grütter consulting

Country Diagnostic Mexico

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Abbreviations

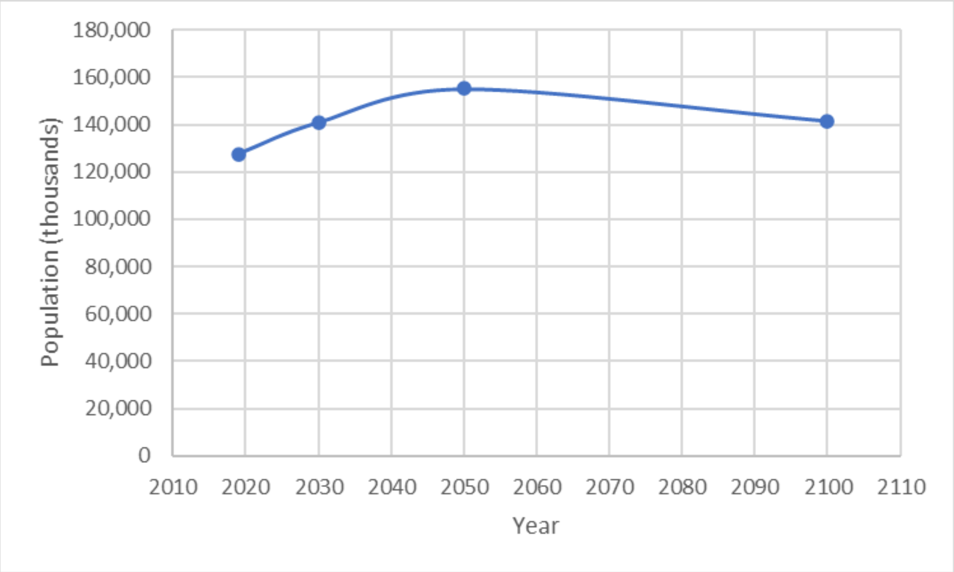
AMIA	Mexican Association of the Automotive Industry
ANPACT	National Association of Bus, Truck and Tractor Trailer Manufacturers
PPP	Public Private Partnership
BANCOMEXT	National Bank for Foreign Trade
BANOBRAS	National Bank of Public Works and Services
BDAN	North American Development Bank
BRT	Rapid transit bus
CAF	Latin American Development Bank
CFE	Federal Electricity Commission
CFF	Cities Finance Facility
CICC	Intersecretarial Commission on Climate Change
CONATRAM	National Commission of Mexican Transporters
CRE	Energy Regulatory Commission
ENME	National Electric Mobility Strategy
ERT	Transport Network Companies
EV	Electric Vehicle
FCC	Climate Change Fund
FIDE	Electricity Saving Trust Fund
FIFINTRA	Trust Fund For The Public Transport Financing Promotion Fund
FONADIN	National Infrastructure Fund
FOTEASE	Energy Transition and Sustainable Energy Use Fund
FONATUR	National Tourism Development Fund
GEI	Greenhouse Gases
GIZ	German Society for International Cooperation
GNC	Compressed Natural Gas
HEV	Hybrid Electric Vehicle
IACC	Inter-Ministerial Commission on Climate Change
INECC	National Institute of Ecology and Climate Change
ISAN	New car tax
ITM	Mexican Institute of Transportation
KfW	State Development Bank of the Federal Republic of Germany
NAFIN	National Financial
NAFTA	North American Free Trade Agreement
NAMA	Nationally Appropriate Mitigation Action
NDC	Nationally Determined Contribution
PEII	Promotion of Electromobility through Investment in Recharge Infrastructure
UN	United Nations
PHEV	Plug-in Hybrid Electric Vehicle
PPP	Public Private Partnership
PRODESEN	National Electricity System Development Programme
PROTRAM	Federal Mass Transit Support Program
RTP	Mexico City's Passenger Transport Network
SCT	Ministry of Communications and Transport
SEDATU	Ministry of Agrarian, Territorial and Urban Development
SEMARNAT	Ministry of the Environment and Natural Resources
SENER	Ministry of Energy
SHCP	Ministry of Finance and Public Credit
SIT	Integrated Transport System
SRI	Income Tax

STE	Electric Transport System
ULS	Ultra Low Sulfur
ZEBRA	Zero Emission Bus Rapid-deployment Accelerator
ZMVM	Mexico Valley Metropolitan Area

1. Country Brief

The surface of Mexico is 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 according to the Figure 1 (United Nations, Department of Economic and Social Affairs, Population Division, 2019).

Figure 1: Population Projection for Mexico



Source: (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 according to the Table 1**Error! Reference source not found.**.

