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E-Motion Country Intervention Strategy Mexico

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Authors	Jürg Grütter and Andres Chaves
Revision	Daniel Wunderlin
Contact	Rte. des Esserts 92, 1854 Leysin, Switzerland jgruetter@transport-ghg.com, www.transport-ghg.com

Abbreviations

AC	Air Conditioning
AECID	Spanish Agency for International Development Cooperation
AFD	French Development Agency
AMIA	Mexican Association of the Automotive Industry
ANPACT	National Association of Bus, Truck and Tractor Trailer Manufacturers
AssetCo	Special Purpose Company (SPV / SPE / SPC)
BANCOMEXT	National Bank for Foreign Trade
BANOBRAS	National Bank of Public Works and Services
BAU	Business As Usual
BDAN	North American Development Bank
BEB	Battery Electric Buses
BRT	Bus Rapid Transit
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CAF	Andean Development Corporation
CF	Cash Flow
CFE	Federal Electricity Commission
CFF	Cities Finance Facility
CONATRAM	National Commission of Mexican Transporters
CONUEE	National Commission for the Efficient Use of Energy
CRE	Energy Regulatory Commission
EIRR	Economic Internal Rate of Return
EV	Electric Vehicle
FA	Financial Assistance
FC	Fast Charge
FCC	Climate Change Fund
FIDE	Electricity Saving Trust Fund
FIFINTRA	Trust Fund For The Public Transport Financing Promotion Fund
FIRR	Financial Internal Rate of Return
FONADIN	National Infrastructure Fund
FOTEASE	Fund for Energy Transition and Sustainable Use of Energy
GCF	Green Climate Found
GHG	Greenhouse Gases
GIZ	German International Cooperation
HDV	Heavy Duty Vehicle
ICCT	International Council on Clean Transportation
IDB	Inter-American Development Bank
IEA	International Energy Agency
IMCO	Mexican Institute for Competitiveness
IMT	Mexican Institute of Transportation
INECC	National Institute of Ecology and Climate Change
KfW	State Development Bank of the Federal Republic of Germany
LCV	Light Commercial Vehicle
NAFIN	Nacional Financiera
NDA	National Designated Authority
NDC	Nationally Determined Contribution
OEM	Original Equipment Manufacturer
PM	Particulate Matter
PNUD	United Nations Development Programme

P4G	Partnering for Green Growth and the Global Goals 2030
PTO	Public Transport Operator
PPP	Public Private Partnerships
PRI	Principles for Responsible Investment
PROTRAM	Federal Support Program for Mass Transportation
SCT	Ministry of Communications and Transportation
SEDATU	Ministry of Agrarian, Territorial and Urban Development
SEMARNAT	Ministry of the Environment and Natural Resources
SEMOVI	Secretariat of Mobility of Mexico City
SENER	Ministry of Energy
SHCP	Ministry of Finance and Public Credit
SPV / SPE / SPC	Special Purpose Vehicle / Special Purpose Entity / Special Purpose Company.
STE	Mexico City Electric Transport Services
TA	Technical Assistance
TCO	Total Cost of Ownership
UNEP	United Nations Environment Programme
WACC	Weighted Average Capital Cost
WRI	World Resources Institute
WTW	well-to-wheel
ZEBRA	Zero Emission Bus Rapid-Deployment Accelerator

Contents

1. Introduction

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

2. Country Diagnostic[1]

2.1. General

Mexico has a land surface area of 5,144,295 km^2 (Secretaría de Medio Ambiente y Recursos Naturales, 2010). In 2020 its population was about 126,014,024 inhabitants (Instituto Nacional de Estadística y Geografía, 2021), and is expected to reach 141 million by 2030 (United Nations, Department of Economic and Social Affairs, Population Division, 2019).

According to the World Bank, the GDP per capita in constant 2010 prices for 2019 was US$ 10,268 (Grupo Banco Mundial, 2020) and the 2020 Population and Housing Census (Instituto Nacional de Estadística y Geografía, 2021) reported 12 cities with more than one million inhabitants.

The automotive industry has a 3% share of the national GDP generating 1.8% of the total employment in the country. Although no electric buses are currently produced in Mexico, within the framework of the Zero Emission Bus Rapid-deployment Accelerator (ZEBRA) program, BYD stated its intention to produce zero-emission buses in the region by 2022 (ZEBRA, 2020).

The Mexican Institute for Competitiveness (IMCO) generated in 2013 a study that evaluated in 34 Mexican cities the costs associated with health damages from air pollution such as premature deaths, hospitalizations and consultations and losses in productivity based on PM_{10} concentrations (see table below) (Mexican Institute for Competitiveness, 2013). On a national level the cost of air pollution was estimated at 323 MUSD in 2010.

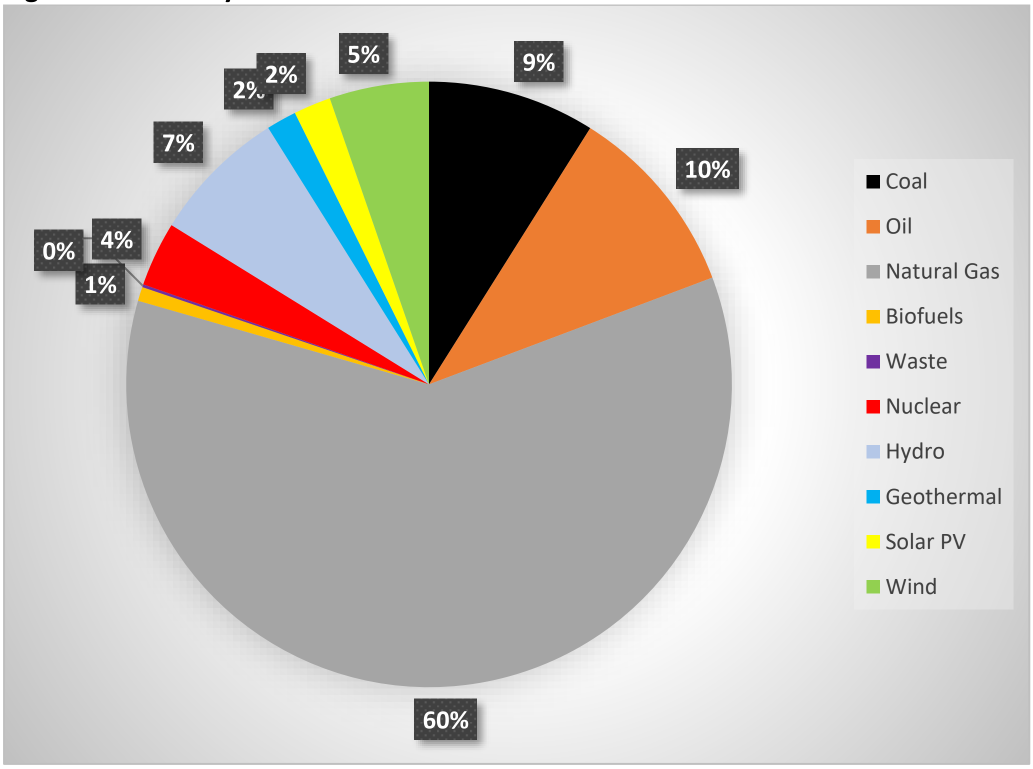
2.2. Climate and Energy Policies

The net Greenhouse Gas (GHG) emissions of Mexico are estimated at 734 $MtCO_{2e}$ in 2017 (Instituto Nacional de Ecología y Cambio Climático, 2020). The baseline scenario for 2030 projects GHG emissions of 991 $MtCO_{2e}$ of which 250 $MtCO_{2e}$ from the transport sector (Government of Mexico, 2020). The Government of Mexico committed in its NDC to reduce its emissions by 22% by 2030. For the transport sector the target is set at 18%, reaching 218 $MtCO_2e$ by 2030. The *Climate Change Strategy to 2050* published in 2016 established that within 10 years the use of electric vehicles (EV) in public transport shall be common and within 40 years in all types of transport (SEMARNAT-INECC, 2016).

In 2019 Mexico produced 17% of electricity based on renewables[2]. Natural gas is by far the largest source of electricity production, followed by oil and coal (see following figure).

[1] See Report Grutter Consulting, 2020, Country Diagnostic Mexico for further details
[2] Including nuclear energy, the share is 21%

Figure 1: Electricity Generation Mexico 2019



Source: IEA

The renewable energy target for 2025 is 35.5% and for 2030 37.7%. However, the actual renewable energy share for 2018 falls with 17% far short of the target for 2018 with 25% (SENER, 2018). Based on the projections of SENER 55% of the capacity addition until 2032 shall be renewable and the rest conventional technologies (SENER, 2018). This would result in a slight decrease of the carbon grid factor by 2030. The carbon factor of the electricity grid of Mexico in 2019 is 0.529 $kgCO_2/kWh$[3].

2.3. Transport Sector

In 2019 more than 50 million vehicles were operating in the country with a private vehicle ownership (cars plus motorcycles) of 349 vehicles per 1,000 inhabitants (Instituto Nacional de Estadística y Geografía, 2020).

Since 2004 the country has the vehicle emission standard Euro 3 or 4 depending on the vehicle type[4]. Euro 6 standards are under discussions and are compulsory for Heavy Duty Vehicles (HDVs) since 01/2021[5]. NOM-163-SEMARNAT-ENER-SCFI-2013 also established maximum CO_2 emission levels for passenger cars. Fuel sold has a maximum sulfur level of 15ppm (NOM-016-CRE-2016).

[3] GHG emissions / net production

[4] https://www.transportpolicy.net/standard/mexico-light-duty-emissions/#:~:text=The%20evaporative%20emissions%20standard%20is,any%20similar%20OBD%20systems%20allowed. And https://www.itf-oecd.org/sites/default/files/docs/impact-vehicle-emissions-air-quality-mexico_0.pdf

[5] https://theicct.org/sites/default/files/publications/Mexico-HDV-Emission-Standards_ICCT-Policy-Update_23022018_vF.pdf

Road transport GHG emissions of Mexico in 2019 are estimated at 141 million tCO_{2e}[6] based on a bottom-up transport model calibrated with top-down fuel consumption data. Taxis represent in 2019 around 5% of GHG emissions, buses 8% and LCVs 13%. Noteworthy is that the mentioned commercial vehicles represent 48% of $PM_{2.5}$ and 26% of NO_x emissions of the transport sector due to being primarily diesel vehicles whilst passenger cars and motorcycles used by private persons are predominantly gasoline powered. GHG emission from the transport sector are expected to grow under a BAU scenario by around 40% reaching 195 million tCO_{2e} by 2030 (see table below).

Table 1: Projected 2030 Transport Emissions

Vehicle category	NO_x	$PM_{2.5}$	CO_2 TTW	CO_2 WTW	Energy in TJ
Passenger car	43,850	1,125	113,442,433	135,509,304	1,634,815
Taxi	3,330	65	10,223,789	12,175,140	147,529
Motorcycles	13,967	252	4,475,688	5,382,764	64,584
small bus	1,518	12	2,722,089	3,253,111	39,145
standard urban bus	60,659	517	13,242,827	16,637,692	178,716
coach	13,721	107	2,389,140	3,011,181	32,242
LCV	31,077	1,426	19,352,125	24,451,930	271,264
Truck < 7.5t	59,714	386	11,717,614	14,673,185	158,132
Truck 7.5-16t	22,547	137	4,202,038	5,260,971	56,708
Truck 16-32t	25,604	160	4,473,137	5,609,806	60,366
Truck >32t	52,818	307	9,163,090	11,477,863	123,658
Total	328,807	4,495	195,403,970	237,442,946	2,767,160

Source: (Grutter Consulting, 2021)

The Ministry of Communications and Transportation (SCT) is in charge of planning the transportation sector. Its mission is to promote safe, efficient and competitive transportation and communication systems that respect the environment. This entity has conducted several studies with the aim of developing a public policy on electro-mobility as the *initial public policy document on electro-mobility* (Steer Davies Gleave, 2018). However, no such policy has been published to date.

The Ministry of Environment and Natural Resources (SEMARNAT) is responsible for controlling pollutant emissions, for this purpose it carries out the *National Inventory of Pollutants*, participates in the *Inter-Ministerial Commission on Climate Change (IACC)* by including aspects of adaptation and vulnerability to the adverse effects of climate change with the SCT, developed the *National Strategy for Electric Mobility*, as well as the project *Harmonization of Regulations on Mobility* that seeks to consider sustainable mobility within the planning of human settlements and the *Clean Transport Program* that seeks to achieve efficiency in cargo transport.

The organization of public transport depends on the territory where this activity is carried out; however, it can be grouped into two typologies (Carrillo, de los Santos Gómez, & Briones, 2020):

- High capacity or structured transport system, represents 12% of the public transport offer and is characterized by mass urban transport systems such as metro, trolleybus or Bus Rapid Transit (BRT) that operate with an established regulation, as well as a defined tariff, schedules and frequencies and in which, generally, there is a partial or total participation of the state.
- Medium and low capacity transport system: semi-structured or unstructured, represents 88% of the public transport offer and is characterized by concession schemes by routes or individuals to small carriers, granted by the State. These systems present difficulties in their control, operation and service quality.

[6] Tank-to-wheel approach; well-to-wheel approach including Black Carbon: 172 $MtCO_{2e}$

Due to the diversity of operation schemes, there are different business models implemented. In medium and low-capacity public transportation the systems are semi-structured and unstructured. An individual or a company of micro-entrepreneurs ("route-enterprise" or corridor) is in charge of purchasing, operating and maintaining the buses. A common practice in the individual model is to lease the vehicle to a driver, so that, in practice, ownership and maintenance are separate from operations (Carrillo, de los Santos Gómez, & Briones, 2020).

