electric (DHL, 2019). Since 2010 Coca-Cola has started to contribute to electric mobility in Colombia with the first fleet of green trucks with 12 electric vehicles. Coca-Cola has also entered the Renting Colombia modality (Renting Colombia, 2020).

As of November 2020, Colombia had an estimated 10,728 EVs including PHEV (ANDEMOS, 2020). Electricity grid operators play a key role in the charging station infrastructure. At the national level, EPM, Enel, with emphasis on Bogota, Celsia and companies such as Terpel are also betting on charging stations, although with a more interurban focus. Some 100 public charging stations have been installed in the country (Celsia, 2020), (Enel, 2020), (EPM, 2020), (Terpel, 2019).

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

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

Enabling factors	**Authorities' interest in electromobility:** the National Government has shown its interest by publishing policies that seek to promote electromobility as well as the incentives stated in the *Electric Mobility Law*. Likewise, major cities such as Bogota, Medellin and Cali have shown their interest incorporating electric vehicle fleets and setting as a goal the expansion of this technology in their systems. **Public policy for urban transportation systems:** the policies issued at the national level that structure the SITM and SETP allow to improve the business structures of the operators in the system, which allows having a more robust institutional structure as they are not in charge of individuals. These schemes facilitate the inclusion of electromobility, which requires such capabilities. **The automotive industry in the country:** Colombia has an automotive industry that has been strengthened over time mainly made up of assemblers, which allows the production of trucks, buses, cars and motorcycles that can be electric thus reducing costs since these vehicles are currently imported. **Structured entities in the transportation sector:** Since Transmilenio started operating in Bogotá, Colombia initiated a process of change that has allowed for a radical change in the business structure of the public transportation sector. The BRT systems model has allowed to move from a scheme of atomized ownership and the so-called "guerra del centavo" (penny war), to one in which the main cities of the country already have a sector of transportation entrepreneurs that have brought formality to the sector.
Barriers	**Initial investment costs:** the differential between the initial investment of the electric vehicle with respect to a conventional vehicle makes the acquisition difficult for most public transport services. **Lack of knowledge of the technology:** although pilot projects have been carried out in the main SITM to learn about the operating conditions of the vehicles, in general, this is a privilege for the most robust systems. **Reinvestment for battery replacement:** since the systems contemplated in the inclusion of electromobility in the transportation systems are made up of vehicles with batteries, considerable reinvestments must be made in year 7 or 8, which requires the owner to have resources or financing that is aware of this flow of resources. **Financial conditions of transport systems:** in general, transport systems do not have financial solvency, which increases the investment risk for traditional financiers, who, considering the payment history of previous loans, prefer not to participate in these schemes. **Institutional capacity:** in general, local transport authorities and transport systems have limited institutional capacity, which hinders the regularization, supervision and adequate control of the systems. Strengthening the technical capacity of existing officials, as well as providing additional vacancies, facilitates the operation of the system, financial control, among others. **Low supply of electric vehicles:** the supply of electric vehicles is still limited to a few manufacturers with national presence, so the options for purchasing and obtaining spare parts are expensive. **Recharging infrastructure:** is a very important limitation, because in general there is a low level of development in some cities and the implementation of the recharging infrastructure has some complexities, such as having exclusive land, making adjustments to the distribution network due to the high power required to charge the buses, among others. **Coordination with local and regional authorities:** although the law 1964 of 2019 establishes a roadmap with the percentage of electric buses that must be included at the time of fleet replacement or fleet addition, this is a national policy that needs to be adapted to the local context. In addition, each municipality must establish a roadmap, allocate resources for this type of projects and have instruments for their implementation, since to date, there are no local policies except for some cities such as Bogota or Medellin.

Colombia has very good enabling conditions for the promotion of e-mobility and considers this as a national priority. Many important steps have already been taken and the potential for fast growth of the EV sector are deemed as high.

3. Actor Mapping

National Planning Department (DNP)

It is an entity of the National Government that coordinates, articulates and supports the short-, medium- and long-term planning of the country, and guides the public policy cycle and the prioritization of investment resources (National Planning Department (DNP), 2020).

Ministry of Transportation (MinTransporte)

It is an administrative organization responsible for ordering the activities of infrastructure, transportation and transit in the country. This ministry is responsible for the transportation sector and for promoting plans and strategies to improve mobility and sustainable development in the country (Ministry of Transportation, 2011).

Ministry of Energy (MinEnergía)

It is the entity in charge of directing national policy regarding mining, hydrocarbons and energy infrastructure (Ministry of Mines and Energy, 2021). The UPME is a Special Administrative Unit of the National order, of a technical nature, attached to the Ministry of Mines and Energy. Its purpose is to plan in an integral, indicative, permanent and coordinated manner with the agents of the mining and energy sector, the development and use of mining and energy resources; to produce and disseminate the information required for policy formulation and decision making; and to support the Ministry of Mines and Energy in the achievement of its objectives and goals (UPME, 2021).

Energy and Gas Regulatory Commission (CREG)

The CREG is the commission that has the function of regulating monopolies in the provision of public services, when competition is not, in fact, possible; and, in other cases, to promote competition among those who provide public services, so that the operations of monopolists or competitors are economically efficient, do not involve abuse of a dominant position and produce quality services (CREG, 2017).

Ministry of Environment and Sustainable Development (MinAmbiente)

It is the governing body for the management of the environment and renewable resources, in charge of defining the policies that will be subject to the recovery, conservation and protection of the nation's environment. Its main interest related to the transportation sector are the GHG emissions and particulate matter for which the sector is responsible, so it has a clear inclination to bet on sustainable mobility, more specifically in electric mobility (MinAmbiente, 2018).

Ministry of Finance and Public Credit (MHCP)

The MHCP is the public entity that coordinates macroeconomic policy; defines, formulates and executes the country's fiscal policy, influences the economic, governmental and political sectors, and manages the Nation's public resources from a budgetary and financial perspective (Public Function, 2021).

Financiera de Desarrollo Nacional (FDN)

It is a mixed public- private development bank specialized in the financing, management, bidding and structuring of infrastructure projects (National Development Finance, 2021).

Bancoldex

It is a development bank that promotes business growth and foreign trade in Colombia. In relation to the transportation sector and in conjunction with the national government, the bank has enabled several lines of credit to support electric mobility.

FINDETER

It is a development bank that offers comprehensive solutions through planning, structuring and technical assistance. As direct support to the country's SITM, the entity has an exclusive line of credit, called "Commitment integrated mass transport systems", aimed at financing the operation of these systems. It is also the entity in charge of implementing the MovE NAMA in conjunction with WWF.

Municipal Authorities

This refers to the mobility, transportation or transit secretary, which plan, regulate and control aspects related to land transportation (passengers and cargo), pedestrian and vehicular traffic, in accordance with the social and economic development model of their cities, providing services that meet the needs of users and promoting a culture of road safety and a healthy environment.

Transport Companies and Managers

In order to improve public transport services in Colombia, the national government has stipulated the implementation of Integrated Mass Transit Systems (SITM). Within this framework, companies or managers of these systems have been set up in the main cities, responsible for contracting and control. Such is the case of Transmilenio in Bogotá, Metro Cali, Metroplús in Medellín, Transcaribe in Cartagena, among others. These companies are public, however, with some exceptions, the companies providing transport services are private.

Coordination mechanisms

In general, in order to develop policy instruments, ministries come together with a particular objective in mind. The entity in charge of policy articulation is the DNP. Currently, there is an Inter-institutional Roundtable on Sustainable Transport, with the participation of the Ministry of Environment and Sustainable Development, Ministry of Energy, Ministry of Transport, UPME and DNP. This roundtable is in charge of monitoring the initiatives, lines of action and public policies regarding sustainable transport in Colombia. At this moment the technical secretariat is in charge of DNP.

National Association for Sustainable Mobility (ANDEMOS)

It is the association that represents and watches over the interests of the national assemblers and exporters of automotive vehicles in the country (National Association of Sustainable Mobility, 2019).

National Association of Colombian Businessmen (ANDI)

It is the most important business association in Colombia. It is made up of a significant percentage of companies belonging to sectors such as industrial, financial, agro-industrial, food, commercial and services, among others. It also plays a fundamental role in the promotion of good mobility, promoting good practices at the time of negotiation between the parties involved in the transportation sector. (Asociación Nacional de Empresarios de Colombia, 2019)

Delivery Companies

Delivery companies have shown interest in electromobility. DHL Express has had Renault Kangoo ZE electric vehicles in the country since 2015 and incorporated 5 more units in 2018, operating in Pereira, Barranquilla, Medellin and Bogota (DHL, 2018). TCC added a fleet of electric vehicles to its operations. These vehicles are part of the acquisition of a more sustainable fleet, including 12 electric vans (TCC, 2020b, 2020a). Recently, Servientrega joined forces to innovate with its fast (last mile) delivery fleet called Green Car, which consists of 40 light vehicles and 20 electric bicycles. The light vehicles are officially motorbikes, however, they can easily replace a small truck with a two-ton capacity (El Tiempo, 2018; Servientrega, 2020).

Energy Companies

Energy companies have been involved in electromobility, providing not only energy, but also charging infrastructure and even the purchase of electric vehicles. Enel, a marketer in Bogotá and Cundinamarca, includes within the portfolio of its Enel X business line, the installation of electric chargers for EVs for individuals, companies or public administration and recharging at public access charging stations (Enel X, 2020a). Celsia, a marketer in Valle del Cauca, Tolima and Chocó, as a power generation and transmission company with a vocation for renewable energies, it has a strong interest in energy storage, and therefore in the use of second life batteries (Celsia, 2019). Celsia participated in the acquisition of the first electric buses for SITM MIO in Cali, in its charging infrastructure and electricity supply.

Proparco

Proparco is a subsidiary of French Development Agency (AFD) focused on private sector development. Proparco financed the first BEB fleet in Bogota with FDN and the consortium Ashmore – Somos-K for 52 MUSD in long-term and local currency financing including the replacement of bus batteries in 2028 (Proparco, 2021).

GIZ

GIZ conducted the study *Economic and Financial Evaluation of E-Buses in Colombia*, which aims to: (i) perform a financial exercise to estimate the impact (costs) of several bus technologies (diesel, electric, natural gas vehicles) in a real transportation operation; (ii) perform an economic analysis to help identify the project scheme that best contributes to the welfare of the country; and (iii) propose a financing mechanism that allows the mobilization of resources (public and/or private) in an efficient manner, in order to implement a fleet electrification program for public transportation (GIZ, 2019). In addition, the *Design of a Measurement System for the National Electric Bus Program*, which estimates GHG emission mitigation indicators and co-benefits in $PM_{2.5}$ emissions of the national electric bus program and support to establish governance structure for e-mobility with support to establish

governance structure for e-mobility with Integrated Mass Transport Systems (SITM) (GIZ & Hill, 2020). They are currently working with the national government (Ministry of Transport and DNP) on the design of an investment fund to promote the upgrade of public transportation systems to electric technologies through the leverage of public resources to finance fleets and take advantage of scale economies, aiming to buy buses to several cities in parallel.

Inter-American Development Bank IDB

The IDB has conducted regional studies to promote electromobility. In addition, through the *Sustainable Urban Transport in Colombian Cities* project, IDB seeks to accelerate electric buses deployment in Colombian cities through: (i) the study for the structuring of a public transport operator for the operation of electric buses in Bogotá Phase V Stages 1, 2 and 3; (ii) development of technical guidelines for the purchase of low emission vehicles for up to 50 passengers in Colombian cities; (iii) support in the structuring, design and implementation of urban electromobility projects in 2 cities in Colombia; (iv) standards study to promote the safe deployment of electric vehicles in the country; (v) support for the strengthening of the National Electromobility Policy focused on urban public transportation; (vi) development of mechanisms to promote electromobility in Colombia and (vii) technical workshops to strengthen the Management Entities in charge of the implementation of electromobility projects in public transportation (IDB, 2020).