Table 1: Mexican cities with more than one million inhabitants

Position	City	Population	Position	City	Population
1	Mexico City	9,209,944	7	Guadalajara	1,385,629
2	Tijuana	1,922,523	8	Monterrey	1,142,994
3	Leon	1,721,215	9	Nezahualcoyotl	1,077,208
4	Puebla	1,692,181	10	Mexicali	1,049,792
5	Ecatepec de Morelos	1,645,352	11	Queretaro	1,049,777
6	Juarez	1,512,450	12	Culiacan	1,003,530

Source: (Instituto Nacional de Estadística y Geografía, 2021)

2. Policy Framework Relevant for E-Mobility

2.1. Climate Change and Environmental Policies

In order to identify the sectors that contribute most to greenhouse gas (GHG) emissions since 1990, Mexico has prepared the *National Inventory of Greenhouse Gas and Compound Emissions (INEGYCEI)*. In 2012, Mexico contributed 1.37% of global emissions derived mainly from the burning of fossil fuels, making it the country with the 13th highest emissions in the world (Agencia Internacional de Energía, 2014).

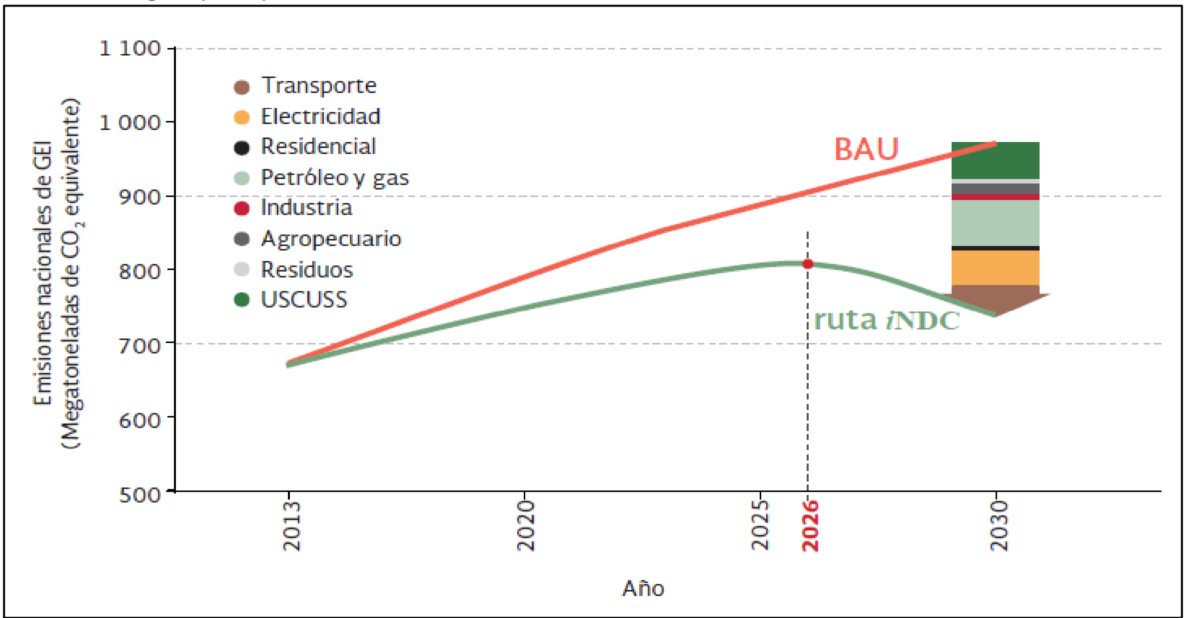
Table 2: Net emissions of greenhouse gases in Mexico

Sector	Emissions in Mt of CO_2 equivalent				
	2013	2014	2015	2016	2017
1 Energy	493.8	492.6	503.6	539.2	522.4
1A Fuel-burning activities	452.9	443.8	459.2	488.7	485.8
1A3 Transport	164.8	163.4	171.4	178.6	170.3
1B Fugitive emissions from fuel manufacturing	41.0	48.8	44.4	50.5	36.6
2 Industrial processes and product use	52.8	55.5	54.1	55.2	58.0
3 Agriculture, forestry and other land uses	-49.9	-48.9	-46.3	104.8	106.7
4 Waste	43.6	44.4	45.9	46.5	46.7
Total	540.3	543.7	557.3	745.6	733.8

Source: (Instituto Nacional de Ecología y Cambio Climático, 2020)

Within the *Nationally Determined Contribution, the* baseline of emissions is established, for which in 2030 the emissions would reach 991 $MtCO_{2e}$, with 250 $MtCO_{2e}$ from the transport sector (Government of Mexico, 2020). The Figure 2 represents the BAU scenario, as well as the emission reduction targets for the coming years (Government of Mexico, 2015).