High-capacity transport systems are characterized by a defined structure and operate under three models (Carrillo, de los Santos Gómez, & Briones, 2020) (Dalberg, 2020):

- Concession to one or several private companies: through this model the government gives the concession to one or several private companies for a defined period and generally takes care of the provision of land and infrastructure for the vehicle depots. In addition, in these concessions the government is in charge of regulating operational aspects such as the bus, the fare collection system and the payment rate. Under this scheme Mexibús and Mexicable operate in Mexico City and RUTA in the city of Puebla. Generally, the financial risks are assumed by a local trust or other type of guarantee, and remuneration is paid per passenger.
- Public-private participation: in this scheme the local government hands over the operation of the transportation system to a private company by means of a public concession. In this scheme, the private party is in charge of the purchase, operation and maintenance of the vehicles and a third party is in charge of fare collection. The government entity concentrates the resources for the administration of the system and is responsible for its planning. Under this model, the BRT Metrobús, Acabús, Optibús, Transmetro, Metrobús and Metroenlace operate. In addition, the mitigation of financial risks is done through a trust. Operators are remunerated per kilometer.
- Public system through a decentralized public agency, in which the administration and operation of the system depends on a decentralized public company and the fare collection by a third party. Financial risk mitigation is assumed by the government budget and the remuneration system is per kilometer in BRT and per passenger in corridors or routes.

The operating concessions are issued by the local state authority in accordance with its current legislation. In general, the secretary of mobility or transport is in charge. This authority must issue a prior declaration of service demand in the geographic area where unsatisfied demand is detected, and after that, the call and specific conditions of operation. A route or area of operation may be granted. In some states the number of concessions to individuals or natural persons is limited to a maximum of three, as well as the maximum duration of the concessions.

In accordance with Article 97 of Mexico City's *Mobility Law*, units used for public passenger and cargo transportation services must be replaced every 10 years, with the exception of electric and sustainable technology vehicles, which will be governed by their reference manual.

Since 2002, Mexico City has implemented the *Taxi Replacement Program*, which seeks to encourage the renewal of the cab fleet through the issuance of bonds and financing at preferential rates that pursues to eliminate the main barrier for dealers, as they are not creditworthy, since a large part of the population is not bankable and does not have a credit history with commercial banks. This program has been carried out annually since 2012, achieving a total of 1,859 vehicles replaced by 2019. A subsidy of MXN $50,000 is offered for highly efficient vehicles (USD 2,500) or MXN $100,000 for hybrid or electric vehicles (USD 5,000) when purchasing a new unit and scrap the old unit. In addition, financing is facilitated by means of a support through financial entities of the Nacional Financiera (NAFIN).

2.4. EV Policies and Activities

Mexico published the *National Electric Mobility Strategy Vision 2030*[7], which sets a goal of having 10 urban areas with electric mobility in their public transportation by 2030, as well as a 5% share of total sales of new electric or hybrid vehicles by 2030, 50% by 2040 and 100% by 2050 (SEMARNAT, 2018).

In addition to the national instruments, the federal states incorporate within their programs strategies to incorporate electric mobility. As an example, the *Management Program to Improve Air Quality in the State of Mexico 2018-2030* proposes to prioritize the implementation of electric transportation and public systems over those that use fossil fuels, to provide the necessary infrastructure for electric vehicles, to implement an electric cab program, among others (Secretaria del Medio Ambiente, 2018). Mexico City in the *Government Program of Mexico City 2019-2024* proposes to promote innovation and technological improvement through comprehensive programs to promote electromobility (Gobierno de la Ciudad de México, 2019). The city also published the *Strategy for Electromobility of Mexico City 2018 - 2030,* in which it proposes to promote electric public transportation with incentives and support for both public and private operators, with the goal that 20% of the fleet will be electric in 2030 and 80% of the cabs will be hybrid or electric for the same year. In addition, Mexico City strives to achieve 1,500 public charging points in 2024 and to establish by 2030 an appropriate disposal scheme for electric batteries (C40 Cities Finance Facility (CFF) en colaboración con Carbon Trust México, 2018).

The National Government has promoted different incentives for the purchase and use of electric vehicles such as the one provided in Article 8 of the *Federal Law of the Tax on New Vehicles,* which grants tariff exemption to EVs (SEMARNAT, 2016).

Mexico City is moving forward with its Taxi Replacement Program, which seeks to promote the renewal of the cab fleet through the issuance of bonds and financing at preferential rates. The program gives priority to hybrid and electric cars, for which the value of the bond is double that of highly efficient vehicles (Secretaría de Movilidad, 2020).

The light urban vehicle sector in Mexico includes a wide variety of owners who provide services to other companies. Some manufacturing companies have their own delivery fleet. 99 Minutos of the postal company, which is dedicated to last mile transportation for electronic commerce and operates in Mexico City, Guadalajara, Monterrey, Merida and Queretaro included in its operations for Mexico City 14 electric vans in 2019 (Duarte, 2019). Another company that has included this technology in its operations is Bimbo, which has an electrification model in which vehicles are manufactured through its subsidiary company *Moldex*. The company has 400 EVs in operation and expects to introduce 4,000 more by 2024 (Grupo BIMBO, 2020).

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

[7] The final version of this strategy is not published, these goals were released as a preliminary. The document is currently under legal review and is expected to be published soon.

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

Enabling factors	• Experience in the automotive industry: Mexico has different production plants, which allows it to have the infrastructure to develop a local production that strengthens the reliability in the acquisition of this new technology. At the same time local manufacturing sites are often a barrier for new technologies as they are not eager to change their production methods and fear new entrants. • Existence of structured transport systems: the schemes that have been developed in different states for the provision of mass transport services have evolved and allow for a distribution of responsibilities and greater institutional capacity in regulation, which is conducive to the transition to electrical technologies. • Interest of EV manufacturers in the national market: different manufacturers have launched electric vehicles and have supported the installation of charging infrastructure. • Tax benefits: import benefits, purchase tax, property tax, among others are factors that together favours the adoption of electromobility and help mitigate the impact of differential costs between technologies. • Duration of public transportation concessions: the concession length in many states is adequate (10 years on average with the possibility of renewal). This allows the structuring of contracts with more favourable conditions for operators and facilitates the return on investment. • Availability of natural resources: Mexico has deposits of lithium, silver, manganese, copper, graphite, silicon, iron, among other minerals used in the production chain of electric vehicles domestically, as well as for export to countries such as the United States.
Barriers	• Prevalence of unstructured and semi-structured systems: public transportation in Mexico is predominantly individually owned units in both buses and taxis. This makes the process of fleet renewal difficult, since they are not subject to credit and therefore do not have the financial conditions to acquire electric vehicles. • Cost-benefit evaluation conditions: the federal government has developed guidelines for carrying out cost-benefit analyses that do not consider the social and environmental benefits of electric buses, which is why the initial cost of the vehicles takes on a significant weight compared to other technologies. • Absence of subsidies to the transportation system: especially in individual systems such as taxis and minibuses ("route-enterprise" operation schemes), there is no intervention from the government to guarantee the financial stability of the operation, so vehicle owners do not have the capacity to borrow for fleet renewal. • Lack of national policies and commitment to electric mobility: The country has not (yet) issued meaningful EV targets and continues to favour gas powered vehicles. • Structure of access to public debt: Mexico's legal framework establishes that federal entities cannot directly or indirectly contract obligations or loans with foreign entities. Sometimes, the resources that are finally allocated to the federal entities offer higher interest rates than those offered by local banks.

3. Actor Mapping

Ministry of Communications and Transport (SCT)

The Ministry of Communications and Transport is responsible for promoting transport systems, strengthening the legal framework, defining public policies and designing strategies for port development, air, rail, road and motor transport.

Climate Change Fund (FCC)

The FCC captures and channels public, private, national and international financial resources to support the implementation of actions to address climate change.

National Infrastructure Fund (FONADIN)

FONADIN is in charge of coordinating the federal public administration for infrastructure investment. This fund created the Federal Support Program for Mass Transportation (PROTRAM) to support the financing of investment projects in urban mass transportation, as well as to promote the institutional strengthening of planning, regulation and administration of urban public transportation systems. This program offers financing to local and state governments to cover up to 50% of infrastructure investment in public transportation projects. The support is provided to federal, state or municipal public entities, as well as concessionaires for studies, recoverable contributions (*mezzanine,* guarantees, capital) and non-recoverable contributions (studies, investments in public works and subsidies) and financing in mass transportation equipment, workshops, warehouses, among others (Fondo Nacional de Infraestructura, 2018).

Fund for Energy Transition and Sustainable Use of Energy (FOTEASE)

The objective of FOTEASE is to implement actions to contribute to the fulfilment of the National Strategy for Energy Transition and Sustainable Use of Energy.

Ministry of the Environment and Natural Resources (SEMARNAT)

The mission of the Ministry of the Environment and Natural Resources is to ensure the protection, conservation and use of the country's natural resources through a comprehensive and inclusive environmental policy. This secretariat is responsible for controlling pollutant emissions. It developed the National Strategy for Electric Mobility (Secretaría de Medio Ambiente y Recursos Naturales, 2019).

Ministry of Finance and Public Credit (SHCP)

This secretariat is in charge of proposing, directing and controlling the Federal Government's policy in financial matters and participates in infrastructure and public transportation in investment schemes (Secretaría de Hacienda y Crédito Público, 2020).

Ministry of Agrarian, Territorial and Urban Development (SEDATU)

This ministry promotes the sustainable and inclusive development of the country through the design, coordination and implementation of land-use planning, agrarian development, urban development and adequate housing policies (Secretaría de Desarrollo Agrario Territorial y Urbano, 2021).

Ministry of Energy (SENER)

The Secretariat of Energy is in charge of leading the country's energy policy, guaranteeing a competitive, sufficient, high quality, economically viable and environmentally sustainable energy supply (Secretaría de Energía, 2020). The National Commission for the Efficient Use of Energy (CONUEE) is linked to this secretariat under the objective of promoting energy efficiency and be the technical body for sustainable energy use, together with SEMARNAT and SCT design standards to achieve energy efficiency in the transport sector (Comisión Nacional para el Uso Eficiente de la Energía, 2020). The Secretariat has recently included electromobility in its agenda, and is expected to have an influence on issues such as energy system planning in the face of energy demand, charging infrastructure, among others.

Federal Electricity Commission (CFE)

The Federal Electricity Commission is a non-profit public company of a social nature, which provides the public electricity service. It is responsible for the transmission and distribution of electricity (Comisión Federal de Electricidad, 2021).

Energy Regulatory Commission (CRE)

The Energy Regulatory Commission participates in the definition of electricity tariffs, seeking a harmonious balance between users and permit holders, and contributing to the development of a competitive energy market (Comisión Reguladora de Energía).

Electricity Saving Trust Fund (FIDE)

FIDE is a private non-profit organization, created in 1990 to promote actions that induce and encourage the rational use of electricity. It provides technical and financial support to private or public companies interested in the efficient use of electricity.

National Institute of Ecology and Climate Change (INECC)

The INECC is a public organization linked to SEMARNAT, in charge of generating and integrating technical and scientific knowledge to support the structuring of public policies related to the environment. Under this objective, the INECC conducts research on the maximum permissible levels for emissions from mobile sources, and contributes to the mechanisms to achieve energy efficiency and reduce the impact of the transport sector on the environment (Insitituto Nacional de Ecología y Cambio Climático, 2020).

Mexican Institute of Transportation (IMT)

The IMT is a decentralized body of the SCT responsible for providing technical assistance to the transport sector. Among its duties is the promotion of new technologies such as electricity (Secretaría de Comunicaciones y Transportes, 2006).

National Bank of Public Works and Services (BANOBRAS)

This bank is the leading institution in federal development banking (Banco Nacional de Obras y Servicios Públicos, 2020).

Nacional Financiera (NAFIN)

Nacional Financiera contributes to the country's economic development by facilitating access to financing for MSMEs, entrepreneurs, and priority investment projects. It also acts as a trust entity for the Federal Government. It currently has a line of financing for micro and small transportation companies with the objective of supporting the renewal of the vehicle fleet for operators with 1 to 30 vehicles (Nacional Financiera, 2020).

National Bank for Foreign Trade (BANCOMEXT)

Bancomext aims to contribute to the development and generation of employment in Mexico by financing Mexican foreign trade. It operates by granting loans and guarantees, directly or through commercial banks and non-bank financial intermediaries, to Mexican companies to increase their productivity and competitiveness (BANCOMEXT, 2021).

North American Development Bank (BDAN)

BDAN is a bilateral financial institution established and capitalized by the Governments of the United States and Mexico to provide financing to public and private entities to support the development and implementation of environmental infrastructure projects. They provide assistance for projects and actions that contribute to preserve, protect or improve the environment in the border region (Banca de Desarrollo de América del Norte, 2021).

Mifel Banking

It is a private bank that provides financing for investment projects, with an emphasis on transport projects and a 70% market share in these projects in the country (Banca Mifel, 2021).

State and Municipal Governments

It is the responsibility of local authorities, especially states, to manage mobility in their territories (Asociación Mexicana de Autoridades de Movilidad, 2020).

Trust Fund for The Public Transport Financing Promotion Fund (FIFINTRA)

This trust fund was generated in the framework of a financial support programme to replace minibuses with new buses in 1999 in Mexico City. This fund operates in conjunction with NAFIN and receives financial resources from Mexico City's annual budget, budget extensions, interest generated and the payment collected from the scrapping of old units (Gobierno de la Ciudad de México, 2019).

National Commission of Mexican Transporters (CONATRAM)

It is an association composed mostly of individuals (man-truck), micro, small and medium enterprises engaged in freight and passenger transport. Its mission is to provide its members the dialogue with government agencies to improve competitiveness in the sector (CONATRAM, 2020).