World Wildlife Fund WWF

WWF is working together with the Ministry of Transportation, the National Planning Department (DNP), the Mining and Energy Planning Unit (UPME), the Ministry of Environment and Sustainable Development (MADS) and the Territorial Development Finance (FINDETER) in the development of the *NAMA MovE - Electric Mobility and Low Emissions,* which is a NAMA Facility[8] funded project. (IDEAM, PNUD, MADS, DNP, CANCILLERÍA, 2018). This project will build a regulatory and financial enabling environment that will allow for the massification of electric vehicles. It will establish the regulatory and technical standards for commercialization and operation, implement a large-scale communications and capacity building strategy, define an electricity tariff scheme for transportation and establish quotas for the governmental fleet to showcase the benefits of electric vehicles, and thus stimulate market demand (NAMA Facility, 2021).

C40 Cities Finance Facility CFF

The C40 Cities Finance Facility and the International Council on Clean Transportation (ICCT) with funding from P4G have developed the Zero Emission Bus Rapid-Deployment Accelerator (ZEBRA). This initiative involves the participation of vehicle manufacturers, distributors and investors. This initiative provides technical assistance in the generation of business models that facilitate electromobility (Posada, Delgado, Xie, & Maltese, 2020). ZEBRA has also developed the E-bus radar platform that monitors electric bus fleets in public transportation systems in Latin America, quantifying the avoided CO_2 emissions (LABMOB; UFRJ, 2021).

[8] NAMA Facility is an initiative of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Department for Business, Energy and Industrial Strategy (BEIS) of the United Kingdom (UK). Its mission is to finance innovative projects that tackle specific local challenges for reducing emissions in sectors and countries with strong potential for up-scaling, replication and the ability to influence wider sectoral changes.

UN Environment Programme UNEP

The UN Environment Program, with the support of the European Union, through the EUROCLIMA+ Program and the Spanish Agency for International Development Cooperation (AECID), supports countries in Latin America and the Caribbean to make the transition to electric mobility. To this end, it promotes dialogue, learning and regional exchange. This program collaborated in the development of the National Electric Mobility Strategy (Ministerio de Ambiente y Desarrollo Sostenible, 2020)

4. EV Deployment Scenarios

5 different EV scenarios have been constructed which are contrasted with a 0-EV scenario:

- 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.
- 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.
- EV scenario based on projections of UPME in Colombia (UPME & MinMinas, 2019).
- EV scenario based on official national targets in Colombia.
- EV "high-growth potential" scenario focusing on the potential for commercial vehicles targeted by the e-mobility fund with an EV target of 100% of new registered vehicles for these categories by 2030. In all other vehicle categories the maximum of the 3 other scenarios has been chosen.

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

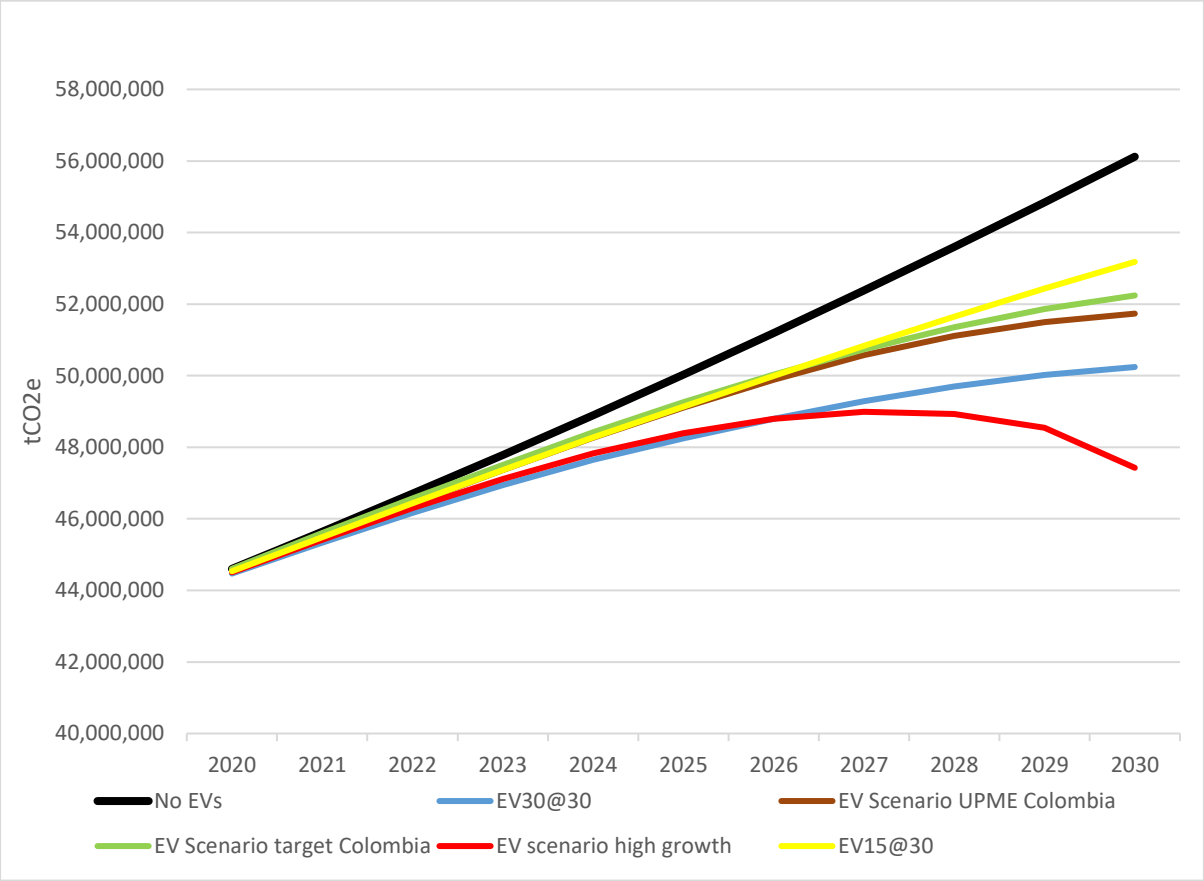
Table 3: Scenario Results

Impact	Scenario	By 2025	By 2030
GHG reduction WTW in tCO_{2e} per annum	IEA 15@30	890,000	2,900,000
	IEA30@30	1,780,000	5,900,000
	UPME projection	920,000	4,400,000
	Colombian target	770,000	3,900,000
	"Potential" scenario	1,640,000	8,700,000
Electricity demand of EVs in GWh per annum	IEA 15@30	1,060	3,500
	IEA30@30	2,130	7,000
	UPME projection	770	3,600
	Colombian target	780	3,800
	"Potential" scenario	1,710	8,500

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.

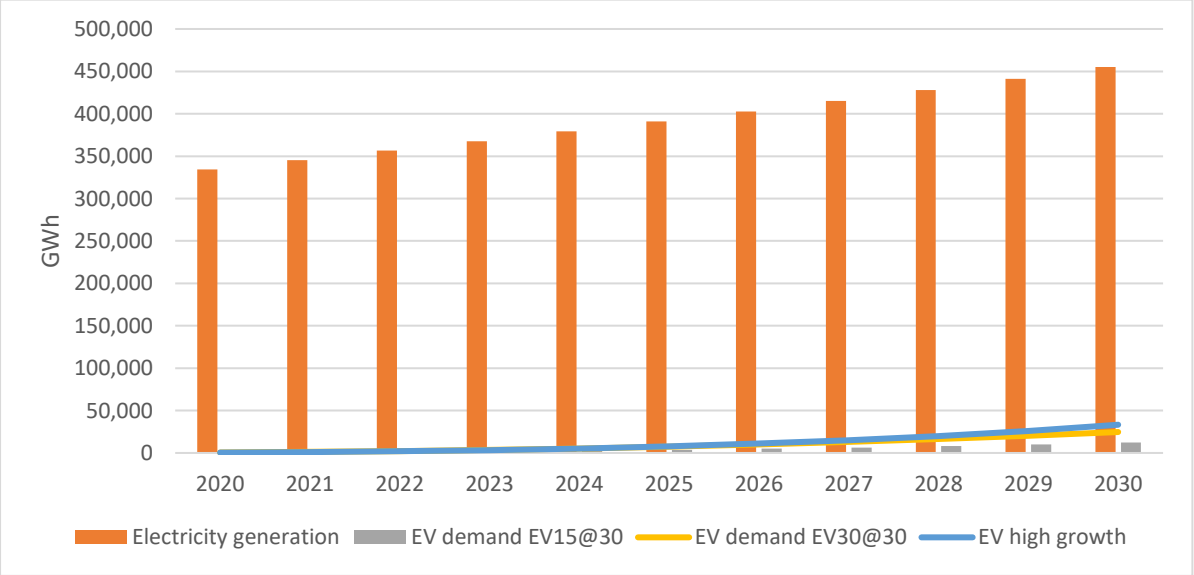
Figure 2: Projected GHG Transport Emissions Colombia BAU with no EVs and with EV Scenarios (WTW)



Source: Grutter Consulting

The 2030 projected electricity demand of EVs represents 8% of same year electricity generation for the EV scenario using national targets and 10% for 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.

Figure 3: Projected Electricity Demand EVs



Source: Grutter Consulting

The Colombian grid system has a peak in the early evening (from 5-9 PM). 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. Plugging EVs to the grid too early i.e. before 10PM may however result in this additional demand coinciding with the evening peak electricity demand resulting in a higher risk of overloading of the power distribution network ultimately requiring additional generation capacity and network upgrades. Especially LCVs and passenger cars, but also taxis could be prone to be charged too early as people return home and plug-in their vehicle. This will require smart management involving e.g. controlled charging and using Demand Side Management (DSM) instruments.

The Medium Voltage (MV) networks in the urban areas of Colombia are considered in good shape for accommodating the connection and the load of charging sites for commercial vehicles in the range of 500 kW to 5 MW. Especially for the 'industrial networks' (operated at 34.5 kV), a connection should in general not be of much concern and could be realised pretty quickly. Also in 'non - industrial networks' (operated at 13.2 or 13.8 kV), connections at the lower end of the 500 kW to 5 MW range should usually be realised reasonably fast. The connection of larger charging sites (several MW's) to 'non - industrial networks' may more likely require new feeders, which may take more time to install.

An area of concern is the quality of the electricity networks. Although the duration of an interruption in power supply is on average less than one hour, the number of interruptions per year is high in Bogotá (18-20 per year) and even higher in Medellín (almost 40 interruptions per year). This means that e.g. for ultra-fast charging sufficient redundancy must be built into the system.

5. Market Analysis[9]

5.1. Current EV Market and Finance Conditions

A special credit line for electric vehicles including specifically commercial units started operations in October 2020 with disbursements through Banco Popular and Banco de Colombia (BCR). Conditions vary between banks and are fixed also per project and credit subject. The offer of Banco Popular[10] (comparable for BN and BCR) for commercial EVs is currently:

- Loans in national currency or USD;
- USD interest rate is prime rate USA plus 2.5% - this equals to around 7%[11];
- Commission of maximum 1.5%;
- Tenor up to 10 years (in practice however loans are in accordance with each business and income streams e.g. as concession contracts for buses are for 7 years loan tenors are for maximum 7 years; for taxis BCR finances only for up to 5 years);
- Maximum 80% of vehicle investment (chargers or bus depot upgrades are not included).

[9] See also for further details Grutter Consulting, 2021, Assessment of Commercial EV Demand in Colombia
[10] Vehículos eficientes -Créditos Verdes | Banco Promerica Colombia
[11] BN fixes the interest rate at 7% for the initial 2 years and then applies a base-rate plus spread. BCR uses as reference rate LIBOR.