Figure 2: National GHG emissions under the baseline scenario (BAU) and unconditional commitment to reduction targets (iNDC), 2013-2030



Source: (Government of Mexico, 2015)

In accordance with the above, the Government of Mexico is unconditionally committed to reducing its emissions by 22% by 2030, and the transport sector by 18%, reaching 218 $MtCO_2e$. Similarly, the target for black carbon reduction is 51%. These reduction targets can be increased to 36% for GHG emissions and 70% for black carbon conditional on technology transfer and financing. To achieve the proposed reduction in emissions in the transport sector, an average of 5 $MtCO_2e$ is expected to be emitted annually, with an average annual variation of 2.39% from 2020 to 2025 and 2.22% from 2025 to 2030 (Government of Mexico, 2020).

The commitments acquired in the transportation sector are (i) the homologation within the North American Free Trade Agreement (NAFTA) of environmental regulations for new and in-service vehicles, as well as for non-road vehicles such as locomotives, boats and mobile agricultural and construction machinery; (ii) the provision of ultra-low sulfur gasoline and diesel; (iii) achieving an increase in the natural gas vehicle fleet; (iv) clean fuels; (v) modernization of the vehicle fleet; (vi) reducing the import of used vehicles and (vii) promoting multimodal transportation of cargo and passengers (Government of Mexico, 2015). According to the *Nationally Determined Contribution 2020 Update*, the implementation routes and the participatory process identified opportunities regarding the strengthening of regulations applicable to motor vehicles, the encouragement of alternative transportation systems, the promotion of clean transportation programs, the development and implementation of the *National Electric Mobility Strategy* and urban planning oriented towards efficient public transportation systems (Government of Mexico, 2020).

Since the issuance of the *General Law on Climate Change* in 2012, which, within the framework of the Paris Agreement, regulates the actions for mitigation and climate change, within which the reduction of emissions in the transport sector is contemplated and establishes the responsibilities at the different levels of government, a series of programs and strategies are developed at the national level based on the compliance with this law.

The *Climate Change Strategy to 2050* published in 2016 established that within 10 years the use of electric vehicles in public transport shall be common and within 40 years in all types of transport (SEMARNAT-INECC, 2016). Mexico published the *National Electric Mobility Strategy Vision 2030,* 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).

Among the Nationally Appropriate Mitigation Actions (NAMAs) highlighted in the transportation sector are the *Green Routes Program, through the replacement of urban public transportation units that use diesel as fuel with low emission units that use Compressed Natural Gas (CNG), Energy Efficiency in Federal Cargo Transportation,* the *NAMA of Federal Cargo Transportation for trucks and small carriers and* the *Renewal of the Vehicle Fleet in Mexico*. Although these actions are aimed at reducing carbon emissions, they stand out for promoting efficient fuel use and fleet renewal, without highlighting electromobility in particular.

In addition to the national instruments, the federal states incorporate within their programs strategies to incorporate electric mobility, for 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 promote before the federation the complete deductibility in hybrid and electric cars, 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).

2.2. Energy Policies

Within the framework of the *Energy Transition Law, the* Ministry of Energy published the *Transition Strategy to Promote the Use of Cleaner Technologies and Fuels*, which establishes as actions related to electromobility, the strengthening of the Mexican Official Standards for minimum performance and fuel quality, and the promotion of the use of hybrid vehicles. The following actions have been undertaken: the establishment of programs for the renewal of the vehicle fleet, the promotion of mandatory programs for the replacement of the public transportation vehicle fleet with high energy efficiency vehicles, including electric vehicles, and the development of technical standards for electric vehicle recharging systems (Secretaría de Energía, 2020).

The *Energy Sector Program 2020-2024* establishes, as a specific action, the establishment and coordination of a comprehensive policy, within the framework of the Agenda, for the transition towards a system of nationally produced electric vehicles that use renewable energies generated with equipment produced in Mexico (Secretaría de Energía, 2020).

The *National Electricity System Development Program* (PRODESEN) 2020-2034 states that in the framework of the development of the *National Strategy for Electric Mobility*, the Ministry of Environment and Natural Resources has foreseen the reduction of 3.5 and 5.0 $MtCO_{2e}$. It also mentions the development of the *Cities Alliance for the Electric Mobility Network*, which seeks to encourage the joint development of skills and mechanisms to promote electric mobility in 10 Mexican cities with the worst air quality. This program proposes three scenarios for the development of electromobility, including 4.81, 3.46 million and 2.39 million vehicles by 2034 for the highest, medium and lowest impact electromobility scenarios (Secretaría de Energía, 2021).

Mexico has developed regulations concerning pollutant emission limits for vehicles. The main ones are listed in the following table.