National Association of Bus, Truck and Tractor Trailer Manufacturers (ANPACT)

This association is composed of the main manufacturers of heavy vehicles in Mexico such as Scania, Mercedes-Benz Autobuses, Hino Motors, Volvo, among others. Its objective is to represent, harmonize, promote and execute strategies for the development of this sector (ANPACT, 2020).

Mexican Association of the Automotive Industry (AMIA)

The AMIA represents manufacturers of light vehicles in Mexico, mostly gasoline. They are an actor that participates in consultations for the development of public policies and regulations (SCT, SEMARNAT, GIZ, 2015).

Cities Finance Facility CFF

The C40 Cities Finance Facility is supporting the cities of Mexico City, Guadalajara, Monterrey and Hermosillo by developing the feasibility studies for a new bus corridor project called *Eje 8*, a feeder route of *Mi Macro Periférico*, three feeders of the new line 3 of Monterrey's subway system and the BRT line along *Bulevar Solidaridad*, respectively. All these projects are focused on electric buses. The CFF aims to deliver a replicable model of how to finance clean buses in developing countries and emerging economies (C40 Cities Finance Facility, 2021).

C40 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. BYD, Foton, Yutong and Sunwin committed to commercialize a zero-emission bus model in Mexico City within 12 months and to guarantee the commercial availability of a model throughout the country within a maximum of 18 months. This initiative provides technical assistance in the generation of business models that facilitate electromobility (Posada, Delgado, Xie, & Maltese, 2020).

Carbon Trust

The Carbon Trust has developed studies for the implementation of electromobility in Mexico such as the *Mexico City: Carbon Trust Initiative to Form a Public Policy and Promote Electric Transportation*, a public policy guidance document, with the aim of developing a sectoral program, finding areas of opportunity and designing schemes to meet climate change objectives (WRI Mexico, 2018).

German Cooperation Agency GIZ

GIZ is in charge of implementing the C40 Cities Finance Facility program in Mexico. Also, GIZ worked with CEPAL in the generation of the document *Towards public electromobility in Mexico*, within the framework of the *CEPAL-BMZ/GIZ Cooperation Program* and the project *Sustainable Development Pathways for Middle Income Countries in the framework of the 2030 Agenda for Sustainable Development in Latin America and the Caribbean*. This publication presents proposals for the implementation of electromobility, including suggestions focused on an industrial policy for electromobility, the evaluation of Mexico's current automotive industrial policy and the identification of strategies to promote the development of the national industry of electric public transportation vehicles, especially electric buses (CEPAL, 2020).

State Development Bank of the Federal Republic of Germany KfW

KfW is developing a vehicle renewal program with the support of National Financial (NAFIN). This program grants a scrapping bonus and favorable financial conditions, especially for the "man-truck". It has a counterpart of resources from the participating states and its target are buses, cabs and LCVs.

World Resources Institute WRI

WRI has provided technical assistance to the Secretariat of Environment and Natural Resources (SEMARNAT) in the development of the *National Electric Mobility Strategy* (WRI Mexico, 2019). WRI has also worked in cities evaluating alternatives for the implementation of low-carbon fleets and the comparison of technologies as in the *Monterrey project: Analysis for the introduction of low-carbon vehicles in the Transmetro system* (WRI México, 2018).

Inter-American Development Bank (IDB)

IDB has worked in technical cooperation in the public transportation sector in Mexico. Under the project *Knowledge Exchange in the Implementation of Dual Concessions for Public Transportation*, an exchange was granted for the knowledge of the operation segmentation models used in Santiago de Chile and Bogota (IDB, 2019). In addition, the *Program to Support the Expansion of Public Transportation in Mexico City* included among its objectives the analysis of electric buses in the design of a system to renew the fleet of concessioned buses in this city; this program is in the implementation phase (IDB, 2020).

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. They are responsible for implementing the *GCF Readiness: Advancing a regional approach to e-mobility in Latin America*[8] programme in 14 countries including Mexico. This programme has as outcomes: (i) regional capacity to assess e-mobility technology are strengthened in the context of broader climate change mitigation strategies, (ii) enabling policy and business models to scaleup e-mobility adoption are identified and improved, (iii) climate finance strategies and regional pipeline strengthened. This programme started in December 2019 and has a duration of 30 months.

World Bank Group

The World Bank has issued a request for a consultancy in the framework of the Clean Vehicle Finance Program (CVFP) - Mexico on 29 June 2021. Through this project, it is expected to: (i) identify the gaps and challenges of the EV market from the financial sector perspective, (ii) develop a business case for EV adoption and financing and (iii) explore potential investment structures and partnerships to enhance financing the EV market with key stakeholders, under the Clean Vehicle Finance Program (CVFP).

4. EV Deployment Scenarios

3 different EV scenarios have been constructed which are contrasted with the scenario of no electric vehicles:

- 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 “high growth” 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 EV30@30 scenario has been chosen.

No Mexican scenario was realized as the 5% target rate of EVs in 2030 published in the *National Electric Mobility Strategy Vision 2030* includes also hybrid vehicles and not only EVs. Mexico also has the goal of having 10 urban areas with electric mobility in their public transportation by 2030 but the share is unknown (SEMARNAT, 2018). Overall, it is clear that the Mexican target for EVs falls far short even of the moderate IEA scenario.

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.

[8] For more detailed information, see GCF website: https://www.greenclimate.fund/document/advancing-regional-approach-e-mobility-latin-america

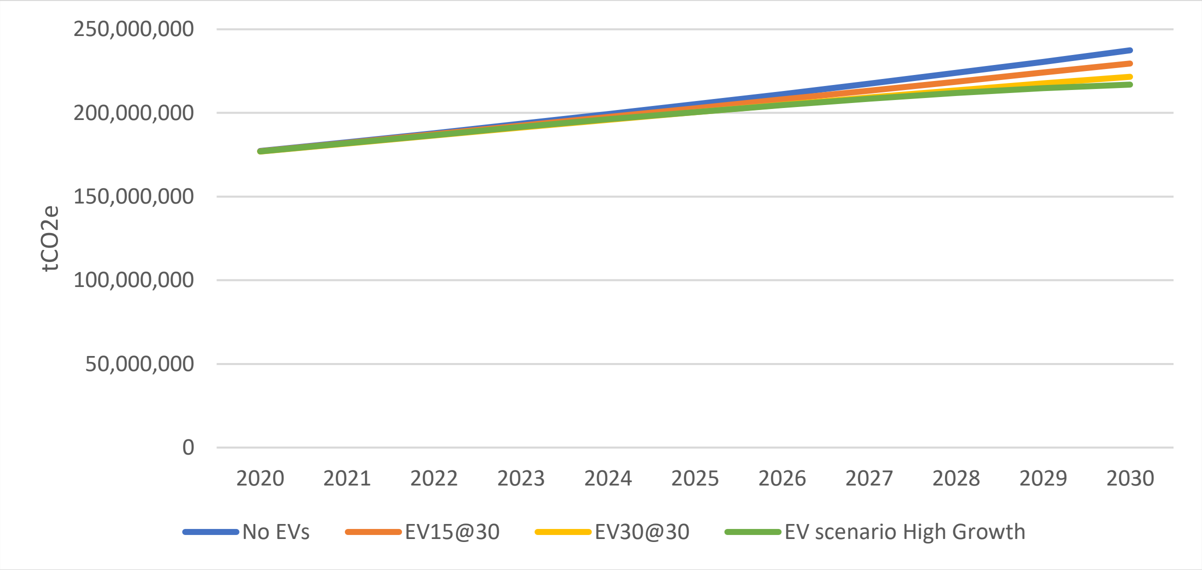
Table 3: Scenario Results

Impact	Scenario	By 2025	By 2030
GHG reduction WTW in tCO_{2e} per annum	IEA 15@30	2,370,000	7,900,000
	IEA30@30	4,730,000	15,800,000
	"High growth" scenario	4,600,000	20,500,000
Electricity demand of EVs in GWh per annum	IEA 15@30	3,700	12,000
	IEA30@30	7,400	25,000
	"High growth" scenario	7,900	33,000

Source: (Grutter Consulting, 2021)

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

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



Source: Grutter Consulting

The 2030 projected electricity demand of EVs represents 7% of same year electricity generation for the EV scenario with the highest growth scenario. The electricity demand increase resulting from EVs is very gradual and thus leaves enough time to the country to plan a potential production expansion.

The Mexican grid system has a peak late afternoon (5PM) and again around 8PM. Maximum demand in summer months from May to August is significantly higher than in the rest of the year due to cooling. 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.

5. Market Analysis[9]

5.1. Current EV Market and Finance Conditions

Electric transport has been operating in Mexico since the 1950s using trolleybuses. Recently, cities like Mexico City, Guadalajara and Monterrey have introduced electric transportation through subway lines, light rail, cable cars and electric cabs.

200-300 EVs are sold per annum in Mexico. The figure is not increasing since 2016 (Instituto Mexicano del Transporte, 2020).

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 9.1%[10];
- 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 Mexico an overnight charged bus would require a battery set of 430 kWh whilst a fast-charged unit could be equipped with a 240 kWh battery set and 300 kW chargers (on average 1 per 8 buses)[11].

[9] See also for further details Grutter Consulting, 2021, Assessment of Commercial EV Demand in Mexico
[10] see (Grutter Consulting, 2021a) for details of calculations
[11] For details see report 2

Table 4: Summary Financial Assessment 12m BEBs Mexico

Criteria	Result	Assessment
TCO	0.94 – 1.05 USD/km for BEBs versus 0.98 USD/km for diesel Euro IV bus[12]	Non-discounted the cumulated lifetime costs for BEBs are comparable to diesel buses.
Capital investment	300-330,000 USD for BEB[13]; versus 150,000 for diesel bus	Significantly higher capital requirement incl. higher loan demand; negative impact on debt to equity ratio
Equity investment	100,000 for BEB[14] versus 30,000 for diesel bus	Significantly higher equity demand which might overstretch the capabilities of small and medium enterprises
Profitability[15]	FIRR of -1 to 9%	Investment in e-buses is in general not profitable (below the WACC of 9.1%).
Discounted Payback	Incremental investment is not recovered with savings during asset lifetime (9yrs)	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	The investment in BEBs will affect the liquidity position of the companies in a negative manner and will affect negatively the solvency 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, especially fast-charged units, are potentially an interesting alternative. However, BEBs will require a different financial structuring and financial incentives to be a viable business proposal in Mexico.

5.2.3. Electric Taxis

The following table summarizes the financial assessment of e-taxis. The comparison is based on a gasoline taxi versus Nissan Leaf or BAIC e-taxi with a 60kWh battery set.

Table 5: Summary Financial Assessment E-Taxis Mexico

Criteria	Result	Assessment
TCO[16]	0.15 USD/km for e-taxis versus 0.15 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 16,000 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[17]	FIRR of 11%	Investment in e-taxis is profitable (above the WACC of 9.1%).
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.

[12] 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.
[13] Includes bus, charging infrastructure, grid connection, bus depot upgrades
[14] Banks only finance 80% of BEB but not of charging infrastructure, grid connection and depot upgrades due to not being collateral
[15] FIRR of incremental investment compared to diesel bus
[16] Includes CAPEX, energy, maintenance and finance costs; does not include other costs such as the driver which are independent of the technology chosen
[17] FIRR of incremental investment compared to gasoline taxi

Cash Flow	Negative cumulative CF entire period	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

Source: (Grutter Consulting, 2021a); see Annex 3 for details including assumptions

The investment in e-taxis with current financial conditions and business models is marginally 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 Mexico 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. Including the potential loss of profits the FIRR drops to -20% for e-taxis as of 2020 and with reduced e-taxi prices projected e-taxis would only turn profitable in 2025. 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 3.7t diesel version as used commonly e.g. by postal service companies versus a JAC EX350, with a battery set of 92 kWh which is sufficient due to relatively low daily mileage of LCVs.

Table 6: Summary Financial Assessment e-LCVs Mexico

Criteria	Result	Assessment
TCO[18]	0.37 USD/km for e-LCVs versus 0.34 USD/km for fossil unit	Non-discounted the cumulated lifetime costs for e-LCVs is slightly higher than of a diesel unit
Capital investment	76,000 USD for e-LCV versus 28,000 USD for fossil unit	Significantly higher capital requirement incl. higher loan demand
Equity investment	17,000 USD for e-LCV versus 6,000 USD for fossil unit	3x higher equity demand
Profitability[19]	FIRR of 2%	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.
Cash Flow	Cumulative negative CF until year 15	The investment in e-LCVs results in a cumulative negative liquidity impact until near to end of asset lifetime

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

[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 LCV

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
AFD loan conditions non-sovereign public sector	3.5%	AFD
Assumed shares	30% GCF and 70% 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	3.1%	Calculated based on above data
Resultant minimum loan rate for LCVs and taxis based on lending through public banks	5.1%	
Lending rates for buses, LCVs and taxis	80% maximum	
Loan tenure	9 years buses; 6 years taxis 7 years LCVs	

5.3.2. E-Buses

Concessional finance would result in an interest rate of 3.1% instead of 12.5%. 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.