Whilst banks have been quite successful in financing private EVs (which are basically upper-class vehicles; e.g. the Audi e-tron has been one of the most sold EVs in Colombia), the demand for commercial EV financing has been limited (involved banks have not yet financed any commercial EVs).

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;
- 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) calculated at 7.1%[12];
- 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. To comply with operating conditions in Colombia an overnight charged bus would require a battery set of 370 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)[13].

[12] see (Grutter Consulting, 2021a) for details of calculations
[13] For details see report 2

Table 4: Summary Financial Assessment 12m BEBs Colombia

Criteria	Result	Assessment
TCO	0.72 – 0.78 USD/km for BEBs versus 0.76 USD/km for diesel Euro IV bus[14]	Non-discounted the cumulated lifetime costs for BEBs are comparable to diesel buses.
Capital investment	290,000-320,000 USD for BEB[15]; 190,000 for diesel bus	Significantly higher capital requirement incl. higher loan demand; negative impact on debt to equity ratio
Equity investment	100,000 for BEB[16] versus 40,000 for diesel bus	Significantly higher equity demand which might overstretch the capabilities of small and medium enterprises
Profitability[17]	FIRR of 5-10%	Investment in e-buses is in general not profitable.
Discounted Payback	Incremental investment is not recovered with savings during asset lifetime (15yrs)	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 entire lifespan (due also to replacement batteries and chargers in year 8 and 10)	The investment in BEBs will affect the liquidity position of the companies 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 3 for details including assumptions

The investment in BEBs with the current financial conditions and business models is not profitable, a high risk, requires a significant increase in owners capital and results in potentially serious liquidity problems. 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 Colombia.

5.2.3. Electric Taxis

The following table summarizes the financial assessment of e-taxis. The comparison is based on a gasoline taxi (brands compared are Kia, Chevrolet) versus Nissan Leaf or BAIC e-taxi with a 60kWh battery set.

[14] 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 15-year lifespan.

[15] Includes bus, charging infrastructure, grid connection, bus depot upgrades; Prices of BEBs have considerable variations between countries and depend on factors such as vehicle specifications, number of units purchased, battery size etc.

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

[17] FIRR of incremental investment compared to diesel bus

Table 5: Summary Financial Assessment E-Taxis Colombia

Criteria	Result	Assessment
TCO[18]	0.212USD/km for e-taxis versus 0.12 USD for gasoline unit	Non-discounted the cumulated lifetime costs for e-taxis are the same as for gasoline units.
Capital investment	32,000 USD for e-taxi versus 14,000 USD for gasoline unit	Significantly higher capital requirement incl. higher loan demand
Equity investment	8,000 USD for e-taxi versus 3,000 USD for gasoline unit	Significantly higher equity demand which might overstretch the capabilities of taxi owners
Profitability[19]	FIRR of 2%	Investment in e-taxis is not profitable.
Discounted Payback	Incremental investment is not recovered	The payback time is longer than the asset lifespan. This indicates a high risk profile of the investment.
Cash Flow	Negative cumulative CF until year 7	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 3 for details including assumptions

The investment in e-taxis with current financial conditions and business models is not profitable, has a high risk and high owner capital requirements. One of the major additional 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 (most public chargers available in Colombia are 7-14 kW chargers). 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 Jac X250 of 3.7 tons diesel version as used by postal service companies versus a Stark E-cargo, with a battery set of 81 kWh which is sufficient due to relatively low daily mileage of LCVs in urban settings.

Table 6: Summary Financial Assessment e-LCVs Colombia

Criteria	Result	Assessment
TCO[20]	0.22 USD/km for e-LCVs versus 0.14 USD/km for fossil unit	Non-discounted the cumulated lifetime costs for e-LCVs is significantly higher than of a diesel unit
Capital investment	59,000 USD for e-LCV versus 23,000 USD for fossil unit	Significantly higher capital requirement incl. higher loan demand
Equity investment	13,000 USD for e-LCV versus 5,000 USD for fossil unit	Slightly higher equity demand
Profitability[21]	FIRR of -16%	Investment in e-LCVs is not profitable
Discounted Payback	Incremental investment is not recovered with savings	The payback time is longer than the asset lifetime. This indicates a high risk profile of the investment.

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

Cash Flow	Cumulative negative CF over asset lifetime	The investment in e-LCVs results in a cumulative negative liquidity impact

Source: (Grutter Consulting, 2021a); see Annex 3 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.

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 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% (0.75% interest rate + 0.5% service fee)	GCF conditions public sector non-vulnerable countries; GCF/B09/08
Grant share GCF of total CAPEX for buses	10%	
Total loan and parts AFD and GCF for buses	70% of CAPEX; 20% GCF and 50% AFD	
AFD loan conditions non-sovereign public sector	4.0%	AFD
Bank spread for on-lending	2%	Assumed
Resultant minimum loan rate for buses if based on project finance with public lender e.g. municipality	2.3%	Calculated based on above data
Resultant minimum loan rate for LCVs and taxis based on lending through public banks	4.4%	
Lending rates for LCVs and taxis	80% maximum	
Loan tenure	12 years buses 6 years taxis & LCVs	
WACC new	3.3% buses 3.4% taxis	

5.3.2. E-Buses

The level of concessionallity would be dependent if the recipient is a public body e.g. municipality or public bank. An 80% lending rate on the total CAPEX is also assumed. The concessional loan helps to resolve liquidity issues and results in an improvement of the investment profitability but investment risks remain high with an unsatisfactory payback time. It is clear that concessional loan conditions are an important feature but are not sufficient to tilt an investors decision with the current risk profile of BEBs in the country..

An upfront grant of 10% on the total initial investment combined with concessional finance is modelled.. Following impacts can be observed:

1. The TCO of BEBs is now between 0.61 and 0.65 USD/km and therefore considerably lower than the TCO of diesel buses which is 0.76 USD/km.
2. The differential FIRR for investing in BEBs instead of diesel buses is now between 9% and 16% and thus above the WACC indicating a profitable investment.

3. Owners capital requirements are reduced significantly.
4. The additional investment in the BEB is recovered within 10-15 years (without concessional finance this is not recovered during the lifespan of buses) which is shorter than the concession period.

It can be concluded that the grant combined with the concessional loan resolves fully the profitability and risk issue.

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).

Figure 4: Dynamic Payback versus Projected BEB Price Decrease

Source: Grutter Consulting; annual decrease of BEB projected at 4% based on decreasing battery price projections of BNEF[22]

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. Taxis are privately owned and managed. The assumed business model goes through loans managed by public banks (idem to the current loan structure) which would receive the concessional conditions of the Program. The on-lending interest rate would drop from currently 7.5% [23]for e-taxis to 5.2%. The main impact of the concessional loan is that the dynamic payback time is reduced slightly. Whilst this is interesting from a liquidity perspective the core issue will remain to realize a fast-charging network.

The figure below shows the trend of decreasing dynamic paybacks of e-taxis. Clearly with decreasing prices they get more attractive. However, the graph below does not 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.

[22]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.
[23] BBVA Colombia

Figure 5: Dynamic Payback versus Projected e-Taxi Price Decrease

Source: Grutter Consulting; annual decrease of e-taxis projected at 7% based on price parity expected by 2030 (see Electric vehicle trends | Deloitte Insights)

5.3.4. E-LCVs

LCVs are privately owned and managed. The assumed business model is through loans managed by public banks (idem to the current loan structure) which would receive the concessional conditions of the Program. The on-lending interest rate would drop from currently 9% to 5.2%. The impact of the concessional loan is however limited. Even a 20% upfront grant will not make the investment commercially attractive. At least for this vehicle segment the commercial viability is still a few years off and is therefore recommended to not enter this market with the program.

5.4. BAU versus Project EV Market Deployment

5.4.1. Approach

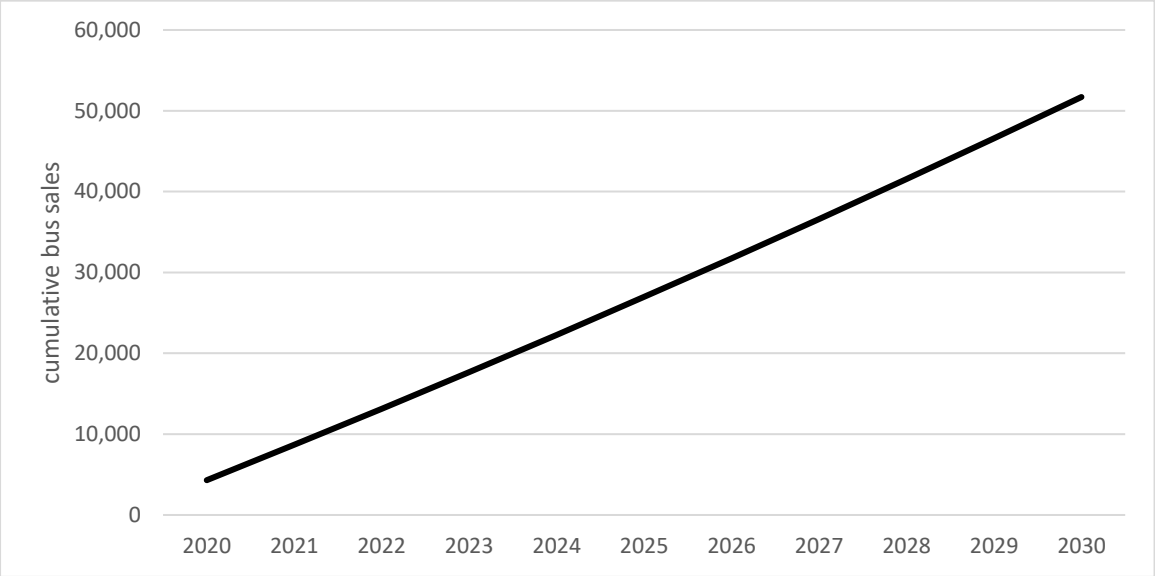
Under a BAU scenario EVs will pick up without commercial support. The question is when and how much. The following chapters will model the BAU deployment expected for the different commercial EV technologies due to decreasing EV prices and therefore increasing financial profitability of latter and the scenario of commercial EV deployment with program activities. This allows to model the with and without program scenario 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 Colombia based on vehicle replacement and market growth rates.

Figure 6: Total Projected Cumulative Market Demand for Urban Buses in Colombia



Source: (Grutter Consulting, 2021)

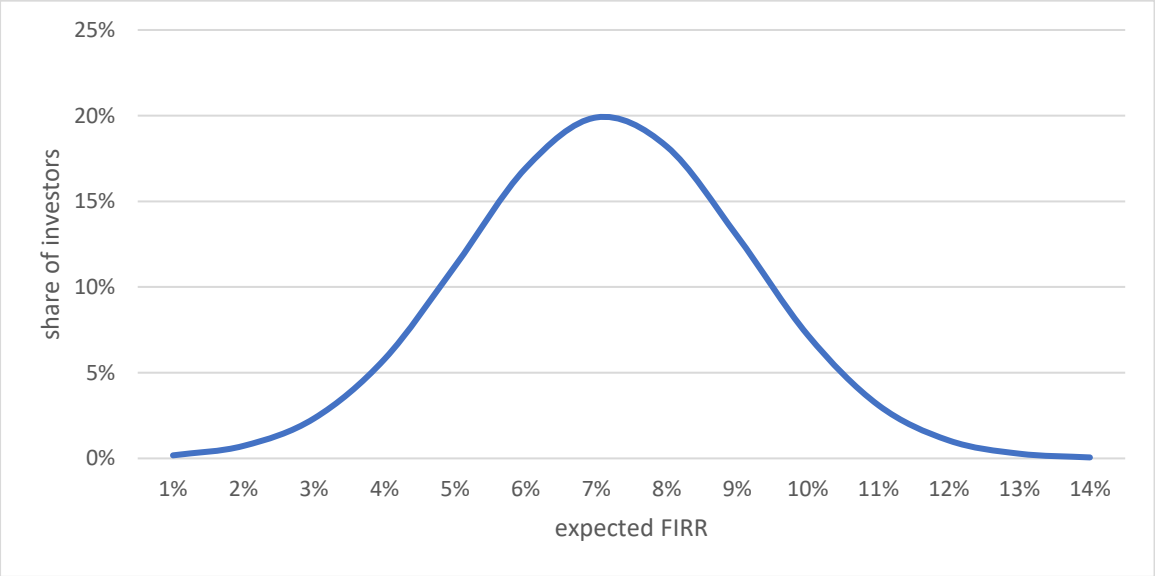
Projected BAU Demand for E-Buses

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 30%.
- 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 20% higher maintenance costs than expected.
- 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 in 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 7.1%.