Table 3: Mexican standards for vehicle emission limits

Standard	Description
NOM-042 SEMARNAT-2003	Maximum permissible emission limits for total or non-methane hydrocarbons, carbon monoxide, nitrogen oxides and particulate matter from the exhaust of new motor vehicles with a gross vehicle weight not exceeding 3587 kilograms, using gasoline, liquefied petroleum gas, natural gas and diesel, as well as evaporative hydrocarbon emissions from the fuel system of such vehicles
NOM-076-SEMARNAT-2012	Maximum permissible emission limits for unburned hydrocarbons, carbon monoxide and nitrogen oxides from the exhaust, as well as evaporative hydrocarbons from the fuel system, which use gasoline, liquefied petroleum gas, natural gas and other alternative fuels and which will be used for the propulsion of motor vehicles with a gross vehicle weight greater than 3,857 kilograms new at the plant
NOM-163-SEMARNAT-ENER-SCFI-2013	Carbon dioxide (CO_2) emissions from exhaust and their equivalence in terms of fuel efficiency, applicable to new motor vehicles of gross vehicle weight up to 3,857 kilograms
NOM-044-SEMARNAT-2017	Maximum permissible emission limits for carbon monoxide, nitrogen oxides, non-methane hydrocarbons, non-methane hydrocarbons plus nitrogen oxides, particulate matter and ammonia, from the exhaust of new diesel-fueled engines gross vehicle weight greater than 3,857 kilograms, and from the exhaust of new motor vehicles with a gross vehicle weight greater than 3,857 kilograms equipped with such engines

Source: (Secretaría de Medio Ambiente y Recursos Naturales, 2017); (2013); (2012); (2003)

2.3. Transportation Policies

The Ministry of Communications and Transportation 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.

This 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 to reaching 1,500 public recharging points in 2024 and establishing an appropriate disposal scheme for electric batteries, so that by 2030, 100% of these will be properly disposed of (C40 Cities Finance Facility (CFF) en colaboración con Carbon Trust México, 2018). Other governments, such as the State of Nuevo Leon, State of Puebla and State of Jalisco aims to promote sustainable mobility and encourage the use of low environmental impact (Gobierno de Nuevo León, 2016) (Gobierno de Puebla, 2019) (Gobierno de Jalisco, 2018).

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).

2.4. Other Policies and Regulations

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 cars whose propulsion is through rechargeable electric batteries, as well as electric cars that also have an internal combustion engine or hydrogen engine; the increase of the maximum deductible amount of Income Tax (ISR), related to payments for the temporary use of hybrid or electric automobiles of up to 285 pesos per day; and the implementation in 2014 of tax based on the carbon content of fossil fuels which is applied to the producer or importer of fossil fuels to discourage their use and mitigate national emissions, with the exception of natural gas and jet fuel (Secretaría de Medio Ambiente y Recursos Naturales, 2016).

In addition, the Federal Electricity Commission (CFE) provides a separate meter for home chargers, so there is no variation in the home rate and therefore no significant increase in the cost of service, since there are unit cost limits for the tariff depending on consumption (Máñez Gomis, Bermúdez Forn, Pardo González, & Orbea Otazua, 2019).

At the state level, most Mexican states exempt payment of the annual ownership tax, and in the case of states in the Valley of Mexico metropolitan area, electric and hybrid vehicles are not required to undergo environmental verification and are excluded from the "no driving today" program, which restricts vehicle traffic by days depending on the last digit of the license plate. Additionally, in 2019, a 20% discount on toll rates was offered on certain urban highways in Mexico City for hybrid and electric vehicles through a sign called "*Ecotag*" and there are exclusive parking lots, some with charging stations (Máñez Gomis, Bermúdez Forn, Pardo González, & Orbea Otazua, 2019) (Quirós-Tortós, Victor-Gallardo, & Ochoa, 2019).

2.5. Summary

Mexico has policies that favor electromobility, the most relevant of which are summarized in the Table 4. However, it should be emphasized that electromobility has not been favoured, especially in the public transportation fleet, over other technologies such as gas as a priority policy at the federal level.

Table 4: Relevant Policies for Electromobility in Mexico as of December 2020

Policy	Main components
General Import and Export Tax Law Decree DOF 03/09/2020	Import and export tax exemption for new electric vehicles for the transportation of ten or more persons , automobiles and goods vs. 20% for fossil. Valid until September 2024.
Federal New Car Tax Act DOF 30/11/2016	Exemption from the vehicle acquisition tax (ISAN) for vehicles of up to fifteen passengers (vs. between 2%-17% depending on price for fossil) and trucks with cargo capacity of up to 4,250 kg (vs. 5% for fossil).
Property Tax Law (state level)	Mexico City exempts EVs for public transportation and new electric cars from this payment (vs. 0.245%.for fossil for cab service and 0.5%FF for fossil buses)[1]
National Climate Change Strategy to 2050	It establishes the vision of the transport sector in the next 10 and 40 years, for which electric transport is considered as common.
National Electric Mobility Strategy Vision 2030	Proposes to have 10 urban areas that have incorporated electric mobility in public transport by 2030.
Transition Strategy to Promote the Use of Cleaner Technologies and Fuels	Defines 5 actions for the promotion of electromobility, including the development of technical standards
FF: Factor Fiscal, calculated as the maximum gross vehicle weight in tons divided by 30 [1]This tax is modiffied every year affected by a depreciation factor	