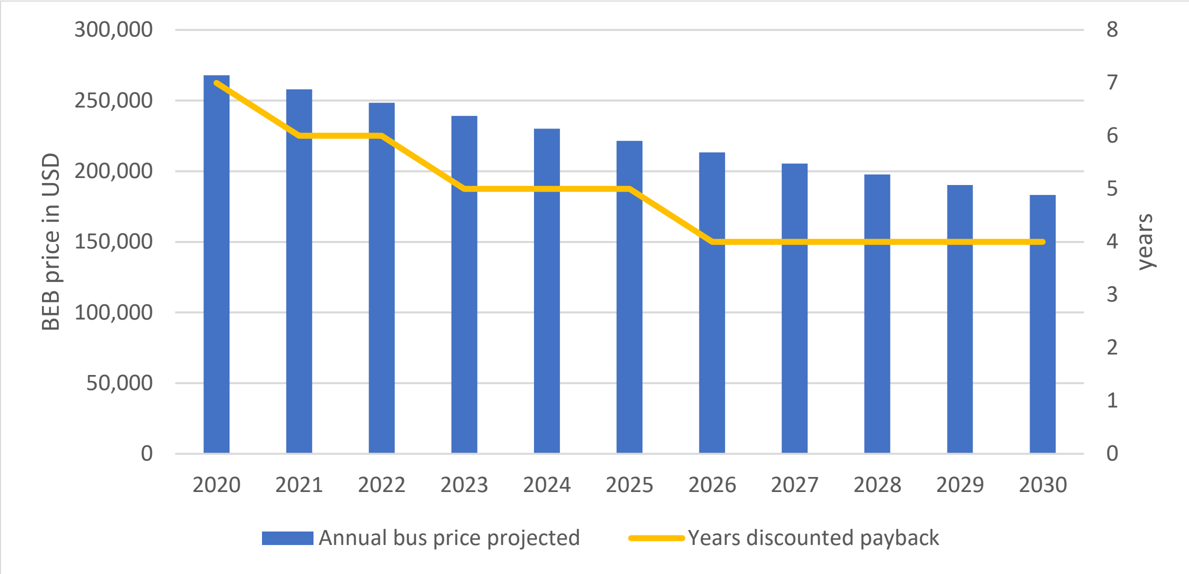
An upfront grant of 10% on the total initial investment (including vehicle, chargers, grid connections and bus depot upgrades) combined with concessional finance is modelled. The concessional finance is re-structured to 20% equity, 10% grant, 70% loan with GCF 20% of the concessional loan at 1.25% and AFD and/or other co-financiers 50% of the concessional loan @ 3.5% with a tenure of 9 years. This results in a loan interest rate of 2% and a new WACC of 3.0%. Following impacts can be observed:

1. The TCO reduces considerably with values between 0.81 and 0.90 USD (fast versus overnight charged buses) and now clearly lower than for diesel buses with a TCO of 0.98 USD/km:
2. The differential FIRR increases significantly and is now between 4% (overnight charged BEBs) and 17% (fast-charged BEBs) and above the WACC of 3% for all types of BEBs indicating a profitable investment.
3. Owners capital requirements are reduced significantly.
4. The risk and the capital exposure of the entrepreneur is reduced greatly. The discounted payback for the incremental investment is 5-7 years which is considered to be a reasonable time-frame and shorter than the commercial usage time of buses (9 years) and 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 3: 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[20]

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. To be able to operate in double-shift or for longer periods e-taxis require high powered charger (100kW or more) to enable a re-charge of additional 100km range within 15 minutes or less. Such charging infrastructure must be located at strategic points with high taxi affluence e.g. in the waiting areas of inter-urban bus stations, at train stations, airports, large commercial centres etc. Access to such fast-chargers would be privileged or prioritized for taxis. The establishment of such a charging infrastructure faces the typical chicken-egg dilemma and is, at least initially, non-profitable. 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 12.5% for e-taxis to 5.1%. The concessional loan improves the liquidity and is sufficient to make the investment financially attractive.

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.

[20] 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.

Figure 4: 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); constant real USD without real price changes of any parameters except e-taxi price.

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 however only drop from currently 12% to 5.1%. The impact of the concessional loan is very limited. A 20% upfront grant has the following impacts:

1. The TCO is now significantly lower than for gasoline units;
2. The FIRR is higher and above the WACC including concessional finance i.e. the investment is now profitable;
3. Owners capital requirements are lower than with a gasoline unit;
4. The risk and the capital exposure of the entrepreneur is reduced significantly with a dynamic payback time (discounted with the new WACC) at 10 years which is however still long.

It can be concluded that the grant resolves the major commercial investment problems.

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.

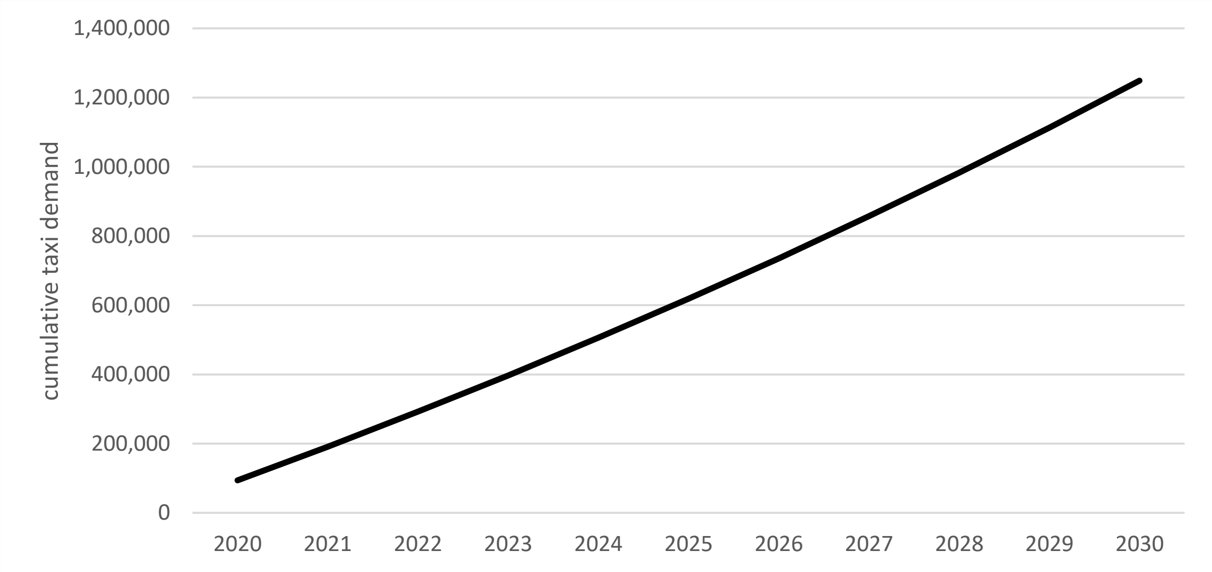
5.4.2. E-Buses

5.4.3. E-Taxis

Market Demand for Taxis

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

Figure 9: Total Projected Cumulative Market Demand Taxis



Source: (Grutter Consulting, 2021)

Projected BAU Demand for E-Taxis

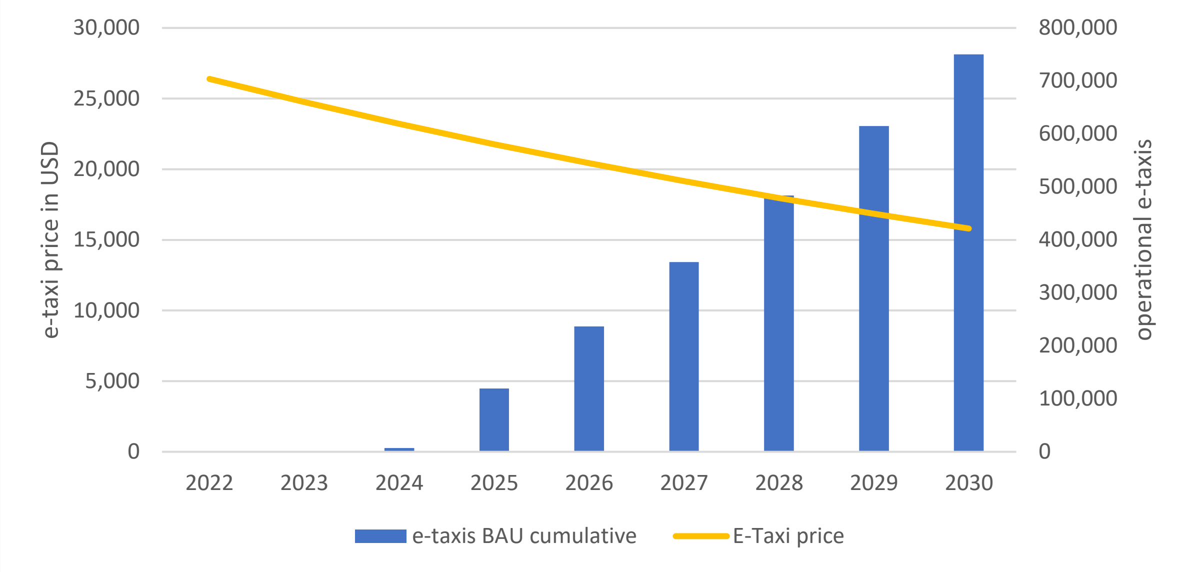
Idem to the e-bus approach, the e-taxi demand is based on comparing the FIRR with the WACC adjusted for a risk rate based on being a new technology using the following criteria:

- 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 around 20%.
- 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[21].

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 Mexico.

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

Figure 10: BAU Projected E-Taxi Uptake in Mexico and Price Trend of E-Taxis



Source: Grutter Consulting

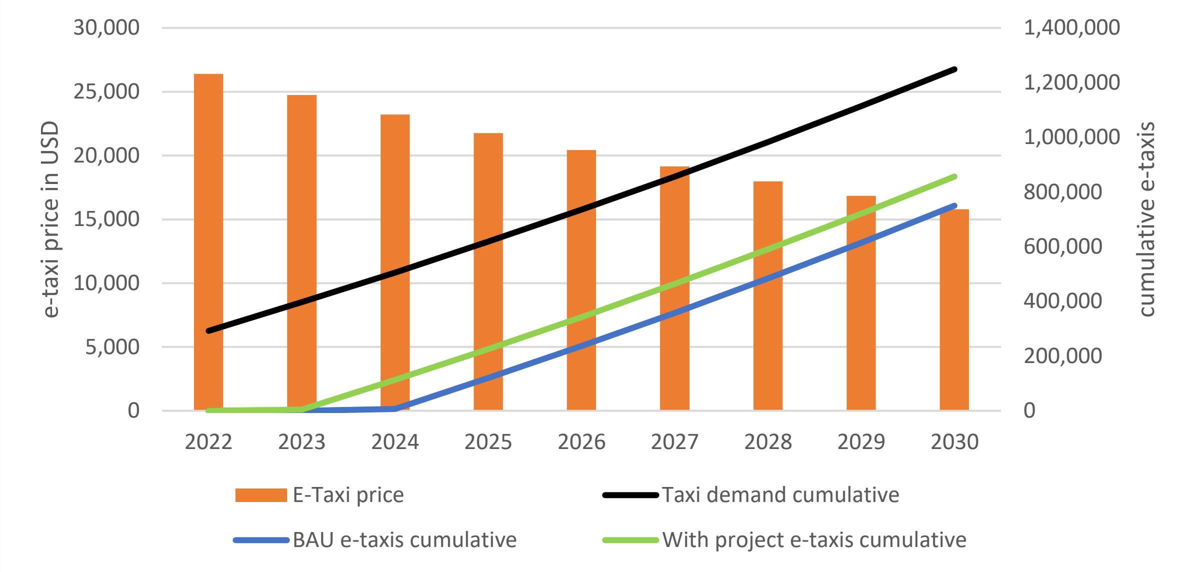
Under a BAU scenario electric taxis start to get commercially viable around 2025 and then increase rapidly.

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 11: BAU and with-Project Projected E-Taxi Uptake in Mexico 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 860,000 instead of 750,000 units with an e-taxi market share of 79% instead of 69%. 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 5.5 million tons of CO_2 reduced;
- Additional 46 tons of $PM_{2.5}$ avoided;
- Additional 2,340 tons of NO_x avoided;
- Additional economic savings of 660 MUSD.

5.4.4. E-LCVs

Due to the limited interest and the grant requirement for LCVs this area is not included in the investment projects for Mexico 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 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 Mexico

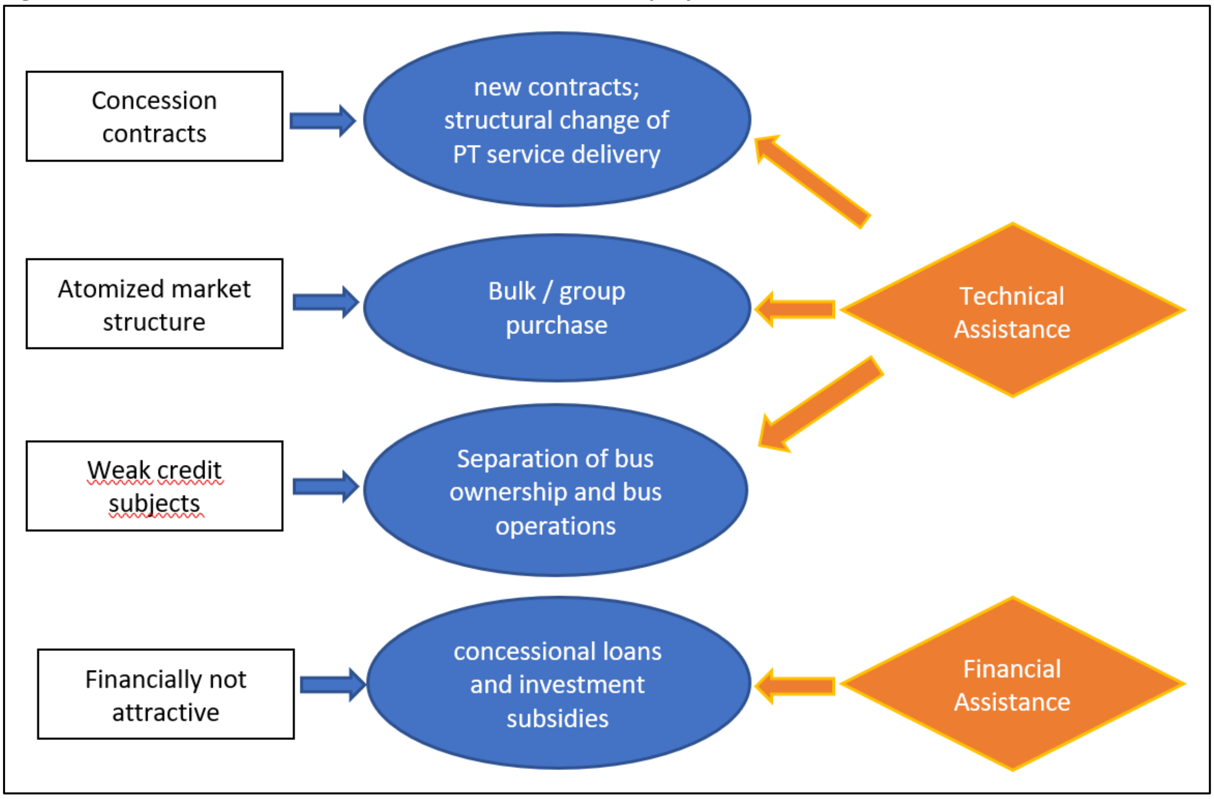
Barrier Type	Concrete Aspects
Concession contracts	The variability in concession contracts in the different states makes the financing processes difficult. Concession contracts also do not offer to creditors guarantees that assets are kept and operated by another transport operator in case of default or loss of concession. With the exception of structured mass transportation systems, payments are fixed per route and go directly to the operator i.e. the creditor has no guaranteed direct payment from the fare box.