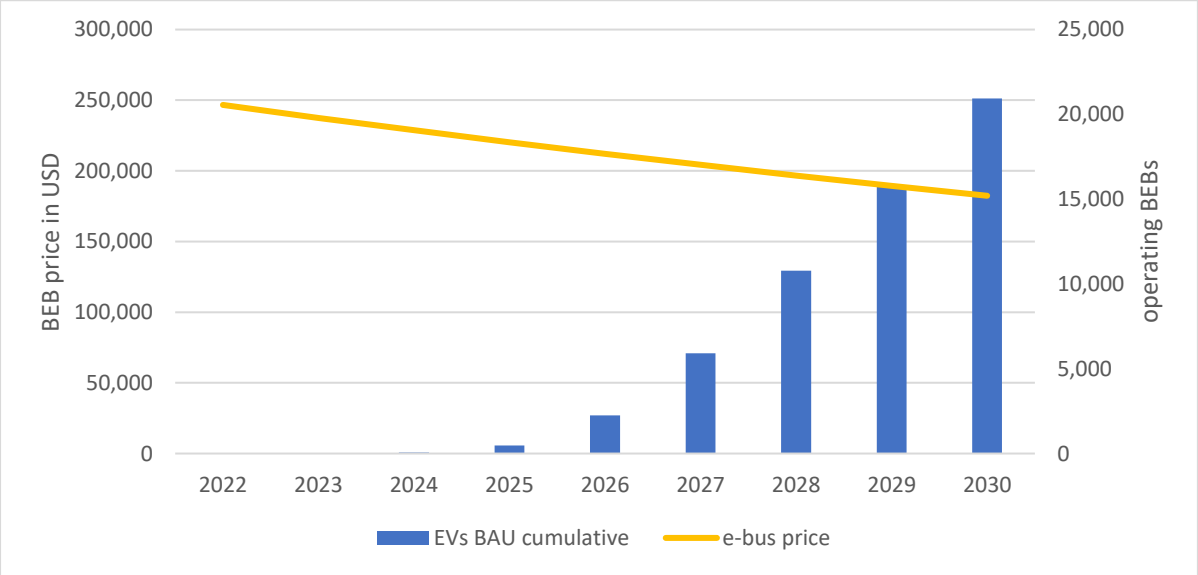
Figure 7: Expected FIRR of Investors



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 Colombia.

Figure 8: BAU Projected E-Bus Uptake in Colombia and Price Trend of E-Buses



Source: Grutter Consulting

Under a BAU scenario BEBs in Colombia start to get commercially viable around 2026 and then increase rapidly. With the BAU scenario the Colombian target of 34,000 e-buses by 2030 could not be reached.

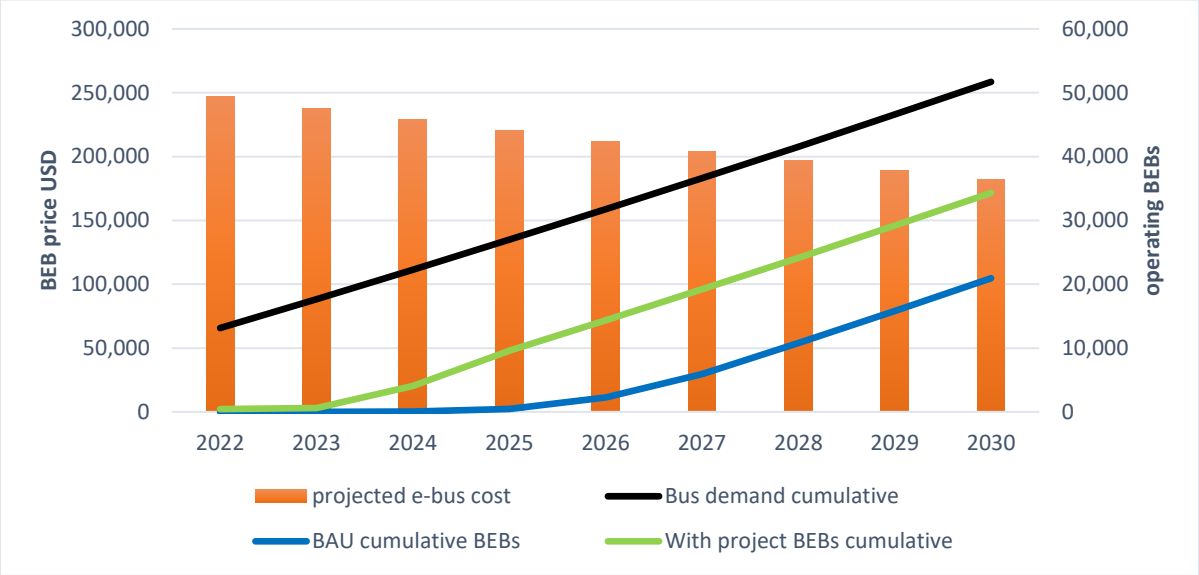
Projected with-Project Demand for E-Buses

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 2026 is assumed. 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 9: BAU and with-Project Projected E-Bus Uptake in Colombia and Price Trend of E-Buses



Source: Grutter Consulting

Comparing the with and without project scenario we can state an increase in the uptake speed (slope of the function). The e-bus fleet reaches by 2030 34,000 instead of 21,000 units with a BEB market share of 49% instead of 34% by 2030. 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):

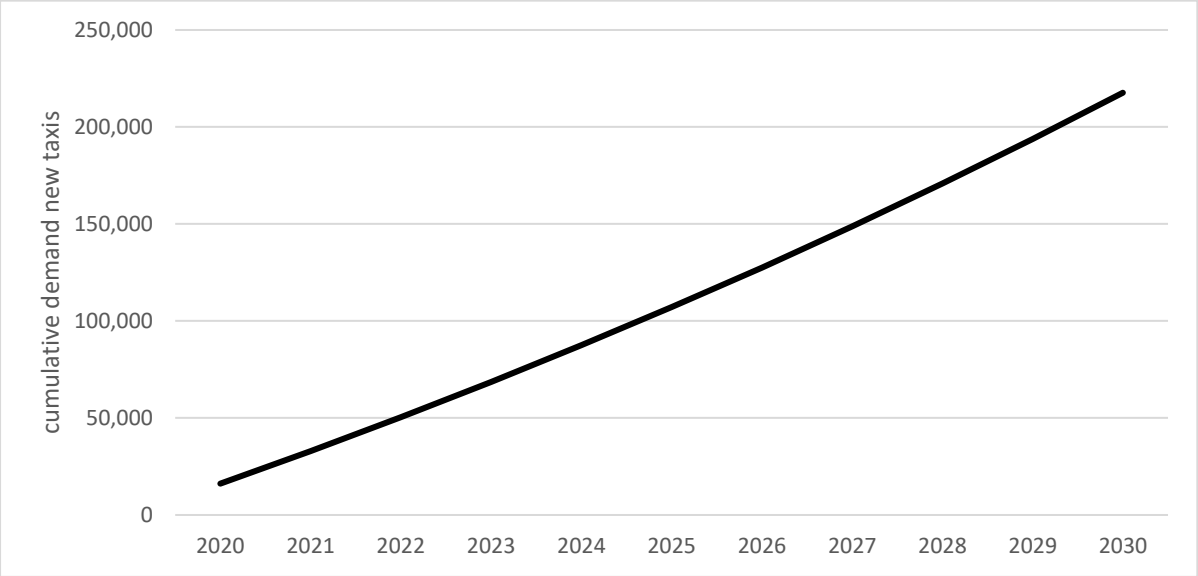
- Additional 7.68 million tons of CO_2 reduced;
- Additional 278 tons of $PM_{2.5}$ avoided;
- Additional 33,000 tons of NO_x avoided;
- Additional economic savings of 479 MUSD.

5.4.3. E-Taxis

Market Demand for Taxis

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

Figure 10: Total Projected Cumulative Market Demand Taxis



Source: (Grutter Consulting, 2021)

Projected BAU Demand for E-Taxis

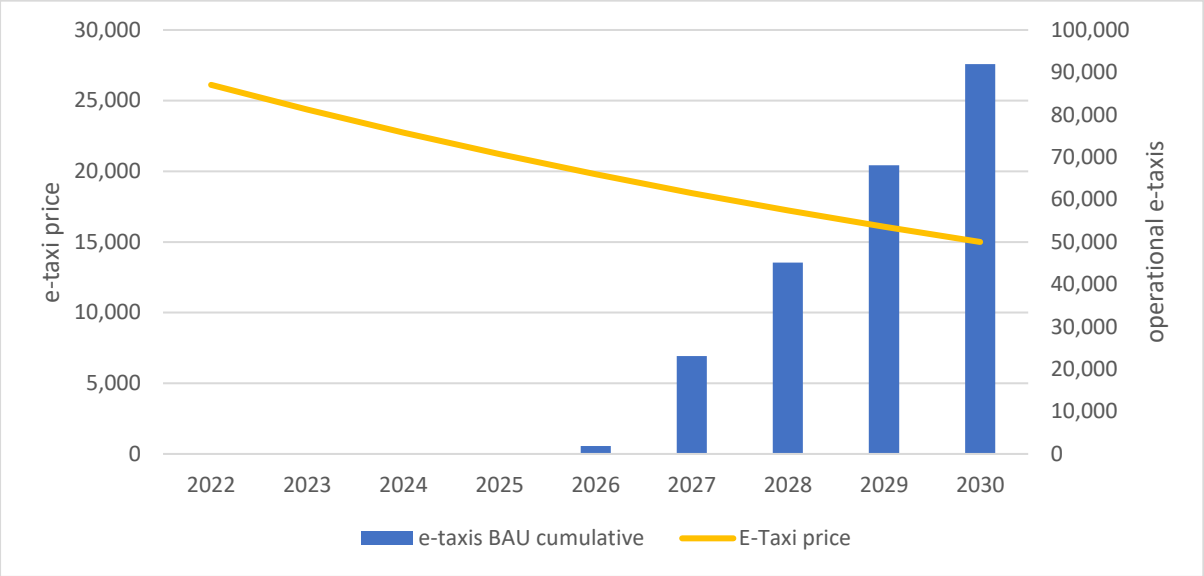
Idem to the e-bus approach, the e-taxi demand is based on comparing the FIRR with the WACC adjusted for a risk rate based on being a new technology using the following criteria:

- Performance risk of e-taxis 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 taxis). The medium risk rate is modelled with 20% higher energy costs.
- Performance risk of e-taxi maintenance costs: The medium risk rate is modelled around e-taxis having up to 20% higher maintenance costs than gasoline units primarily due to higher spare parts costs.
- Revenue losses modelled at medium of 2,400 USD per annum based on not being able to operate fully due to lack of a fast-charging infrastructure which results in driving range limitations[24].

Idem to e-buses the modelling assumes a risk propensity distribution. The following curve shows the trend projection of decreasing e-taxi prices and the BAU projection of uptake of e-taxis without project intervention in Colombia.