3. Macro-Economic Impact of EVs

Scrapping Programs

The Federal Motor Transport Vehicle Renewal Scheme began in 2003 as a Scrap Repair Program, adding the Motor Transport Modernization Program with the support of NAFIN. In 2015, the Decree was issued to encourage the renewal of the vehicle fleet, which benefits cargo and passenger transportation with units older than 10 years and that acquire a new or semi-new unit (up to 6 years). It grants an income tax discount equivalent to the lesser of the price of the used vehicle, 15% of the new vehicle or the amount listed in the following table, with the exception of urban and suburban buses, for which this table is not taken into account. In order to access the discount, the presentation of the certificate of destruction of the used vehicle was considered mandatory. The program sought to serve a maximum of 6,000 vehicles in 2015 and 2016, with a minimum participation of 3,000 renewed vehicles for owners of up to 5 vehicle units (Estados Unidos Mexicanos, 2015).

Table 5: Maximum Scrapping Fees 2015

Vehicle category	Max. amount
3-axle truck (≥14,500 kg)	8,600 USD (MXN 160,000)
2-axle truck (≥11,794 kg)	5,800 USD (MXN 107,000)
Bus type 1[1] (≥ 10 asientos)	13,400 USD (MXN 250,000)
Bus type 2[2] (≥ 30 asientos)	7,800 USD (MXN 145,000)

[1] Bus with passenger capacity > 10 persons and weight > 6,864 kg
[2] Bus with 6 wheels or more and passenger capacity > 30
Source: (Estados Unidos Mexicanos, 2015)

Currently the State Development Bank of the Federal Republic of Germany KfW is developing with the support of NAFIN a vehicle renewal programme for public transport (buses and taxis), which includes electric vehicles with a scrappage component which grants differential bonuses depending on the technology of the vehicle to be purchased, this bonus takes the highest possible value for electric vehicles. This programme has a budget of EUR 12 million, of which EUR 2 million will be used for technical assistance. Although it is in a design phase, the states that have shown interest and have committed resources are Mexico City, Oaxaca and Jalisco (Gómez, 2020).

In addition, efforts have been made at the local level with this type of programs. In Mexico City there is a *Vehicle Replacement Program for Taxis* and recently the *First Program for the Replacement of Vehicles* that are 10 or more years old, which provide public collective passenger transportation service classified as route has been announced. The program consists of providing financial support of MXN $475,000 (USD $23,400) for the acquisition of new buses, through resources obtained from the Public Transportation Financing Promotion Fund (FINTRA). The program expects to benefit 427 microbuses. To access the benefit owners must sign a letter of commitment, which specifies that the unit will be scrapped after receiving the new unit, which eliminates the barrier of service interruption (Gobierno de la Ciudad de México, 2020). The State of Mexico has a scrappage programme and the State of Sinaloa has a vehicle renewal programme, however, it does not have a scrappage component.

Although some states define a maximum useful life for the public transport fleet, the conditions of the system and the difficulties of the transporters have led them to generally exceed these limits and the scrapping processes in practice are voluntary. Mexico City has implemented a specific programme that seeks to incentivise the scrapping of units by means of a voucher, but these processes are still isolated. One of the most important difficulties encountered by the Mexico City programme, as well as by KfW in the development of its own programme, has been the structuring of the scrappage system.

Automobile Industry

The automotive industry has a 3% share of the national GDP generating 1.8% of employment in Mexico. 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 1,440 zero-emission buses in the region by 2022 (ZEBRA, 2020).

Cost of Air Pollution

With the objective of estimating the costs of air pollution, the Mexican Institute for Competitiveness generated in 2013 a study that evaluated in 34 Mexican cities the costs associated with health damages such as premature deaths, hospitalizations and consultations and losses in productivity based on PM10 concentrations (see table below) (Mexican Institute for Competitiveness, 2013).

Table 6: Estimated Economic Costs of Air Pollution in 2010

Site	Annual cost 2020 (millions)
National	MMXN 4,124 (323 MUSD)
Valle de México	MMXN 1,361 (107 MUSD)
Guadalajara	MMXN 206 (16 MUSD)
Monterrey	MMXN 461 (32 MUSD)

Source: (Instituto Mexicano para la Competitividad, 2013)

Social Aspects

Currently, travel times within the main urban areas in Mexico reach up to 2 hours a day, as in the case of the Mexico Valley Metropolitan Area (ZMVM), which means the loss of millions of man-hours and the effects derived from a poor quality of life, if we take into account the average expenditure dedicated to transportation, this represents 18% of the income of the citizens of the ZMVM and 35% for the poorest strata (Secretaría de Movilidad, 2013).