Atomized market structure of bus operators	Many small and some medium-sized operators exist in Mexico.
Financially weak operators	Operators have a fragile balance sheet. To access loans they need to provide real guarantees beyond vehicles. As they only take relatively small loans and are considered a high risk, the resultant interest rate is high and loaning levels are low.
Financial barriers	BEBs are not profitable. The FIRR is below the WACC and the repayment period for the incremental investment in electric buses is more than 9 years. The investor needs to invest up to 2.5x the owners capital required for fossil buses, increases significantly his debt levels and suffers from a negative cash flow with the current market offer for e-buses prevalent in Mexico. To reduce operational costs operators also do not insure vehicles against collision damage and full loss. This again makes it impossible to accept vehicles as loan guarantee to banks.

Source: Grutter Consulting

E-buses have major environmental and societal advantages expressed in large positive environmental and health impacts. However, reasons such as 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. The following figure shows intervention instruments which can overcome these barriers.

Figure 12: Intervention Instruments to Overcome E-Bus Deployment Barriers



Source: Grutter Consulting

Concession contracts can be updated and changed to incorporate longer periods (e.g. 15 years extendable by 9 years) and with asset turn-over in case of default or concession loss. In the medium term a structural change to the system how public transport is delivered will be required to increase system efficiency and convenience for the customer at it has been developing in some cities. This will imply a change of ownership structure and potentially of service delivery structures. However, at first instance the major barrier is to increase the length of concession contracts as a standard for all states.

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 dependant 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;
- Purchase of buses through a 3rd party and delivery for operations either credit- or leasing-based by operators. This model is used in structured systems as Metrobus.

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 Mexico City, 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. To overcome the problem of guarantees and costly financial conditions a separation of ownership and operations is an important condition, especially in market conditions such as Mexico with many individual small and weak operators. Technical assistance can help to overcome these barriers and structure financially more viable solutions. 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 10% 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.

6.1.3. Possible Business Models

Besides sourcing/procurement, these elements are structured in terms of the following *key scope elements*:

- Financing: as incremental investment is not recovered with savings during asset lifetime (9yrs), financing of CAPEX for BEB-FC fleet and charging infrastructure must either:
    - be subsidized at a level sufficient to ensure that financing can get repaid within one concession term and that the breakeven point can be brought forward to a number of years which is less than the concession duration; or
    - be decoupled from the concessions, which requires residual value risk to be shifted to a third party guaranteeing reuse in a second concession period.
- Maintenance & spare parts/replacements: Public Transport Operators (PTOs) will need to be trained and supported to carry out maintenance and manage spare parts of the BEB-FC fleet and charging infrastructure – unless the structure selected for sourcing the fleet is a finance/lease including maintenance services (akin to a “wet lease").
- Ownership: in the context of the concession contracts, the structure needs to define the legal ownership (as well as any collateral claims/hold on assets as a result from pledges to financiers) – this is considered in the context of bus fleet and charging infrastructure assets

surviving the concession contracts duration. In each case, the best leasing option should be studied and analysed, if applicable, and it should be determined together with the transportation authority whether or not it is in its interest to retain ownership of the vehicles at the end of the concession.

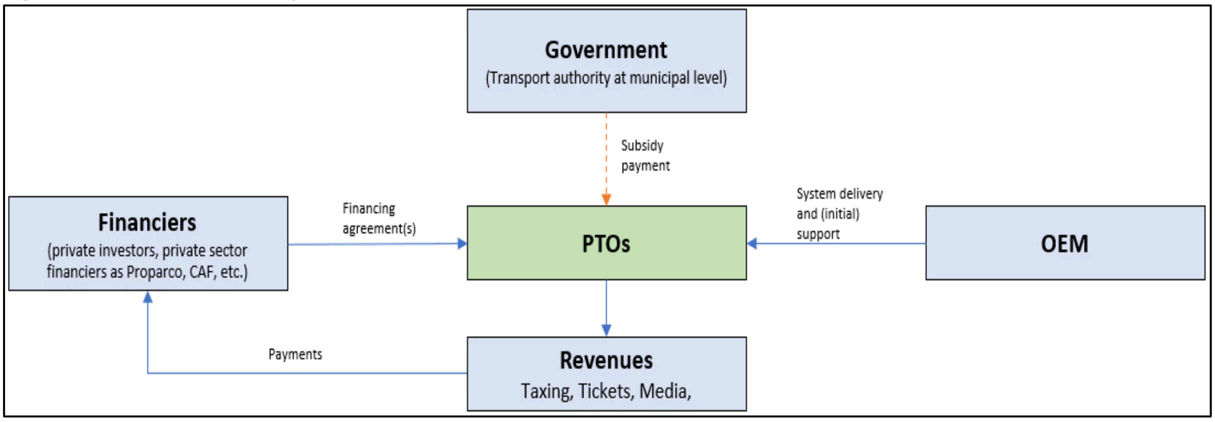
The typical structures that could be followed in the case of Mexico are:

- 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



In the diagnostic report 2 the transport authorities in the main states are listed
Source: Grutter Consulting based on Grutter Consulting / RebelGroup report for IFC, 2021

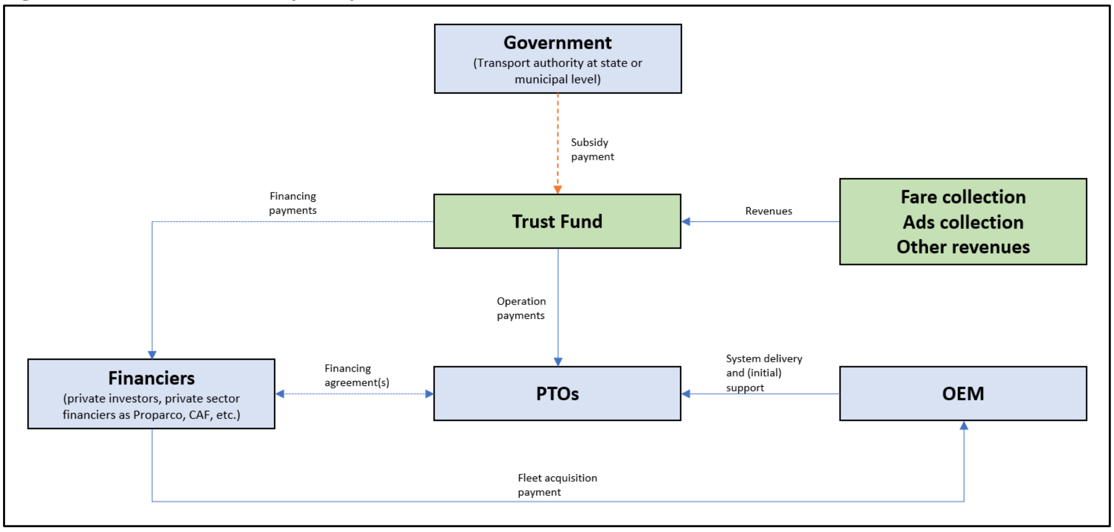
In this structure, PTOs:

- 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[22] from the government to neutralise 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, as shown in the following figure.

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

Figure 14: PTO-led Delivery adaptation



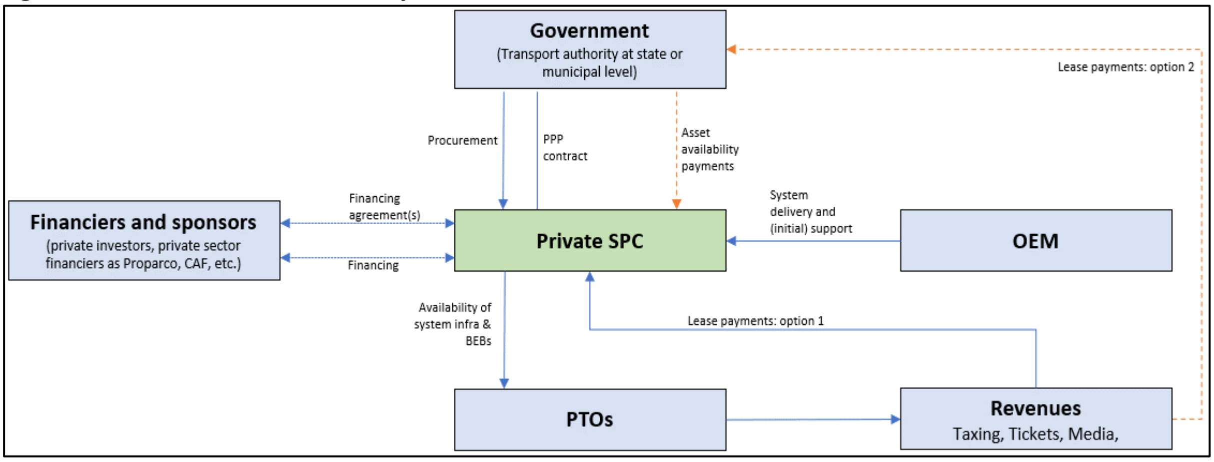
In this structure:

- Government, through the transport authority at state or municipal level depending on the case, grants a subsidy to the operator in order to neutralise the differential costs 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).
- PTOs is responsible for seeking financing for the assets, including the fleet and recharging infrastructure.
- Financiers make direct agreements with PTOs as well as the payment of the fleet to the OEM.
- OEM hands over the fleet to PTOs, who owns the fleet.
- Trust Fund is in charge of receiving the operating subsidy given by the government, as well as revenues such as fare collection, advertising, among others. It also makes the financing payments to the financiers and the payment for the operation to the PTO. Facilitating transparency and the flow of resources.

Option 2: Private Sector-led Delivery

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

Figure 15: Private Sector-led Delivery



OEM: Original Equipment Manufacturer; PTO: Public Transport Operator; SPC: Special Purpose Company; PPP: Public-Private Partnership; In the diagnostic report 2 the transport authorities in the main states are listed
Source: Grutter Consulting based on Grutter Consulting / RebelGroup report for IFC, 2021

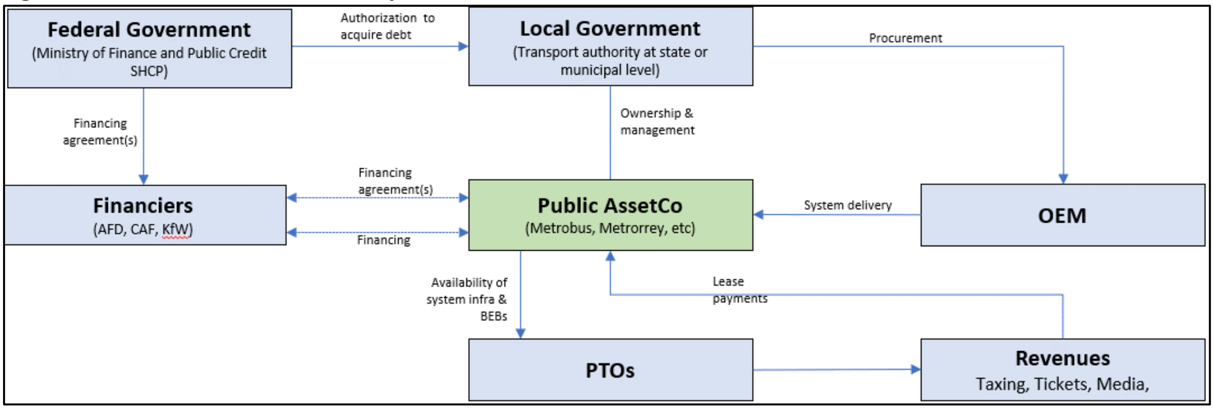
In this structure:

- Government (transport authority at state or 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
    - 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[23] 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 fare infrastructure assets in the event of default on debt service obligations.

Option 3: Public Sector-led Delivery

Standard public sector-led delivery is highlighted in the figure below.