[24] The profit loss has been calculated with 5 days per month with 10 “lost” clients @ 10USD per trip with 40% variable profit.

Figure 11: BAU Projected E-Taxi Uptake in Colombia and Price Trend of E-Taxis



Source: Grutter Consulting

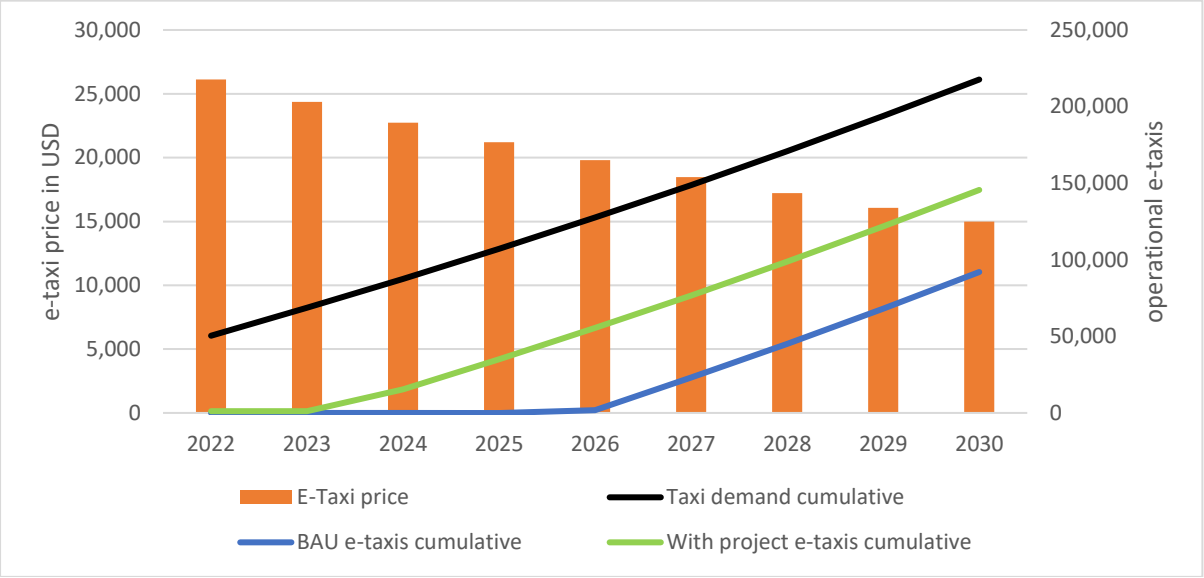
Under a BAU scenario electric taxis start to get commercially viable around 2027 and then increase rapidly. The share of electric taxis by 2030 could reach 40% under BAU , meaning a share higher than the expected number of units under the government scenario. The only issue is, that this movement would take another 5-7 years to commence.

Projected with-Project Demand for E-Taxis

The EV project has as basic function to accelerate EV deployment. It uses financial assistance (FA) to deploy an initial at-scale fleet. FA is also used to deploy an urban fast charging infrastructure. Technical assistance (TA) is primarily used to design the charging infrastructure, for performance measurement and for providing taxi owners with technical and financial information. At the same time capacity building and training reduce the performance risks.

The projected e-taxi 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 by 2022 a charging infrastructure is deployed and an initial fleet of e-taxis has been financed.). 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-taxi market deployment with and without project i.e. under a BAU and with the case of a project intervention.

Figure 12: BAU and with-Project Projected E-Taxi Uptake in Colombia and Price Trend of E-Taxis



Source: Grutter Consulting

Comparing the with and without project scenario we can state than a larger fleet is achieved in shorter time. This impact continues during the entire period due to vehicles being kept in operations for a long period. The e-taxi fleet reaches by 2030 150,000 instead of 90,000 units with an e-taxi market share of 67% instead of 42%. 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 5.1 million tons of CO_2 reduced;
- Additional 30 tons of $PM_{2.5}$ avoided;
- Additional 1,660 tons of NO_x avoided;
- Additional economic savings of 217 MUSD.

5.4.4. E-LCVs

Due to the limited mid-term commercial financial viability of e-LCVs this area is not included in the investment projects for Colombia and thus also no BAU and with-project scenario is developed.

6. Potential Investment Projects

6.1. Urban Buses

6.1.1. Barriers and Interventions Options

The following table summarizes main barriers towards massive e-bus deployment in Colombia. The barrier source gives an indication of what type of changes are required from an institutional perspective and the barrier elements which concrete aspects need to be altered.

Table 8: Barriers towards e-Bus Deployment in Colombia

Barrier Type	Concrete Aspects
Atomized market structure of bus operators	Although the Government of Colombia is working on the implementation of Integrated Mass Transit Systems (SITM) and Strategic Public Transportation Systems (SETP), there are still many small operators in the country, especially outside the largest cities, unformal and low regulated urban massive transport.
Financially weak operators	Operators have a fragile balance sheet. Commercial banks have expressed their disinterest in financing vehicle fleets due to the instability of the transportation systems and their difficulties. In most cities there is no injection of additional resources to compensate for the differences between technical and social tariffs.
Financial barriers	BEBs are not profitable. The FIRR is equal to the WACC but the repayment period for the incremental investment in electric buses is more than 15 years. The investor needs to invest up to 1.5x the owners capital required for fossil buses, increases significantly his debt levels and suffers from a negative cash flow at least for the loan period.

Source: Grutter Consulting

E-buses have major environmental and societal advantages expressed in large positive environmental and health impacts. Whilst the TCO of e-buses is slightly lower than of diesel units, the capital exposure, risks and lack of profitability make it a non-attractive investment. This combined with market conditions (atomized bus ownership) and a political/contractual framework which hampers e-bus deployment result in e-buses not being deployed in cities other than Bogota, Medellin and Cali.

The **atomized market structure** results in very small amounts of buses being purchased. This results in high purchase and maintenance/repair costs and potentially sub-optimal technology solutions. Also, operators lack the know-how on e-bus technologies and are thus dependent on claims of suppliers. Bulk purchase would resolve these problems. This can be based on different organizational models:

- Group purchase based on (ad-hoc) associations;
- Bulk purchase of buses through leading enterprises which thereafter sell buses to smaller companies. However, it has disadvantages as smaller companies might feel that they are being pushed out of the market by depending on larger operators and financing of such fleets is complex as assets are given along to 3rd parties and operators might not have sufficient solvency for such operations;
- Purchase of buses through a 3rd party and delivery for operations either credit- or leasing-based by operators.

Technical assistance can be useful to further develop appropriate bulk-purchase business models and link them with concessional financial instruments.

The **weak credit subjects** will result in a problem of accessing loans and having favourable loan conditions. A separation of bus ownership and bus operations, as has been done successfully e.g. in Santiago de Chile or Bogota can bring in other and financially stronger players which can provide the required owners capital and which can access finance at more favourable conditions. This could also be done with the municipality or government purchasing buses and then leasing or renting them to operators as is done e.g. in various cities worldwide including Medellin. This operation scheme can be replicated in intermediate cities and accelerate the transition to electromobility. Technical assistance can help structure these new systems in intermediate cities that do not have the institutional capacities of large cities. To rely on financial assistance alone would be inefficient as this would require far more support resources and would maintain a non-efficient public transport system.

Concessional loans and investment subsidies are critical to de-risk the investment and to create an attractive financial framework. This includes longer loan tenures, concessional interest rates, higher lending rates, payment guarantees and upfront investment subsidies worth around 20% of the total CAPEX which allows a 3rd party or a bus operator to invest in e-buses whilst receiving an adequate return on investment, an acceptable payback period, limits his equity and capital investment and financial exposure to a comparable rate as for fossil buses and allows for a positive cash-flow.

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6.1.3. Possible Business Models

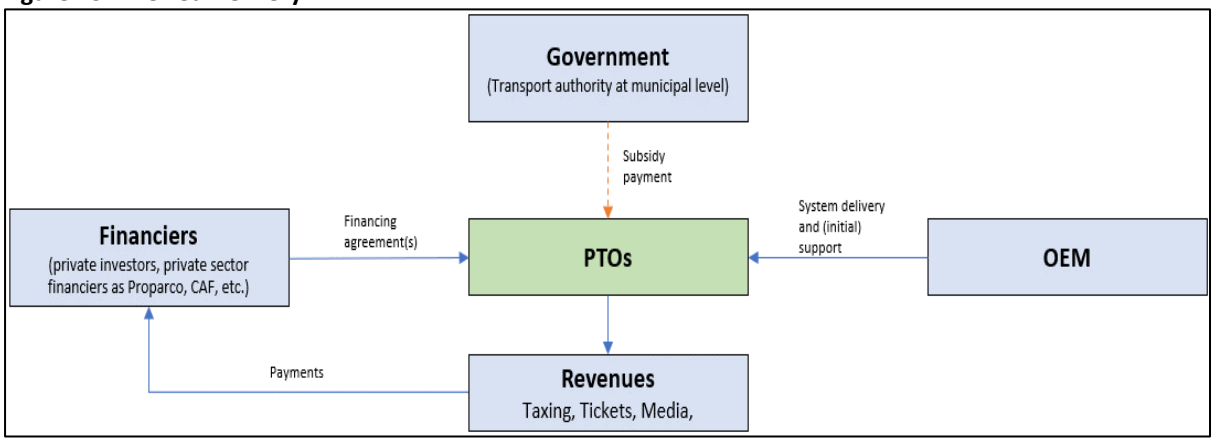
The typical structures that could be followed in the case of Colombia are:

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

Option 1: Public Transport Operator (PTO)-led delivery

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

Figure 13: PTO-led Delivery



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

In this structure, PTOs:

- Procure the BEB fleet and charging infrastructure assets (including initial maintenance training, spare parts, etc.) from a selected OEM;
- Raise the necessary financing for this, possibly in combination with the procurement of the assets themselves; and

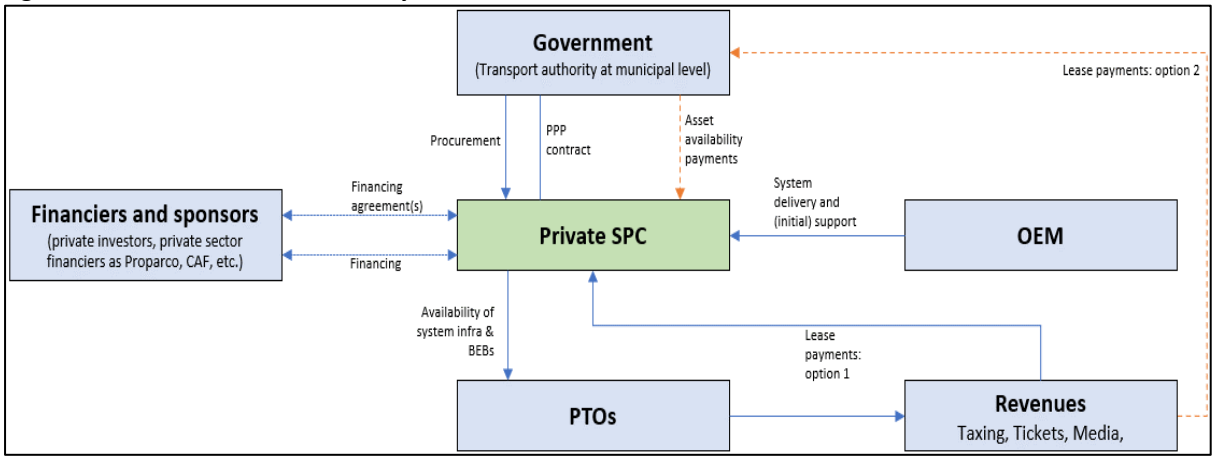
- Receive a subsidy[25] from the government to neutralize the difference between the capital cost and operating cost of diesel bus operations versus BEB-FC operations over the life of the concession (which is presumably shorter than the break-even period).
- Receive a pass-through guarantee from the government that ensures that subsequent concession holders will take over the assets and financial obligations in the event that the PTO concession is discontinued. Funders may require a direct guarantee to the same extent.