The increase in the use of fossil fuels is also reflected in the growth of vehicle-kilometers traveled which have increased by 36% in the ZMVM, from 30 million in 1990 to 84 million in 2010. This means that car use has had an annual growth of 5.3%, while the population only increased by 1.29% per year; in other words, more cars than children are added to the city annually.

In contrast, there is an enormous potential for a change towards efficient modes of transportation and the strengthening of public transportation, as an example, in the ZMVM itself, more than 70% of trips are made on foot, by bicycle and by public transportation, in addition to the fact that 50% of trips are equal to or less than 8 kilometers.

4. Transport Sector

4.1. Actors in the Transport Sector Relevant for E-mobility

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, for this has SCT Centers in each state (Secretaría de Comunicaciones y Transportes, 2009). This Secretariat is part of the technical committees of the:

- Climate Change Fund (FCC), which captures and channels public, private, national and international financial resources to support the implementation of actions to address climate change.
- National Infrastructure Fund (FONADIN), 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), whose objective is to implement actions to contribute to the fulfillment 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, 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. (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, participates in infrastructure and public transportation in investment schemes, the definition of the investment portfolio and the coordination between the private, public and social sectors as the promotion of projects under the Public Private Partnership (PPP) scheme, among others (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. SEDATU has participated, for example, in the National Strategy for Sustainable Mobility, which emphasized the importance of public transport in urban mobility (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).

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. It has participated in alliance with strategic partners in the installation of electric chargers on the national road network, promoting electromobility (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, 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 (ITM)

The ITM is a decentralized body of the SCT responsible for providing technical assistance to the transport sector, providing solutions, contributing to the safety, sustainability and competitiveness of the sector, among its powers is the promotion of the application 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, acting as a facilitator in the creation of infrastructure with high social profitability, through innovative financing schemes, with a long-term vision and expanding the participation of the private sector. It also participates in strengthening the institutional capacity of state and municipal governments through technical and financial assistance (Banco Nacional de Obras y Servicios Públicos, 2020).

National Finance (NAFIN)

National Finance 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 from 1 to 30 units. (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. It offers financing for needs of more than USD 3 million, with a sectoral vision, in sectors such as transport and energy (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. Participates in *Value Arrendadora's Border Vehicle Programme for Public Transport in Mexico* and the *Low Emission Vehicle Acquisition Programme for Mexico's Border Zone*, which seek to finance low emission public transport vehicles (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). In 2017 it financed the acquisition of 222 new transport units for the public transport company Móvil QroBus (Instituto Queretano del Transporte, 2017).

State and municipal governments

It is the responsibility of local authorities, especially states, to manage mobility in their territories through their respective local legislatures and to coordinate with actions taken at the federal level through the *General Directorate of Planning* attached to the *Ministry of Communications and Transport*. Some local authorities, with the support of the World Resources Institute (WRI) and the

National Association of Bus, Truck and Tractor-Trailer Producers, have joined together in the Mexican Association of Mobility Authorities, with the aim of improving mobility and public transportation. In this context, they have called for greater participation of the federal government in the regulation of mobility (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 for which it plans to be a leader in America and internationally recognized under the pillars of sustainability, innovation and technological development (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).

4.2. Urban Mobility in Mexico

Urban transportation in Mexico concentrates the largest number of trips in the largest cities such as those located in the Mexico City Valley, the Guadalajara Metropolitan Area and the Monterrey Metropolitan Area, in total it is estimated that 30,500,000 passengers are transported daily, the service rates depend on the operator and vary between MXN $2 and $14.60 (USD 0.10 and 0.74) by 2020. The table below summarizes the main urban public transportation operators.