Figure 16: Public Sector-led Delivery



In the diagnostic report 2 the transport authorities in the main states are listed
Source: Grutter Consulting based on Grutter Consulting / RebelGroup report for IFC, 2021

[23] This can be provided by entities such as NAFIN

However, it should be noted that Article 117 of the Mexican Constitution states that:

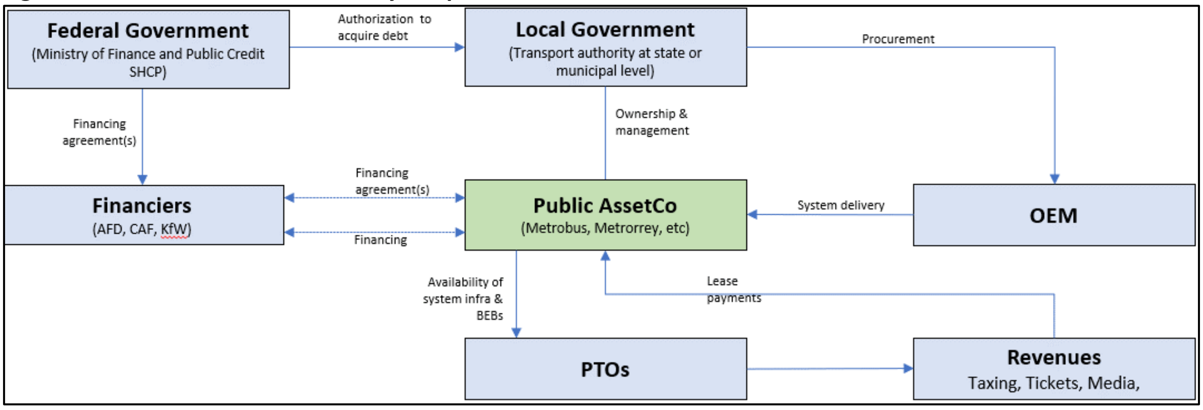
> "States may not in any case directly or indirectly contract obligations or loans with governments of other nations, with foreign companies or individuals, or when they are to be paid in foreign currency or outside the national territory”

In addition, the Federal Public Debt Law states that only the Federation may:

> "contract and manage the public debt of the Federal Government and grant the guarantee thereof for the execution of credit operations that are entered into with international organizations of which Mexico is a member or with national or foreign public or private entities"

This makes it necessary to adapt the model to Mexican conditions, including the Federal Government, which must acquire the international debts and then distribute the resources to a third actor such as the local government, development bank or a decentralized body, among others.

Figure 17: Public Sector-led Delivery adaptation



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

In this structure:

- Government at Federal level (Ministry of Finance and Public Credit) establishes financing agreements with multilateral banks or international funds and authorizes transport authorities (at state or municipal level) to acquire debt.
- Financing agreements are either with the Federal Government (a multilateral development bank or agency as AFD) and the government passing the financing through into the AssetCo.
- Recently, the figure of a trust fund is being used, fed by the resources of the tariff and governmental resources, which guarantees the payment to the financier regardless of the variation in income due to factors such as a reduction in demand or external shocks that result in cost increases;
- 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 (Transport Authority at state or municipal level) or with the AssetCo directly;
- The assets are held and/or managed in the AssetCo with government (state or municipality) 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 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

Six Investment projects for buses have been identified for 5 cities. For Mexico City and Sinaloa the demand for e-buses surpasses the financial capabilities of the fund. Therefore only a certain share of the total expected buses have been included in the program. The following table summarizes the projects which could be funded under the Program (see spreadsheet and (Grutter Consulting, 2021a) for more information).

Table 9: Potential E-Bus Investment Project

Item	Description
Project contents	560 urban e-buses (8-26m units) including their charging infrastructure, grid connection and bus depot upgrade in 5 cities of Mexico
Project owner	Not yet defined (see possible business models in previous chapter)
Project beneficiary	Metrobus, STE, Gov. Of States of Nuevo Leon for buses in Monterrey, Gov. Of State of Sinaloa, PTO in Guadalajara and Hermosillo
Total investment	260 MUSD
Loan components	180 MUSD loan for 70% of the net total CAPEX @ 2% interest rate for 9 years of which the GCF 50 MUSD
Subsidy	26MUSD (10% of total CAPEX)
Environmental impact (cumulative lifespan units)	Reduction of 390,000 tCO_{2e}, 17 tons $PM_{2.5}$ and 2,100 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 e-taxis faces following major barriers:

- Lack of an urban fast-charging network in case of necessity. The same fast-charging network could be potentially used by taxis, cars as well as LCVs.
- Cab service, being individually owned, is a voice-to-voice market lacking technical knowledge. In this type of market, the reputation of the pilot programs takes on great importance. The program developed by Mexico City was not successful and demonstrated the need for appropriate support for e-taxis generating a lack of interest due to investment conditions and operating difficulties. In addition to the rapid obsolescence of the technology[24].

[24] According with STE Interview who is in charge of this fleet

- Serious financial problems of the sector: official taxis struggle under intense competition from ride-hailing services and latter are subject to legal intervention in certain states. The taxi sector is considered to be over-indebted and many loans have gone sour in this area. Not surprisingly bank managers ask for blanket guarantees which is an indicator that the sector is not creditworthy. Uber or related services lack a proper legal framework and operations are potentially financially not feasible if all costs are paid (e.g. appropriate vehicle and passenger insurance, tax and licence payments). It is expected that the market will undergo serious re-structuring. Investing in this area in the next few years thus entails a potential default risk which would need to be well managed.

Considering the barriers, the following can be considered as areas of intervention:

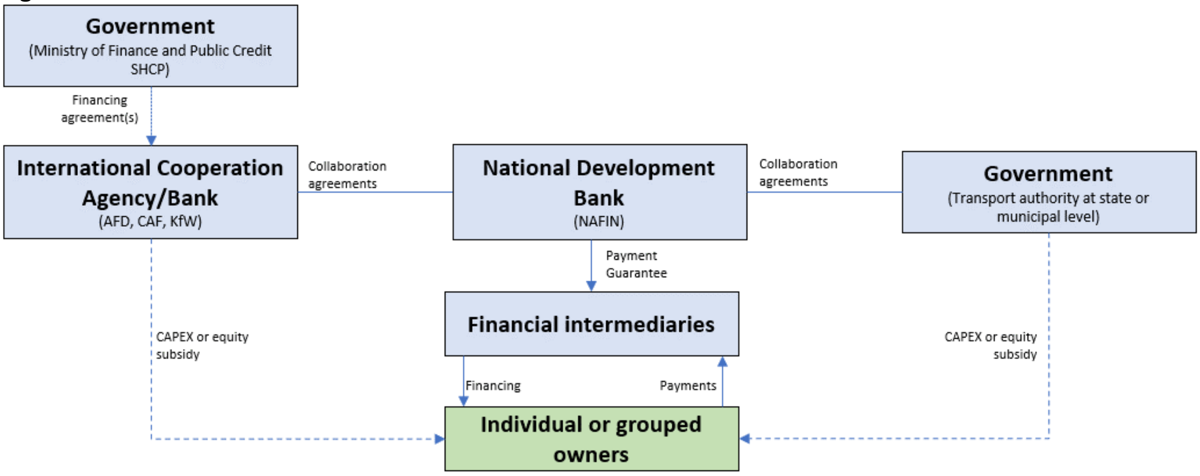
- Support for the development of a public recharging infrastructure system considering its acquisition and operation. This allows the development of a network with easy access for vehicles. To overcome the technical issues technical assistance is required to taxi operators as well as the government to 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. Possible Business Model

The traditional model for the acquisition of Taxis has been characterized as being entirely the responsibility of the individual owner or the entrepreneur grouping more than one vehicle. In this case, the traditional financial sector, or even vehicle sales agencies, are the ones who directly finance the owners. However, for the massification of electromobility in this market segment, additional incentives are needed to reduce the difference in the cost of gasoline or gas vehicles compared to electric vehicles.

The proposed model consists of the generation of Taxi renewal programs with support to the owner to reduce the difference in CAPEX and stimulate the acquisition of electric vehicles. Here it is important the role that local development banks and transport authorities can play, as institutions that lead the structuring of this type of vehicle renewal programs, coordinating financing from banks or international cooperation agencies, and focusing the programs, in coordination with national and international development banks, to individual users or informal micro-entrepreneurs, who are usually considered by financial institutions as not creditworthy.

Figure 18: Possible Business Models for Taxis



Source: Grutter Consulting

These would be the main roles played by each of the actors involved:

1. **International Cooperation Agency or Bank:** contributes with funding mechanisms or lines of credit to national development banks with favourable credit conditions compared to commercial banks. They can also collaborate in the design of vehicle fleet renewal programs (Taxis, LCVs, and even public transport) and in the identification of transport authorities that may be interested.

2. **National Development Bank:** creates lines of credit and establishes cooperation agreements with local transportation authorities to carry out the renovation programs. It is also in charge of selecting and contracting the intermediary financial entities that will operate the program and establish direct links with the atomized owners.
3. **Public Transport Authority:** creates lines of credit and establishes cooperation agreements with local transportation authorities to carry out the renovation programs and make the rules and credit conditions clear to individual operators. It is also in charge of selecting and contracting the intermediary financial entities that will operate the program, and of setting specific criteria on the users that can be part of the project.

4. **Financial intermediaries:** receive resources from both the development banks and the transportation authority, and place loans directly to the atomized owners. These intermediaries are directly responsible for the collection of loans.

This business model necessarily requires the creation of a public or taxi-preferential fast charging infrastructure network, so that individual owners have sufficient incentive to ensure continuous operation throughout the day without resorting to long empty trips to look for charging stations. This is mentioned because failed projects have already been identified in Latin America (Chile, Mexico), where the charging network was minimal and generated many inconveniences for Taxi drivers.

6.2.3. Potential Investment Project

A potential initial investment project is the purchase of 100 electric taxis in the State of Sinaloa and around 1,000 (of targeted 26,000) units in Mexico City including the appropriate fast-charging network. In the case of Sinaloa only a grant would be given to the charging infrastructure as the number of taxis is too small for a loan. The finance to taxis could be given through national development banks as already done with the current taxi financing schemes and would be within the municipal taxi replacement programs. The charging infrastructure could be deployed and managed through CFE.

Table 10: E-Taxi Initial Investment Project

Item	Description
Project contents	1,100 e-taxis combined with a fast-charging network
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 banks e.g. NAFIN; charging network grant for equipment with deployment and operations e.g. through CFE; municipality gives space / land free of charge
Total investment	40 MUSD of which 35 MUSD taxis and 5 MUSD charging infrastructure including grid connection
Loan components	26 MUSD loan for 80% of the total CAPEX e-taxis (excl. Sinaloa) @ 5.1% interest rate for 6 years with a GCF part of 10 MUSD
Subsidy	2.5 MUSD equivalent to 50% of total investment in fast-charging infrastructure
Environmental impact (cumulative lifespan units)	Reduction of 60,000 tCO_{2e}, 0 tons $PM_{2.5}$ and 24 tons of NO_x

Source: Grutter Consulting

7. Proposed Financial and Technical Assistance

7.1. Financial Assistance Instruments

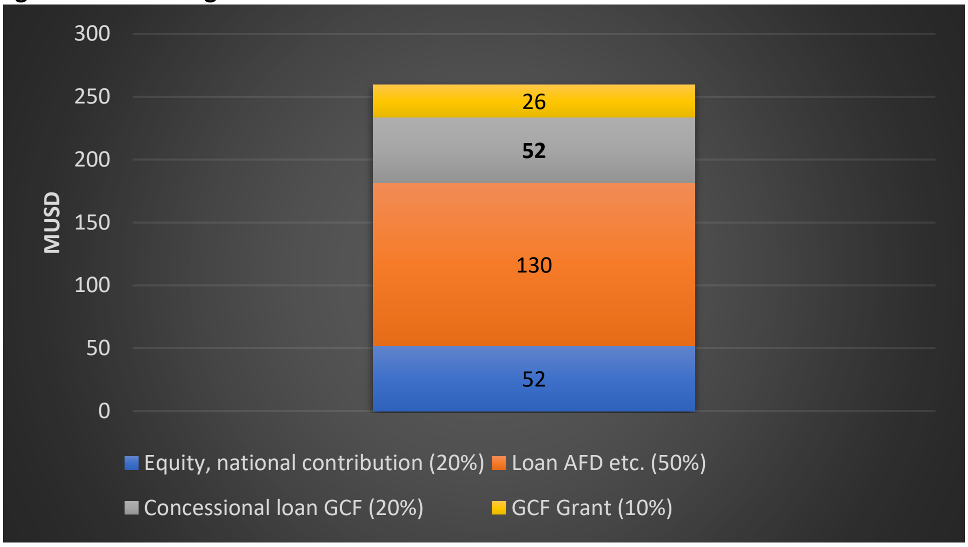
The following table summarizes financial intervention instruments proposed for commercial EV deployment in Mexico.

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

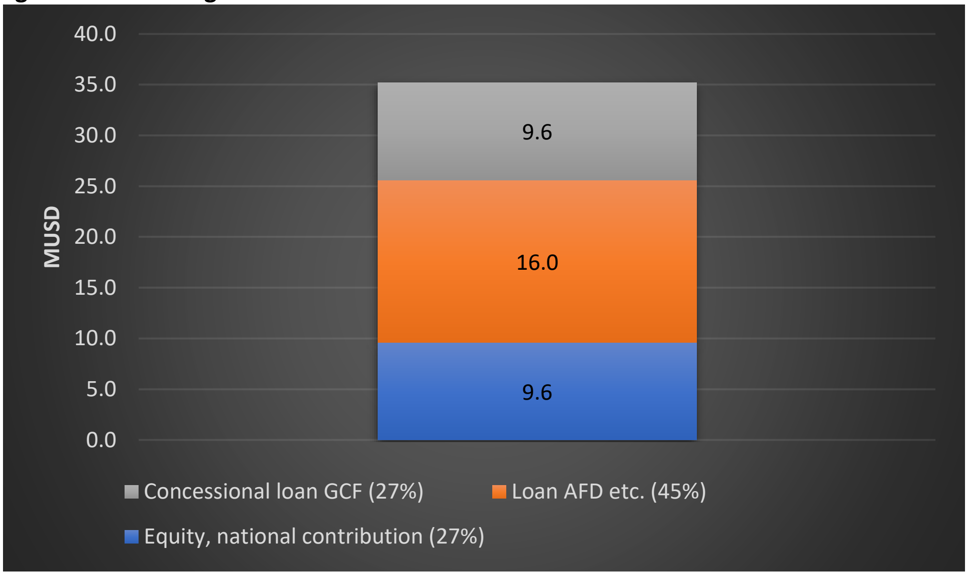
Concessional loans from the GCF are blended with AFD and co-finance and have a long tenure (9 years or longer for buses, 6 years for taxis). GCF loan conditions have been estimated at 0.75% annual interest rate.