This model can include the figure of a trust fund, with the objective of centralising revenues and defining the allocation of payments to the actors involved.

Option 2: Private Sector-led Delivery

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

Figure 14: Private Sector-led Delivery



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

In this structure:

- Government (transport authority at municipal level) procures a “PPP” for a consortium to deliver and finance the BEB fleet and charging infrastructure assets;
- The winning consortium sets up a private sector AssetCo (Special Purpose Company or SPC) which:
  - structures and raises financing from selected financiers and investors
  - procures the buses and charging equipment assets from an OEM
  - ensures the availability to PTOs of buses and charging equipment
  - provides maintenance training and additional spare parts inventor
  - The assets are held and/or managed by the SPC, which is the ultimate legal owner
  - The PTOs are obliged to use BEB-FC's assets as they are made available by SPC and are contractually bound to a care and maintenance obligation, as well as an obligation to transfer the assets to subsequent concessionaires in case a PTO loses its concession
  - In addition, PTOs will either
    - pay the lease fees directly to the SPC - however, as the overall cost of use of the assets must be at most equal to that of the existing diesel buses, in this case the government must pay an "additional" payment stream for the availability of the assets to the SPC

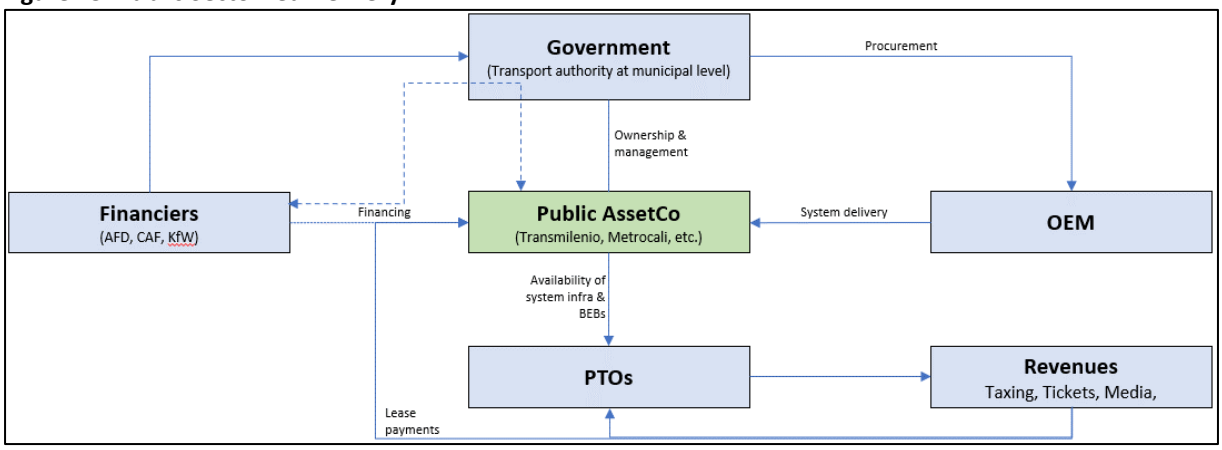
[25] This mechanism is common in Bogotá, where the public tariff is of a social nature and governments subsidies the operation.

- or pay the same lease fees to the government, which in turn pays a "fully loaded" asset availability payment stream to SPC
- it is expected that several enhancements (not shown in the figure) will be necessary to enable this structure, as financiers are likely to require
- a guarantee from the government in the event that SPC defaults on its funding obligations (or, at a minimum, in the event that PTOs default on their lease payment obligations)
- a pledge/first claim on bus and fare infrastructure assets in the event of default on debt service obligations.

Option 3: Public Sector-led Delivery

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

Figure 15: Public Sector-led Delivery



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

In this structure:

- Government (central government or municipalities) procures both financing and BEB system assets;
- Financing agreements are either with the government (a multilateral development bank or agency as AFD) and the government passing the financing through into the AssetCo, or directly with the AssetCo – with government guarantee in case the borrowing entity is not the Ministry of Finance providing the credit signature;
- Supply and deliver contracts (including an initial service & support agreement for maintenance training, initial spare parts, etc.) may be signed by the OEM with the government counterpart (nation or municipality) or with the AssetCo directly;
- The assets are held and/or managed in the AssetCo with government remaining the final legal owner; and
- PTOs are required to lease the BEBs from the AssetCo and are contractually bound to pay lease fees to the AssetCo, keep to a care and maintenance obligation, as well as a handover obligation for transfer of assets to subsequent concession holders should a PTO lose its concession.

A number of improvements (not shown in the figure) are expected to be necessary to enable this structure:

- Regardless of the exact nature of the funders and the financing arrangements, it is expected that funders will require
    - PCG/PRI or similar on government loan repayment obligations if the structure involves direct private sector financing; and/or
    - Pledge/first claim on bus and fare infrastructure assets in case of default on debt service obligations.
- Government and/or AssetCo may require a PTO direct guarantee vis-à-vis the obligations of duty and care of the bus and charging assets, in particular concerning the state of asset maintenance at hand-over to any successor concessionaire.

6.1.3. Potential Investment Project

Investment projects for buses have been identified for 15 cities. This includes short to medium term investment projects in 14 cities as well as a project with Transmilenio concerning electrification of trunk routes. Trunk routes using 18-26 m buses require a different strategy and technology for electrification than feeder routes operating with 12m buses. This is thus a novelty for Colombia (in general for Latin America with exception of trolleybus systems). For the different cities, the demand for e-buses surpasses the financial capabilities of the fund. It has thus been estimated that for the 14 cities excluding Bogota, the fund would finance 30% of proposed e-buses by 2022 and by 2025 around 20% of the bus-only routes buses including infrastructure for Transmilenio/Bogota (concession renovation will take place at this time). The following table summarizes the projects (see spreadsheet and (Grutter Consulting, 2021a) for more information).

Table 9: Potential E-Bus Investment Projects with Fund Finance

Item	Description
Project contents	530 urban e-buses (120 7-9m, 420 10-12m, 140 18m, 170 26m) including their charging infrastructure, grid connection and bus depot upgrade in 15 cities of Colombia
Project owner	Not yet defined (see possible business models in previous chapter)
Total investment	230 MUSD
Loan components	160 MUSD loan for 70% of the net total CAPEX @ 2.3% interest rate for 12 years of which GCF 46 MUSD
Subsidy	23 MUSD (10% of total CAPEX) by the GCF
Environmental impact (cumulative lifespan units)	Reduction of 610,000 tCO_{2e}, 21 tons $PM_{2.5}$ and 2,560 tons of NO_x

Source: Grutter Consulting

The proposed project is an important intervention to kick start the process.

6.2. Taxis

6.2.1. Barriers and Intervention Options

The deployment of electric taxis faces following major barriers:

- E-taxis require a capital investment factor 2.5 of a gasoline unit. The investor could opt for purchasing 2 gasoline units instead of 1 electric one thus increasing considerably his revenue and profit base.
- Lack of urban fast-charging network catering to the needs of taxi drivers. This makes the deployment of electric units a potential financial risk as drivers could lose considerable

potential income and profit due to range limitations of e-taxis and lack of public fast-charging facilities.

To overcome the technical issues, technical assistance is required to taxi operators as well as the government to prevent repeating the mistakes of other cities. Drivers need to be aware of range limitations and of charging speed of batteries and chargers. Average daily distances driven are thereby potentially a misleading figure as high-demand days like e.g. Friday/Saturday require longer ranges with less available charging time whilst constituting an important part of revenues and profits. Technical assistance is required to design an appropriate fast-charging infrastructure catering to the demands of taxis and ride-hailing vehicles. Cities like Amsterdam or London which have a clear e-taxi strategy fostering e-taxis whilst also establishing taxi-exclusive or taxi-preferential charging systems, show that the charging network needs not be established fully from the start. A minimum structure is however required with chargers located at strategic points where taxis often wait whilst also being distributed sufficiently over the urban area to avoid additional distances driven just for charging.

Financial assistance is required for the areas of concessional loans to taxis (vehicle subsidies are not deemed to be necessary). Basically, loan conditions need to be softened in terms of more concessional interest rates and, potentially, an increase in loan tenure. Financial assistance in terms of a concessional loan plus grants is required for the establishment of a fast-charging network for taxis. Such a network will not be financially attractive and is not demanded by law. Thus no party will establish such a network. Once available and once a sufficiently large electric taxi fleet plus other EVs is available the network can be run potentially profitable but initial investments in charging systems will be required.

6.2.2. Potential Investment Project

A potential initial investment project is the purchase of around 1,000 (of targeted 17,000) units in Bogota including the appropriate fast-charging network. Additionally the establishment of a fast-charging network for taxis in Medellin would be financially supported (the targeted number of 150 taxis is to small to warrant a loan). The finance to taxis could be given through Findeter or national banks and would be within the municipal taxi replacement programs.

Table 10: E-Taxi Initial Investment Project

Item	Description
Project contents	1,000 e-taxis combined with a fast-charging network in Medellin and Bogota
Project beneficiary	Charging network is owned by electric utilities depending on location; taxis are owned by individual taxi owners
Financial mechanism	For taxis concessional loan through Findeter / banks; charging network grant for 50% of CAPEX
Total investment	45 MUSD of which 36 MUSD taxis and 9 MUSD charging infrastructure
Loan components	26 MUSD loan for 80% of the total CAPEX e-taxis @ 5.2% interest rate for 6 years with GCF involvement 10 MUSD
Subsidy	4.5 MUSD equivalent to 50% of total investment in fast-charging infrastructure
Environmental impact (cumulative lifespan units)	Reduction of 110,000 tCO_{2e}, 1 tons $PM_{2.5}$ and 36 tons of NO_x

Source: Grutter Consulting

7. Proposed Financial and Technical Assistance

7.1. Financial Assistance Instruments

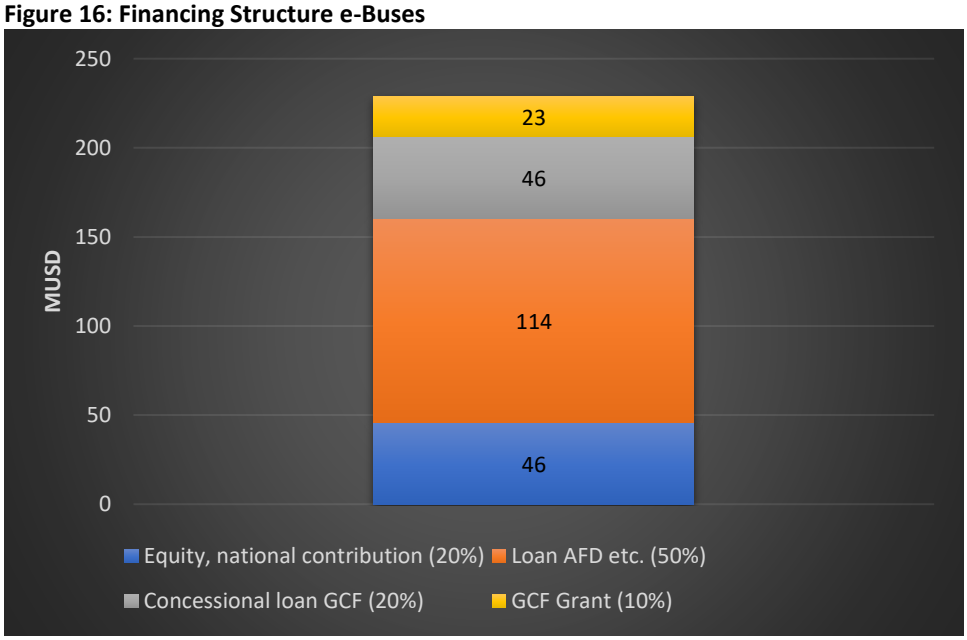
The following table summarizes financial intervention instruments proposed for commercial EV deployment in Colombia.