Table 7: Public Transportation Modes in Mexico

Category	City	Modes of transport offered	Vehicles in operation	Lines in operation	Daily passengers transported
High capacity public transport system (structured)	Mexico City	Metro	276	12	4,300,000
		Metrobus	524	7	976,000
		Mexibús	210	3	388,000
		Trolley	147	8	140,000
		Light Train	18	1	88,000
		Public buses (RTP)	1,360	94	387,000
		Suburban train	20	1	184,000
		Mexicable	185	1	21,000
	Guadalajara	Macrobus (BRT)	120	172	130,000
		Light Train	48	2	280,000
		SITREN	53	2	15,000
		Trolleybuses	23	1	12,000
	Monterrey	Subway (Metrorrey)	40	2	500,000
		Ecotourism (BRT)	80	1	160,000
		Transmetro	86	10	91,000
		Metrobus	535	29	47,000
		Metrolink	100	6	-
	Leon	Optibus (BRT)	92	10	800,000
	Pachuca	Tuzobus (BRT)	-	1	114,000
	Chihuahua and Ciudad Juárez	Metrobus (BRT)	-	1	50,000
	Acapulco	Acabus (BRT)	135	1	100,000
	Puebla	Route (BRT)	-	3	226,000
Medium and low capacity public transport systems (semi-structured and unstructured)	Mexico City	Concessions ("route-enterprise")	2,000	22	-
		Individual concessions ("Man-truck")	15,500	106	11,540,000
	Present in several of Mexico's cities	Concessions ("route-enterprise ")	-	-	-
		Individual concessions ("man-truck")	-	-	10,000,000
Note: in some cases it was not possible to know the number of vehicles in operation and/or trips. This is due to the lack of centralization of information.					

Source: Adapted from (Carrillo, de los Santos Gómez, & Briones, 2020), (Construcciones y Auxiliar de Ferrocarriles S.A. (CAF), 2021) and (BRT Data, 2021).

Since Mexico is a federated state, each state has its own constitution. This has allowed some states to enact Mobility Laws, since the regulation and operation of urban transportation is in their hands. Coordination mechanisms occur directly between the states and the Federal Government, especially when the latter supports local governments through specific programs for mass transportation (PROTRAM), vehicle renewal programs (NAFIN), credit lines (BANOBRAS) or national strategic projects (SCT, FONATUR) that have an impact on mexican cities, such as the recent Maya Train, the Mexico City - Toluca Train, or projects already in operation such as the Buenavista - Cuatitlán Suburban Train. However, Mexico does not have a federal entity that articulates the planning and implementation of public transportation systems in different cities.

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 massive urban transport systems such as metro, trolleybus or 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 or 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 and that present difficulties in their control, operation and quality of service.

Due to the diversity of operation schemes, there are different business models implemented. In medium and low-capacity public transportation 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 the operation (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 quality of buses operated, the fare collection system and the payment rate. Under this scheme Mexibús and Mexicable operate in Mexico City and RUTA, the BRT 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.

Table 8: Characteristics of public transportation concessions in some Mexican states

State	Issuing authority	Max. duration
Mexico City	Secretary of Mobility	20 years
State of Baja California	Institute for Sustainable Mobility of the State of Baja California	30 years[a]
State of Guanajuato	Government Secretary	15 years[a]
State of Puebla	Secretary of Infrastructure, Mobility and Transport	Undetermined[b]
State of Mexico	Secretary of Mobility	10 years[c]
State of Chihuahua	Secretariat for Urban Development and Ecology	10 years[a]
State of Jalisco	Secretary of Transport	10 years[a]
State of Nuevo Leon	Institute of Mobility and Accessibility of Nuevo Leon	20 years[d]
State of Sinaloa	State Executive	10 years

[a] May be extended for equal and successive periods
[b] 30 years for Mass Public Transport Systems
[c] For the first concession and 5 years for the second concession
[d] May be extended

Source: (Gobierno de la Ciudad de México, 2003), (Gobierno del Estado de Baja California, 2020), (Gobierno del Estado de Guanajuato, 2016) (Gobierno del Estado de Puebla, 2019), (Gobierno del Estado de Chihuahua, 2020), (Gobierno del Estado de Jalisco, 2013), (Gobierno del Estado de Sinaloa, 2020), (Gobierno del Estado de Nuevo León, 2019).[1]