Figure 19: Financing Structure e-Buses



Note: Numbers are indicative; total of 560 buses
Source: Grutter Consulting

Figure 20: 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 1,100 taxis
Source: Grutter Consulting

The taxi fast charging network is financed 50% with a GCF grant and 50% with equity/other contributions to be allocated by the owner and manager of the charging infrastructure. The size of this project is to small to warrant a loan.

8 projects for FA have been initially identified:

- 150 18 and 26m e-buses for Metrobus in Mexico City Mendoza to be realized in 2023/2024
- 90 12 and 18m e-buses for STE in Mexico City to be realized 2022/23
- 130 12m e-buses for Monterrey to be realized 2023
- 33 10m e-buses for Guadalajara to be realized 2022
- 50 12m e-buses for Hermosillo to be realized 2025
- 100 12m e-buses for Sinaloa to be realized 2022

- 1,000 e-taxis including urban fast charging infrastructure for Mexico City to be realized 2023
- Urban fast charging infrastructure for taxis for Sinaloa to be realized 2023

The following table summarizes the FA proposed for these projects.

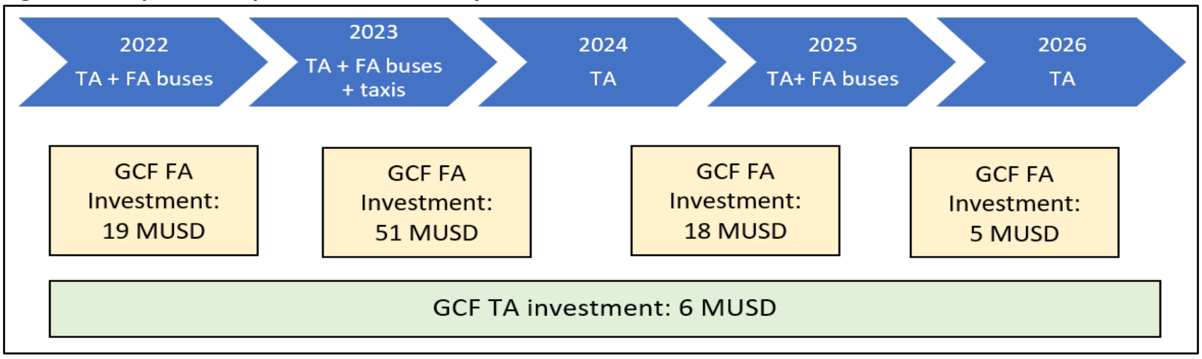
Table 12: FA Potential Projects Mexico

Parameter	e-buses	e-taxis	Total[25]
Total CAPEX	260 MUSD	45 MUSD[26]	305 MUSD
Total loan	182 MUSD	25 MUSD	207 MUSD
Co-finance loan	*130 MUSD*	*16 MUSD*	*146 MUSD*
GCF loan	*52 MUSD*	*10 MUSD*	*62 MUSD*
GCF grant	26 MUSD	5 MUSD[27]	31 MUSD
Equity and other co-finance	52 MUSD	15 MUSD	67 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 National Financial (NAFIN) or other banks with special loan facilities for EVs. The fast charging infrastructure is presumably through electric utilities, basically CFE, which in turn could also establish agreements with private investors.

The total GCF contribution for Mexico from the GCF is estimated at 98 MUSD of which 62 MUSD concessional loan, 31 MUSD grant for FA and 6 MUSD s grant for TA of which 4 MUSD for project preparation and feasibility and 2 MUSD for TA executed by GIZ The following chart shows when investments are expected.

Figure 21: Expected Implementation of Projects



Source: Grutter Consulting

7.2. Technical Assistance Instruments

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

- Homologation of federal incentives that promote the acquisition of vehicle fleet and auto parts, contributing to the reduction of cost differentials with respect to other technologies. It is important to consider not only the reduction of tariffs or taxes at the time of purchase, but

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

also the reduction of taxes on income tax returns to facilitate the conditions for operators of this type of technology.

- Considering the Mexican context and project evaluation methodologies, it is necessary to provide assistance for the adequate inclusion of the benefits, especially environmental, that electromobility generates and that generally makes it a competitive option compared to others. This is especially important in mass public transportation systems and allows for a more equitable vision for decision making.
- Technical assistance for the generation of a differential electricity tariff policy for the recharging of e-vehicles. This type of incentive contributes to the compensation of the investment in recharging infrastructure.
- Training for drivers and maintenance personnel for the proper operation of the vehicles. Driving patterns, battery recharging and unit maintenance directly influence the durability of the vehicles, especially the batteries.
- Support in the legal and financial structuring of innovative business models along with their dissemination to stakeholders. This facilitates the financing of units, the control processes of the authorities and the involvement of the stakeholders.
- Technical assistance to the government in re-structuring public transport sector that would result in stronger and fewer operators e.g. in direction of separation of bus ownership and bus operations. This works to remove barriers to financing for small carriers.
- Policies for the proper disposal and secondary uses of batteries. These batteries can later be used in other production sectors.
- Policy advice including the establishment of concrete sub-sector specific roadmaps on electrification of urban public transport buses, electrification of LCVs and public charging infrastructure.
- Information and knowledge dissemination as well as advisory services to companies and public entities interested in investing in LCVs.
- On-going TA on specific conditions to improve the enabling conditions for e-mobility deployment such as capacity building for insurance companies and firefighters allowing insurance companies to better assess the risk and costs of insuring an electric vehicle and by training specialized fire fighters and vehicle maintenance personnel (mechanics and depot managers) on how to cope with the particular hazards of EVs.
- Technical support for the generation of standards and requirements for electric vehicles and charging infrastructure.
- Dissemination of knowledge and technical assistance to local authorities on the particularities of electromobility, the proper structuring of projects, as well as the analysis of the legal framework of transport for the correct adoption and control of the implementation.
- Support for impact studies on the national energy matrix and the stability of the local distribution network in the adoption of electromobility.
- Support for the structuring of the national electromobility committee, in charge of centralising and coordinating public policy initiatives and activities on electromobility at both national and local level.
- Technical assistance for design an appropriate fast-charging infrastructure catering to the demands of taxis and ride-hailing vehicles.

TA for due diligence / feasibility assessment of the projects worth 4 MUSD is managed and paid directly by the financing agent.

Considering the programmes currently being developed in Mexico, especially the Readiness GCF programme implemented by UNEP, technical assistance activities are subject to the progress made at the time of implementation, with the aim of complementing the activities developed. 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 Mexico of the EV program.

Table 13: Program Impact

Parameter	Direct impact	Total impact
GHG reduction lifetime vehicles cumulative in tons	450,000	26,100,000
• *Buses*	*390,000*	*20,600,000*
• *Taxis*	*60,000*	*5,500,000*
$PM_{2.5}$ reduction lifetime vehicles cumulative in tons	18	1,100
• *Buses*	*18*	*1,050*
• *Taxis*	*0*	*50*
NO_x reduction lifetime vehicles cumulative in tons	2,100	126,000
• *Buses*	*2,080*	*123,000*
• *Taxis*	*20*	*2,000*
Energy savings cumulative lifetime vehicles in TJ	7,100	442,000
• *Buses*	*6,200*	*360,000*
• *Taxis*	*1,100*	*86,000*
Fossil fuel savings cumulative lifetime vehicles in Ml	250	15,600
• *Buses*	*210 million litre diesel*	*12,300 million litre diesel*
• *Taxis*	*35 million litre gasoline*	*3,300 million litre gasoline*
Economic savings cumulative in MUSD	18	2,100
• *Buses*	*16*	*1,400*
• *Taxis*	*2*	*660*

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	305 MUSD	
GCF Loan	62 MUSD	
GCF Grant FA	31 MUSD	
GCF Grant TA	6 MUSD	
Total GCF	**98 MUSD**	
Co-finance ration	**68%**	
GCF investment cost per tCO_2 reduced	**220 USD/tCO_2**	**4 USD/tCO_2**
Total investment cost per tCO_2 reduced	**695 USD/tCO_2**	**12 USD/tCO_2**

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Annex 1: TA Project for Mexico

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

- To structure together with the Investment Unit of the Ministry of Finance and Public Credit (SHCP) the updating of the methodology for cost-benefit assessment of investment programs and projects
- To generate together with the Ministry of the Environment and Natural Resources (SEMARNAT) recommendations for the establishment of a special electricity tariff for e-vehicles.
- To elaborate together with the Ministry of the Environment and Natural Resources (SEMARNAT) the structuring of the second life policy for batteries and disposal at the end of life regarding dangerous waste.
- To elaborate together with the Ministry of the Environment and Natural Resources (SEMARNAT) and other stakeholders the electric vehicle standard, including a specificity for e-buses, e-cabs and e-LCVs. This regulation enables the organized and controlled adoption of electromobility and contributes to building the regulatory framework for electric vehicle manufacturing in Mexico.
- To elaborate together with the Ministry of the Environment and Natural Resources (SEMARNAT), SENER and other stakeholders the homologation standard for recharging infrastructure, considering the national context and the plans for technology transition at national level.
- To structure together with stakeholders, the coordination mechanism for initiatives and projects focused on electromobility, with an emphasis on strengthening the Nation-Local Government relationship. This committee should be linked to the National Electromobility Strategy.
- To elaborate a binding roadmap for e-bus deployment which includes concrete targets, steps and responsibilities.
- To elaborate a roadmap for e-taxi deployment including incentive schemes for deployment of electric taxis.
- To elaborate a roadmap for e-LCV deployment including public incentives for switching towards electric units for public entity.
- 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.
- To design with stakeholders a methodology for structuring electromobility projects focused on access to finance for local authorities and national authorities. This methodology should address national and international, public and private financing mechanisms and have a component related to green financing mechanisms.
- To elaborate a diagnosis of the transport legal framework for the adoption of electromobility in states interested in electromobility, which have advanced electric vehicle project design processes. This includes assessing the duration of concession contracts in the state in relation to the business models proposed.

- To elaborate a study of the impact of electromobility on the energy sector, considering the national energy matrix as well as local distribution networks. This study should elaborate strategies for the adequate response of the national energy system to the growing demand related to electromobility.
- Capacity building on proper battery management (second life and recycling) including an identification of best practices.
- Capacity building for insurance companies, drivers, mechanical workshops and first response staff (firefighters, police, paramedics)
- Design a smart fast charging infrastructure for e-taxis and policies to encourage off peak charging
- To assist the government in re-structuring public transport sector that would result in stronger and fewer operators e.g. in direction of separation of bus ownership and bus operations.

Support to governance and coordination mechanisms

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

- To structure together with the Public Transport Authority appropriate concession contracts and concession conditions conducive to e-bus deployment including concession length, tariff structuring, guarantees etc.
- To elaborate pre-feasibility study for fast charging infrastructure program (≥100 kW), focused on e-cabs and e-LCV's..
- Capacity building in companies that want to adopt electric light-charge vehicles, in operational conditions such as proper driving, recharging and maintenance processes of units and infrastructure.

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

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

Project Preparation TA

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

The project preparation includes the following activities:

- Assistance with the tendering process (define technical specifications for the e-buses, e-taxis or e-LCVs, charging stations, battery size, after sales service etc.)
- Assistance with the selection of the vehicle type to be purchased
- Assistance with the supervision of the contract with the OEM.
- Removal of barriers during the import process (make sure the vehicles are exempt from taxes according to the current la for EV incentives)

- Assistance with the supervision of the contract between owner and operators.
- Assistance with communication and PR work (press releases, events etc.)
- Conduct a legal due diligence with the operators or stakeholders involved
- Assess grid conditions in the places where the vehicles will recharge and conduct the necessary assistance to upgrade the grid.