Table 11: Financial Assistance GCF

Instrument	e-buses	e-taxis
Grants	10% of total CAPEX incl. buses, charging infrastructure, grid connection and bus depot upgrades	50% for fast charging infrastructure
Loans	20% of total CAPEX	30% of vehicle CAPEX

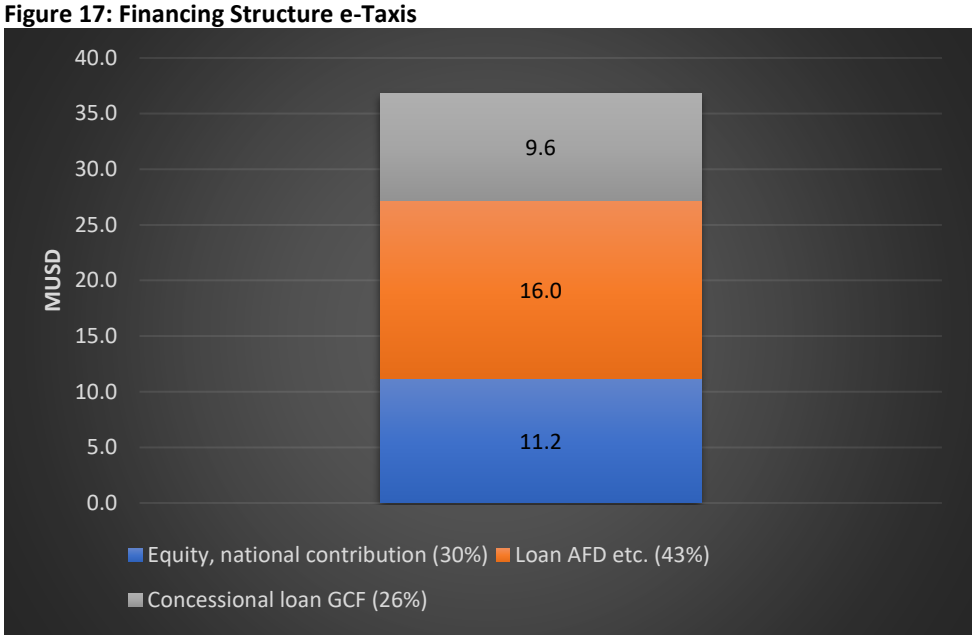
Concessional loans from the GCF are blended with AFD and co-finance and have a long tenure (12 years or longer for buses, 6 years for taxis). GCF loan conditions have been estimated at 0.75% annual interest rate.

Figure 16: Financing Structure e-Buses



Note: Numbers are indicative; total of 530 buses
Source: Grutter Consulting

Figure 17: Financing Structure e-Taxis



Note: Numbers are indicative based on an estimated e-taxi cost including home charger of USD 32,000 per unit and 1,150 taxis
Source: Grutter Consulting

The taxi fast charging network is financed 50% with a GCF grant and 50% with equity/other contributions. The size of this project is too small to warrant a loan.

4 projects for FA have been initially identified:

- 330 e-buses of 7-18m for 14 cities in Colombia to be realized in 2022
- 210 e-buses of 12-26m for bus-only lanes of Transmilenio in Bogota to be realized 2025
- 1,000 e-taxis including urban fast charging infrastructure for Bogota to be realized 2023
- Urban fast charging infrastructure for taxis for Medellin to be realized 2023

The following table summarizes the FA proposed for these projects

Table 12: FA Potential Projects Colombia

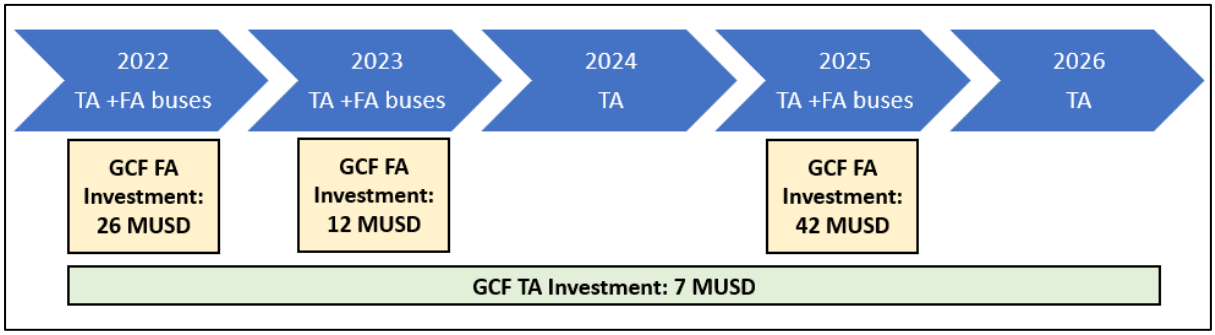
Parameter	e-buses	e-taxis	Total[26]
Total CAPEX	229 MUSD	45 MUSD[27]	274 MUSD
Total loan	160 MUSD	26 MUSD	186 MUSD
Co-finance loan	*114 MUSD*	*16 MUSD*	*130 MUSD*
GCF loan	*46 MUSD*	*10 MUSD*	*55 MUSD*
GCF grant	23 MUSD	4 MUSD[28]	27 MUSD
Equity and other co-finance	46 MUSD	16 MUSD	61 MUSD

The delivery channel or business models for buses are described in 6.1.2. This can result in a public or non-public lending. However, for GCF contributions the same financing structure is requested. The delivery channel for e-taxis is proposed to be through Findeter / public banks or private financial institutions with special loan facilities for EVs.

[26] Due to rounding values might not sum up
[27] Includes taxis as well as fast-charging infrastructure
[28] For charging infrastructure

The total GCF contribution for Colombia from the GCF is estimated at 90 MUSD of which 55 MUSD concessional loan, 27 MUSD grant for FA and 7 MUSD grant for TA of which 5 MUSD for project preparation and feasibility and 2 MUSD for general TA

Figure 18: Expected Implementation of Projects



Source: Grutter Consulting

7.2. Technical Assistance Instruments

The following technical assistance activities to be managed through GIZ are deemed important to create favourable market conditions for mass deployment of commercial EVs:

- Support in the structuring and knowledge of the actors involved in the operation contracts that allow the inclusion of third parties in public transport systems that adopt electromobility.
- Support for the acceleration of the development and implementation of SETPs that are interested in predominantly electric fleet operation, and when relevant structuring of (to the extent possible standardized) PPP framework schemes and e-buses public tenders, which pre-designed legal and technical documentation.
- Institutional training in the different sectors involved in electromobility for an adequate adoption of the technology.
- Colombia has not yet deployed electric buses on trunk routes. Different technological alternatives are available for such services and usage of overnight charged BEBs might be a sub-optimal solution. Technical assistance could be provided on optimal system design independent of interest of specific bus providers.
- Training on the appropriate operating conditions based on the durability of battery autonomy, recharging and maintenance services.
- Technical assistance for the appropriate deployment of electric vehicles in the cabs service, including the design of charging infrastructure, the generation of financial mechanisms and business models that facilitate access to e-vehicles.
- Technical assistance for the generation of guidelines for the correct deployment of recharging infrastructure, considering the particularities of the distribution network.
- Technical assistance for the generation of recharging infrastructure standards.
- Support in the structuring and implementation of pilot programmes focused on the second life of batteries used in electromobility[29].

[29] Colombian Institute of Technical Standards and Certification (ICONTEC) is developing standards for the regulation of electric vehicles as well as the second life and disposal of batteries used in electromobility (Charry Ruiz & Pinilla Rodríguez, 2021).

- Business models for adequate stakeholder participation in the energy chain and the establishment of the electricity supply market for electromobility.

TA for due diligence / feasibility assessment of the projects worth 5 MUSD is managed by the financing agent.

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 Colombia of the EV program.

Table 13: Program Impact

Parameter	Direct impact	Total impact
GHG reduction lifetime vehicles cumulative in tons	720,000	19,600,000
• *Buses*	*610,000*	*14,500,000*
• *Taxis*	*110,000*	*5,100,000*
$PM_{2.5}$ reduction lifetime vehicles cumulative in tons	22	555
• *Buses*	*22*	*525*
• *Taxis*	*1*	*30*
NO_x reduction lifetime vehicles cumulative in tons	2,600	63,000
• *Buses*	*2,600*	*61,000*
• *Taxis*	*40*	*1,700*
Energy savings cumulative lifetime vehicles in TJ	6,500	181,000
• *Buses*	*5,300*	*128,000*
• *Taxis*	*1,100*	*53,000*
Fossil fuel savings cumulative lifetime vehicles in Ml	360	6,900
• *Buses*	*200 million litre diesel*	*4,800 million litre diesel*
• *Taxis*	*45 million litre gasoline*	*2,100 million litre gasoline*
Economic savings cumulative in MUSD	42	1,100
• *Buses*	*37*	*890*
• *Taxis*	*5*	*220*

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

Table 14: GCF Financial Indicators

Parameter	Direct impact	Total Impact
Total CAPEX investment	274 MUSD	
GCF Loan	55 MUSD	
GCF Grant FA	27 MUSD	
GCF Grant TA	7 MUSD	
Total GCF	**90 MUSD**	
Co-finance ration	**68%**	
GCF investment cost per tCO_2 reduced	**125 USD/tCO_2**	**5 USD/tCO_2**
Total investment cost per tCO_2 reduced	**391 USD/tCO_2**	**14 USD/tCO_2**

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Annex 1: TA Project for Colombia

The proposed TA project includes only the components of policy advice, business development and general technical issues, not however the project due diligence and feasibility assessments including final technical design of projects.

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

Colombia has focused its efforts on generating a regulatory framework that promotes electromobility at the national level, in the Electric Mobility Law. It has also advanced efforts in the generation of the National Strategy for Electric Mobility that defines activities for state institutions such as energy efficiency and labelling, restriction of the movement of vehicles based on their polluting emissions, energy tariff scheme, penetration of electrical technologies, territorial planning, zero and low emission vehicle technologies committee.

The **activities in this Work package** are to *strengthen institutions, ministries and the legal framework in order to massively deploy e-buses, e-taxis and e-LCVs*.

Activities:

- To elaborate together with the Ministry of Environment and Sustainable Development (MinAmbiente), Ministry of Energy (MinEnergía), Colombian Institute of Technical Standards and Certification (ICONTEC) and other stakeholders the homologation standard for recharging infrastructure, considering the national context and the plans for technology transition at national level.
- To structure investment mechanisms for the acquisition of e-cabs including the analysis of the inclusion of third parties and leasing schemes. This component should include the legal structuring of such mechanisms and the distribution of responsibilities. In addition, it should consider vehicle renewal and scrappage programs.
- To elaborate together with the Ministry of Environment and Sustainable Development (MinAmbiente) the identification of stakeholders e.g. hazardous waste recyclers and a strategy to dispose batteries.
- Capacity building on proper battery management (second life and recycling) including an identification of best practices. For adoption by institutional entities, capacity building program for municipalities about the benefits of electric garbage trucks and cleaning trucks and further special vehicles.
- Capacity building for insurance companies, drivers, mechanical workshops and first response staff (firefighters, police, paramedics) allowing e.g. insurance companies to better assess the risk and costs of insuring an EV, eco drive for EVs, training of firefighters and vehicle maintenance personnel (mechanics and depot managers).
- To evaluate the technological alternatives in electromobility available in the international market and their applicability to Colombia, especially in countries such as China and India that have adopted new technologies in their trunk systems and can facilitate operating conditions.
- Capacity building in public transport system operators that want to adopt electric light-charge vehicles, in operational conditions such as proper driving, recharging and maintenance processes of units and infrastructure.
- Capacity building in public financial institutions for the generation of financing mechanisms to facilitate the adoption of electromobility

- Capacity building in public institutions focused on access to international funding sources with emphasis on green and environmental mechanisms. As well as in the distribution of resources at the local level to obtain competitive interest rates for the end user.
- Design a smart fast charging public network for e-taxis and policies to encourage off peak charging.
- Support to governance and coordination mechanisms on e-mobility
- Design of scrapping mechanisms

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

Activities:

- To generate dissemination focused on successful models implemented in cities such as Bogota, Medellin and Cali for small cities that are developing their transportation systems.
- To elaborate financial, economic and environmental feasibility studies for public transportation systems adopting electromobility.
- To structure together with the Ministry of Transportation (MinTransporte) appropriate concession contracts and concession conditions in medium and small cities conducive to e-bus deployment including concession length, tariff structuring, guarantees etc.
- Elaborate the design, structuring and provide support in the implementation of electric BRT for urban transport systems. This activity should prioritise systems that wish to adopt electromobility and do not currently have electric fleets.
- Elaborate the diagnosis of the energy distribution network for the adoption of electromobility. This activity should give preference to small and medium-sized cities that have difficulties in institutional capacity.
- Elaborate studies and capacity building activities for the design, planning, structuring and implementation of SETPs with emphasis on the adoption of electromobility

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

Annex 2: List of Interviewed Persons and Institutions

Organization	Full Name	Department	E-mail
UPME - Mining and Energy Planning Unit	Lina Escobar	Demand subdirection	lina.escobar@upme.gov.co
FDN - National Development Finance	Patricia Gomez Escobar	Financing direction	pgomez@fdn.com.co
Third Millenium Company TransMilenio S.A.	María Fernanda Ortiz Carrascal	Assistant General Manager	mariaf.ortiz@transmilenio.gov.co
EPM - Medellin Public Companies	Gian Paolo Montoya	Regulation Transactions Transmission and Distribution Energy	gian.montoya@epm.com.co
EPM - Medellin Public Companies	Marcela Grajales	Capital Management Direction	marcela.grajales@epm.com.co
ZEBRA - Zero Emission Bus Fabric Announcement	Thomas Maltese	Project Manager (Interim)	tmaltese@c40.org
Medellín Chamber of Commerce	Jaime Arenas	Energy Cluster	jaime.arenas@camaramedellin.com.co
Celsia	Mauricio Llanos	Regulatory affairs	mllanos@celsia.com
Metroplús - Medellin Subway	Pedro Buitrago	Buses	pbuitrago@metrodemedellin.gov.co
WWF - World Wide Fund for Nature	María Alejandra González	NAMA Move team	magonzalez@wwf.org.co
Taxatelite	Sandra Díaz	Taxatelite operation team	Mobile: 310 2984105
TCC	Juan Carlos Fajardo	Bogota Regional Manager	jcfajardo@tcc.com.co
Taxis Teleclub S.A.	Ernesto Sandoval	Teleclub Taxis Operation	Mobile: 321 4528302
Auteco Mobility	Alejandro Giraldo	Product Development	rrestrepo@autecomobility.com
EMCALI	Charlie Hurtado	Strategic energy business unit	cehurtado@emcali.com.co
Blanco y Negro – Fanalca	Eduardo Cando	Electrification direction	ercando@fanalca.com
Masivo de Occidente	Leonardo Campino	MDO Innovation	leonardo.campino@mdosas.com

Organization	Full Name	Department	E-mail
Sunwin	Ediltron Gomes	Sunwin LATAM	ediltron.gomes@sunwinbus.com
Taxis Libres	Rafael Sánchez	Operation Management	taxiimperial.operativa@gmail.com
Sumatoria	Juan Carlos Díaz Bohórquez	Associate	juancdiaz@sumatoria.com
Undersecretary of Mobility of Medellín	Luis Sánchez	Undersecretary of Mobility of Medellín	luisalbertosanchez91@gmail.com
Fanalca Group	Santiago Cucalón	Project Development	santiago.cucalon@connexionmovil.com.co
	Víctor Córdoba	General Manager Cable Móvil	victor.cordoba@cablemovil.com.co
Third Millenium Company TransMilenio S.A.	Álvaro José Rengifo Campo	Deputy Manager of Economy	alvaro.rengifo@transmilenio.gov.co
	Felipe Ramírez Buitrago	General Management	felipe.ramirez@transmilenio.gov.co
Ministry of Transportation	Juan Carlos Melo	Sustainable Urban Mobility Unit – UMUS	jmelo@mintransporte.gov.co
Bancoldex	Laura Lanz	Cooperation and International Relations	laura.lanz@bancoldex.com
Electribus	María Cristina Guerra		corporativo@electribus.co
DNP - National Planning Department	Jhonatan David Bernal González	Infrastructure and Sustainable Energy Directorate	jonbernal@dnp.gov.co
Secretariat of Mobility of Bogota	Julián Díaz	DIM Electric Mobility	adiaz@movilidadbogota.gov.co
	Lina Quiñones		lmquinones@movilidadbogota.gov.co
	Luis Castro		lcastro@movilidadbogota.gov.co
	Ángela Mendoza		amendoza@movilidadbogota.gov.co
Corona	Jorge Eleazar Giraldo Montoya		jgiraldom@corona.com.co
Ministry of Environment and Sustainable Development	Francisco Charry	Climate Change Directorate	jcharry@minambiente.gov.co
Ministry of Energy	Sandra Salamanca		szsalamanca@minenergia.gov.co

Organization	Full Name	Department	E-mail
Findeter	Juan Carlos Duque	Head of Integrated Urban Management	jcduque@findeter.gov.co

Annex 3: Details Financial Calculations

Colombia Bus Parameters 12m

Parameter	Value	Unit	Source
Distance driven per bus per annum	59,000	km	Transmilenio
Workday distance driven daily	198	km	calculated
Specific electicity usage	1.1	kWh/km	Chinese average; ADB, 2018; includes AC; includes charger efficeincy loss
Diesel usage	42	l/100km	Monitoring TransMilenio 12m buses padron all operators average
Maintenance cost diesel bus incl. labor excl. Tyres	0.13	USD/km	sumatorio for GIZ
Lifespan bus diesel	10	years	concession contract
Lifespan bus electric	15	years	concession contract
Lifespan battery @ 80% SOC	8	years	current guarantee levels
Interest rate BEB	7.4%		Bancoldex, 2015.Special credit line; spread needs to be added; see also Findeter
Loan duration BEB	12	years	80% concession period

Financial defaults

Parameter	Value	Unit	Source
CAPEX diesel bus	190,000	USD	Euro V, sumatorio
CAPEX overnight charged e-bus	274,000	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	240,000	USD	Based on standard fast-charged bus with 200 kWh set
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	198
Energy usage day	kWh	217
Risk ratio (higher energy consumption)		10%
Reserve ratio		20%
SOC loss year 8		20%
Battery size required year 8	**kWh**	**370**

Charging required at bus depot overnight

Parameter	Unit	Value
Battery capacity	kWh	370
Average daily consumption workday	kWh	217
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	57
Average share of day electricity		26%
Fast-charger	kW	300
Power conversion efficiency of chargers		90%
Average required re-charge day with 300 kW charger	minutes	13
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	8	years	
Commercial interest rate	9%		
in USD			
WACC			
Cost equity	11.2%		UNFCCC, CDM Methodological Tool Investment Analysis Version 10.0, 2019; value for transport sector
Share equity	20%		offers banks
Cost bank loan fossil	9.0%		operators
Cost bank loan EV	7.4%		Findeter
Share bank loan	80%		offers banks
Corporate tax rate	32%		Deloitte, 2020
WACC fossil	7.1%		
WACC BEB	6.3%		

Colombia Buses Financial Feasibility

12m standard bus, USD 2019

Parameter	Diesel	BEB overnight	BEB fast
CAPEX bus	190,000	274,000	240,000
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	190,000	320,000	289,613
Battery replacement yr 8	0	37,000	25,000
Energy cost yr 1	14,620	7,983	7,983
Maintenance cost bus yr 1	7,670	5,369	5,369
Maintenance cost infra yr 1	0	920	992
Finance cost average per year	4,118	9,348	8,188
Economic costs yr 1	4,937	992	992
TCO financial per km	0.76	0.78	0.72
TCO economic per km	0.86	0.80	0.74

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	2.25%
GCF rate	1.25%
AFD rate	4.00%
grant share	10%
Loan share	70%
AFD loan share	50%
GCF loan share	20%
Loan tenure in years	12
WACC and discount factor new BEB	3.3%

Impact concessional finance

	overnight charged	fast charged
TCO financial old	0.80	0.74
TCO financial new	0.65	0.61
Discounted Payback in years old	never	never
Discounted Payback in years new	15	10

Colombia Taxi Profitability

Parameter	Value	Unit	Source
Average battery size	60	kWh	Nissan Leaf 2020; idem BAIC
Battery lifespan	7	years	idem to vehicle lifespan
Vehicle lifespan	7	years	sanchez, 2021
Annual mileage	72,600	km	
Daily mileage	220	km	sanchez, 2021
Charging at home average	70%		Assumption; only re-charge if above-average mileage or night shifts
Charging fast-chargers	30%		
CAPEX gasoline taxis	14,000		Kia Motors Colombia, 2021; Auto Koreana, 2021; Chevrolet, 2021
CAPEX e-taxi	30,000		Nissan LEAF large battery or BAIC
Capex home charger 7.4kW	2,000	USD	Nissan LEAF large battery or BAIC
Gasoline consumption	7.7	l/100km	PNUD; https://www.minambiente.gov.co/images/cambioclimatico/pdf/estudios_de_costos_de_abatimiento/c
Electricity consumption	0.16	kWh/km	Nissan LEAF https://ev-database.org/car/1106/Nissan-Leaf
Charger lifespan	10	years	
Maintenance cost gasoline	0.039	USD/km	Alcaldía Mayor de Bogotá, 2016 excludes tyres
Maintenance cost total e-taxi	0.0156	USD/km	40% lower than gasoline
Loan tenure taxi	6	years	Bank conditions
Loan share taxi	80%		
Interest rate fossil	8.8%		Scotiabank Conozca las entidades bancarias que manejan las tasas de interés más bajas para crédito de vehículo (larepublica.co)
Interst rate e-taxi	7.5%		BBVA Colombia, 2021

gasoline versus e-taxi

Parameter	gasoline	e-taxi
CAPEX vehicle	14,000	30,000
CAPEX charger	0	2,000
Total CAPEX	14,000	32,000
Energy cost	3,239	2,248
Maintenance cost	2,831	1,133
Finance cost average per loan year	543	980
Economic costs yr 1	640	60
Lifespan in years	7	7
TCO financial per km	0.12	0.12
TCO economic per km	0.13	0.12

Impact of concessional finance		
New finance rate for e-taxis	4.38%	incl. spread for COFIDE
GCF rate	1.25%	
AFD rate	4.00%	
grant share	0%	
Loan share	80%	
AFD loan share	50%	
GCF loan share	30%	
Loan tenure in years	6	
WACC and discount factor new e-taxis	3.4%	
Subsidy e-taxi government in USD	2,000	

Impact concessional finance	
	e-taxi
TCO financial old	0.12
TCO financial new	0.11
FIRR minus WACC old	-5%
FIRR minus WACC new	2%
Discounted Payback in years old	never
Discounted Payback in years new	6

TCO Buses

12m standard bus, USD 2019

Parameter	Diesel	BEB overnight	BEB fast
CAPEX bus	190,000	274,000	240,000
CAPEX charging infrastructure	0	8,500	12,113
CAPEX grid connection	0	30,000	30,000
CAPEX depot upgrade	0	7,500	7,500
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