Annex 2: List of Interviewed Persons and Institutions

Organization	Full Name	Department	E-mail
AFD - French Development Agency	Suzanne Spooner	Transport Division	spooners@afd.fr
KFW - State Development Bank of the Federal Republic of Germany	Fabiola Gómez Brechtel	Representative office in Mexico KFW	fabiola.gomez@kfw.de
GIZ - German Society for International Cooperation	Carolina Santos del Río	Senior Project Advisor	carolina.santos@giz.de
E-mobilitas	Gustavo Jiménez	KFW Consultant	gustavo@e-mobilitas.com
ZEBRA - Zero Emission Bus Fabric Announcement	Thomas Maltese	Project Manager (Interim)	tmaltese@c40.org
Metrobus	Candi Ashanti Domínguez Manjarrez	Executive Directorate for Planning, Evaluation and Information Technology	cdominguezm@metrobus.cdmx.gob.mx
	Fredy Velásquez Jiménez		fvelazquez@metrobus.cdmx.gob.mx
ENGIE Customer Solutions México/LATAM	Jorge Suárez Velandia	Senior Business Developer Electromobility	jorge.suarez@engie.com
INECC - National Institute of Ecology and Climate Change	Claudia Alejandra Octaviano Villasana	General Coordination on Climate Change Mitigation	claudia.octaviano@inecc.gob.mx
STE - Mexico City Electric Transport Services	Jorge Rocha Sánchez	Directorate for Technological Development	jrocha_dci@ste.cdmx.gob.mx
	Félix Jacob Santiago Sánchez		fsantiago_gi@ste.cdmx.gob.mx
CFE - Federal Electricity Commission	Pedro Campos Serrano	Electricity Sector Energy Saving Programme (PAESE)	pedro.campos@cfe.mx
SEMOVI - Secretariat of Mobility of Mexico City	Rodrigo Díaz González	Under-Secretariat for Planning, Policy and Regulation	rdiazg@cdmx.gob.mx
	Lídice Rocha Marenco		lrmarenco.semovi@gmail.com
SHCP - Ministry of Finance and Public Credit	Brenda Guadalupe Ciuk Cano	Public Credit and International	brenda_ciuk@hacienda.gob.mx

Organization	Full Name	Department	E-mail
	Ana Consuelo Salas Adato	Affairs Unit (NDA)	ana_salas@hacienda.gob.mx
BANOBRAS - National Bank for Public Works and Services	Roberto Abraham Vargas Molina	Transport Projects Sub-Directorate	roberto.vargas@banobras.gob.mx
Government of Nuevo León	Jesús Uzcátegui Miranda	Urban Engineering	uzcategui.pcu@gmail.com
	Elizabeth Garza Martínez	General Directorate of the Institute of Mobility and Accessibility of Nuevo León	elizagarza@hotmail.com
NAFIN - National Finance	Siddharta Flores Villegas	Sectoral Projects	sfloresv@nafin.gob.mx
	Natalia Santoyo Rivera	Projects Financed by International Financial Institutions	nsantoyo@nafin.gob.mx
	Tomas Garduno Perez		tgarduno@nafin.gob.mx
Ascendal Group	Carlos Botello	Country address, Mexico	carlos.botello@ascendalgroup.com
Mobility ADO	Rafael Augusto Gochez Magaña	BRT General Management	rgochez@mobilityado.com
	Juan Carlos Abascal Alvarez	LATAM Mobility Management	juan.abascal@mobilityado.com
Government of Jalisco	Mariana Bulos Rodríguez	General Direction of Public Transport	mariana.bulos@jalisco.gob.mx
SEMARNAT - Ministry of the Environment and Natural Resources	Diana Guzmán Torres	Climate Change Mitigation Policy Directorate	diana.guzman@semarnat.gob.mx
PROTRAM - Federal support programme for mass transport	Carlos Valdes Mariscal	Protram's Senior Advisor at Fonadin in Banobras	carlos.valdes@banobras.gob.mx carlostren11@gmail.com
Government of Sinaloa	Said Osuna Félix	Secretariat for Sustainable Development	said.osuna@sinaloa.gob.mx
	Efraín Leyva Perea		efrain.leyva@sinaloa.gob.mx
	Jorge Enrique Rodríguez López		jorge.rodriguez@sinaloa.gob.mx
Municipality of Leon Guanajuato	Leopoldo Mora Flores	Transport Service Directorate	leopoldo.mora@leon.gob.mx

<table>
<tr><th>Organization</th><th>Full Name</th><th>Department</th><th>E-mail</th></tr>
<tr><td></td><td>Luis Enrique Moreno Cortés</td><td></td><td>enrique.moreno@leon.gob.mx</td></tr>
<tr><td rowspan="2">Guanajuato State Government</td><td>Fabio Arnoldo Sandoval Reséndez</td><td rowspan="2">Directorate-General for Mobility</td><td>fasandovalr@guanajuato.gob.mx</td></tr>
<tr><td>Martha Carina Gutierrez Mendez</td><td>chernandezg@guanajuato.gob.mx</td></tr>
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Annex 3: Details Financial Calculations

General Parameters			
Parameter	**Value**	**Unit**	**Source**
NCV of diesel	43	MJ/kg	IPCC, 2006, table 1.2
CO_2 emission factor of diesel	74.1	gCO_2/MJ	IPCC, 2006, table 1.4
Density of diesel	0.844	kg/l	IEA, 2005
Well-to-tank mark-up factor diesel	23%		UNFCCC, 2014, Table 3
NCV of CNG	48	MJ/kg	IPCC, 2006, table 1.2
CO_2 emission factor of CNG	56.1	gCO_2/MJ	IPCC, 2006, table 1.4
Density of NG	0.714	kg/m^3	IGU, 2012
Well-to-tank mark-up factor CNG	18%		UNFCCC, 2014, Table 3
Methane slip as % of NG consumption TTW	1.1%		Average low and high value of ICCT, 2015, table 4 for crankcase and tailpipe
Methane slip as % of NG consumption WTW	3.4%		Average low and high value of ICCT, 2015, table 4 for well-to-pump and fuelling station plus TTW slip
NCV of gasoline	44.3	MJ/kg	IPCC, 2006, table 1.2
CO_2 emission factor of gasoline	69.3	gCO_2/MJ	IPCC, 2006, table 1.4
Density of gasoline	0.741	kg/l	IEA, 2005
Well-to-tank mark-up factor gasoline	19%		UNFCCC, 2014, Table 3
GWP_{100} of BC	900		Bond, 2013; see also IPCC, 2013, Table 8.A.6
GWP_{100} of CH_4	28		IPCC, 2013, Table 8.A.
BC fraction Euro 2 gasoline passenger car and LCV	25%		EEA, 2020, tabla 3-92
BC fraction Euro 4 gasoline passenger car and LCV	15%		
BC fraction Euro 2 diesel passenger car and LCV	80%		
BC fraction Euro 4 diesel passenger car and LCV	87%		
BC fraction Euro II HDV	65%		
BC fraction Euro IV HDV	75%		
BC fraction Euro 1 Motorcycle	25%		
BC fraction Euro 2 Mot	25%		
Conversion kWh to MJ	3.6	MJ per kWh	https://home.uni-leipzig.de/energy/energy-fundamentals/03.htm#:~:text=Power%20units%20can%20be%20converted,%3D%203.6%20MJ%20%5B
Battery manufacturing emissions	110	$kgCO_2$/kWh	ICCT, 2018, table 1 (per kWh battery set); average value not taking into account 2nd life usage of batteries

TCO 12m Bus

Parameter	Value	Unit	Source
Distance driven per bus per annum	78,019	km	225km per day with 330 days; SEMARNAT, 2016. Concessioned buses
Workday distance driven daily	225	km	SEMARNAT
Specific electicity usage	1.1	kWh/km	Chinese average; ADB, 2018; includes AC
Diesel usage	54	l/100km	mexico BM
Maintenance diesel bus	0.28	USD/km	http://documents1.worldbank.org/curated/en/410331548180859451/pdf/133929-WP-PUBLIC-
maintenance e-bus	0.20	USD/km	70% of diesel bus
Lifespan bus diesel	9	years	SEDEMA concessioned buses
Lifespan bus electric	9	years	SEDEMA concessioned buses
Lifespan battery @ 80% SOC	8	years	current guarantee levels

Financial defaults

Parameter	Value	Unit	Source
CAPEX diesel bus	153,000	USD	90% of estimate of Diesel Euro V,
CAPEX overnight charged e-bus	286,000	USD	Based on bus with 350 kWh battery set and sur-cost for battery size
CAPEX slow-charged batteries	200	USD/kWh	LFP batteries
CAPEX fast-charged BEB	250,000	USD	Based on standard fast-charged bus
CAPEX batteries fast-charged	250	USD/kWh	NMC batteries
Reduction battery cost in 8 years	50%		US DOE projections, 2017 have a decrease of 12% per annum; applied to 5 years; https://energy.gov/sites/prod/files/2017/02/f34/67089%20EERE%20LIB%20cost%20vs%20price%20m
CAPEX charger excl. Installation per kW	120	USD/kW	Standard chinese chargers, 2 nozzles
CAPEX charger installations civil works	2,500	USD/bus	Civil works for chargers; 2 buses per charger; 5,000 USD per unit
Cost per bus depot upgrade	7,500	USD/bus	Coverage of bus and chargers with roof, no paving, includes labour (20m2 per bus, 250 USD/m2 material and 125 USD/m2 labour)
Cost grid connection of chargers	30,000	USD/bus	Compact sub-stations for groups of chargers; 20kV cables from connection substation to the compact substation, 400V cables from compact substation to chagers; costs not born by electric utility
Maintenance & repair cost of e-buses relative to diesel incl. labour	70%		Based on experience in PR China; ADB, 2018; 10% higher tyre costs; 75% lower maintenance staff and general maintenance; 20% lower repair and spare parts
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	225
Energy usage day	kWh	248
Risk ratio (higher energy consumption)		10%
Reserve ratio		20%
SOC loss year 8		20%
Battery size required year 8	**kWh**	**430**

Charging required at bus depot overnight

Parameter	Unit	Value
Battery capacity	kWh	430
Average daily consumption workday	kWh	248
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	60

Option B: Fast Charging

Parameter	Unit	Value
Battery size	kWh	250
C-rate		0.65
Charging in 30 minutes	kWh	81
Average re-charge during day required with 20% reserve ratio	kWh	48
Average share of day electricity		19%
Fast-charger	kW	300
Power conversion efficiency of chargers		90%
Average required re-charge day with 300 kW charger	minutes	11
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

TCO Buses

12m standard bus, USD 2019

Parameter	Diesel		BEB overnight	BEB fast
CAPEX bus	153,000		286,000	250,000
CAPEX charging infrastructure	0		9,700	12,113
CAPEX grid connection	0		30,000	30,000
CAPEX depot upgrade	0		7,500	7,500
Total CAPEX	153,000		333,200	299,613
Battery replacement yr 8	0		43,000	31,250
Energy cost yr 1	31,629		18,524	14,924
Maintenance cost bus yr 1	21,845		15,292	15,292
Maintenance cost infra yr 1	0		944	992
Finance cost average per year	8,699		16,260	14,213
Economic costs yr 1	6,432		1,312	1,312
TCO financial per km	0.98		1.05	0.94
TCO economic per km	1.07		1.07	0.96

TCO Taxis

Parameter	Value	Unit	Source
Average battery size	60	kWh	Nissan LEAF large battery or BAIC
Battery lifespan	6	years	idem vehicle
Vehicle lifespan	6	years	INECC, 2017
Annual mileage	65,500	km	
Daily mileage	211	km	Based on 310 working days
Charging at home average	70%		Assumption; only re-charge if above-average mileage or night shifts
Charging fast-chargers	30%		
CAPEX gasoline taxis	15,800		Valor promedio 10 ciudades de México. Transconsult, 2018
CAPEX e-taxi	30,000		Transconsult, 2018, calculates with BYD E1 but small battery; thus Nissan Leaf large battery or BAIC
Capex home charger 7.4kW	2,000	USD	Nissan LEAF large battery or BAIC
Gasoline consumption	8.0	l/100km	https://manufactura.mx/automotriz/2013/09/27/cual-es-el-taxi-ideal-para-mexico
Electricity consumption	0.16	kWh/km	Nissan LEAF large battery or BAIC
Charger lifespan	6	years	
Maintenance cost gasoline excl. Tyres	0.02	USD/km	https://www.gob.mx/cms/uploads/attachment/file/395996/CGMCC_ES_06.pdf
Maintenance cost total e-taxi	0.01	USD/km	30 % lower cost (tyres the same or higher; higher spare costs; less maintenance of engine

Transconsult compared with BYD E1. However this car has very limited power, a small battery (30 kWh), as soon as used with load or AC a limited range (in practice less than 200km) and can oinly be charged with 50kW

gasoline versus e-taxi

Parameter	gasoline	e-taxi
CAPEX vehicle	15,800	30,000
CAPEX charger	0	2,000
Total CAPEX	15,800	32,000
Energy cost	4,821	2,117
Maintenance cost	1,507	753
Finance cost average per loan year	898	1,706
Economic costs yr 1	601	222
Lifespan in years	6	6
TCO financial per km	0.15	0.15
TCO economic per km	0.16	0.15

LCVs

1. Petrol Van

Parameter	Value	Unit	explanation
CAPEX van	28,400	USD	JAC X250
Petrol fuel consumption	23.0	l/100km	Instituto Mexicano del Transporte, 2018. Valores para 2017
Maintenance cost	0.03	USD/km	Instituto Mexicano del Transporte, 2018. Valores para 2017
Lifespan	17	years	INECC 2017
Daily distance driven	68	km	commensurate with annual mileage
Annual distance	22,500	km	Buendía, José Luis; Peñaloza, Pedro Abraham. 2016
Interst rate e-LCV	12%		HSBC, 2021. For passenger cars with 80% loan share and 72 month financing
Interst rate commercial LCV	13.5%		NAFIN, 2020
Tenure	7	years	

2. E-Van

Parameter	Value	Unit	explanation
CAPEX e-van	73,600	USD	JAC EX350 3.7t load
Range WLTP	440	km	https://www.alianzaflotillera.com/jac-lanza-vehiculos-para-la-ultima-milla/
Battery size	92	kWh	
Cost battery	18,400	USD	Based on 200 USD/kWh per battery
electricity consumption	0.21	kWh/km	WLTP
Maintenance cost	0.01	USD/m	50% of fossil (as only engine maintenance is included; no tyres, no repairs)
Lifespan van	17	years	assumed same as fossil
Lifespan battery	8	years	
Capex home charger 7.4kW	2,000	USD	
Lifespan charger	17	years	
Charging at home average	90%		Assumption
Charging fast-chargers	10%		Exceptional if long distances were made

fossil versus e-van

Parameter	petrol	e-van
CAPEX vehicle	28,400	73,600
CAPEX charger	0	2,000
Replacement battery cost	0	18,400
Total CAPEX	28,400	75,600
Energy cost	4,761	822
Maintenance cost	563	281
Finance cost average per year	1,789	4,061
Economic costs yr 1	572	100
Lifespan in years	17	17
TCO financial per km	0.34	0.37
TCO economic per km	0.37	0.37