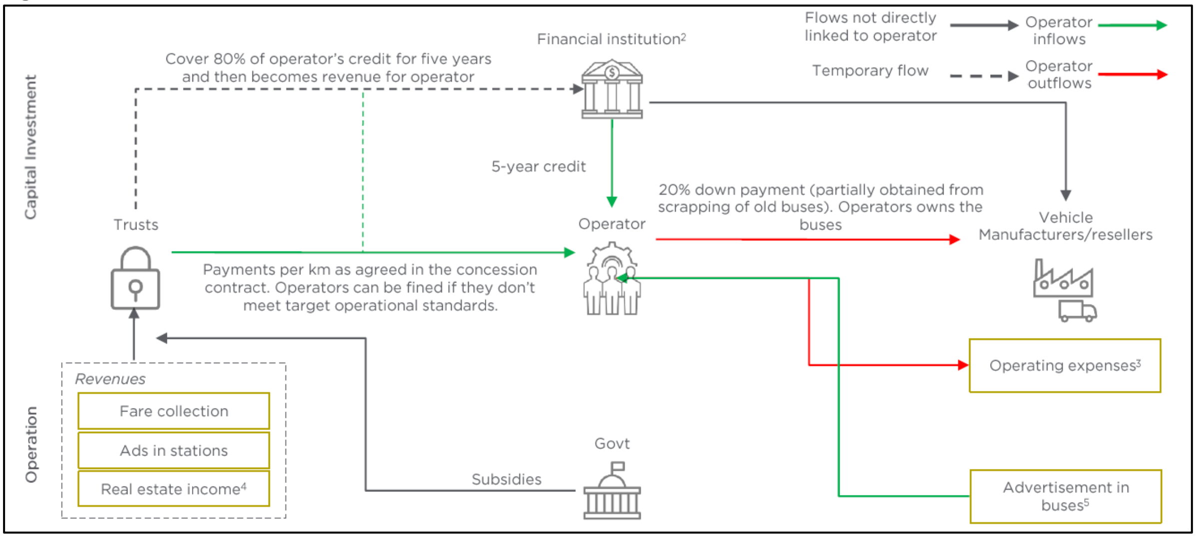
Concession contracts specify operating conditions such as route length, estimated frequency, number of estimated stops, operating hours, direction of traffic and characteristics of the vehicle fleet. Other conditions vary due to the wide range of operating schemes in Mexico. One of the most recognized models is operated by Metrobús, which grants the concession of corridors to an operator, which is subject to the service programming and operation rules defined by Metrobús and updated according to the service demand. Within this scheme, a minimum annual mileage per vehicle and a payment scheme per kilometer run are specified (Secretaría de Movilidad de la Ciudad de México, 2016).

In the structured systems, with respect to the obligations of the operators they are to carry out the activities according to the defined operation regulations and the public transport regulations applicable to the territory. In addition, a scheme of vehicle maintenance is defined, a minimum fleet layout, the acquisition of policies and insurance, responsibility to third parties and the participation in the Technical Council of the System, which is mostly formed by representatives of the local government. This Council is in charge of supervising, regulating and qualifying the service provision of the respective operator (Sistema de Tren Eléctrico Urbano, 2008).

The financing models used for the acquisition of the vehicle fleet vary depending on the operator, for example, for Metrobús and the scheme used in the Mexico City corridors, their financing schemes are summarized in the following figures. The Metrobús model is considered innovative compared to traditional transport systems and has allowed for greater control of the system and a redistribution of risks.

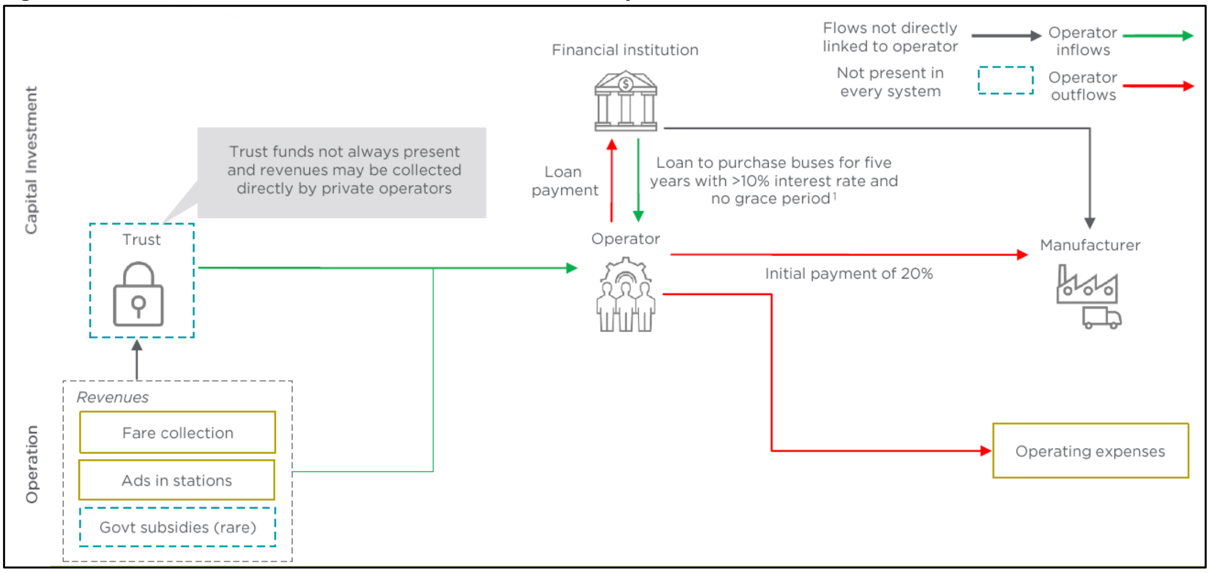
[1] Except for mass transit systems, for which it is defined by agreement between the parties. A mass transit system is understood to be one that is operated on specific roads, with specialized technical bearings and special vehicle equipment.

Figure 3: Metrobús Financial Scheme



Source: (Dalberg, 2020)

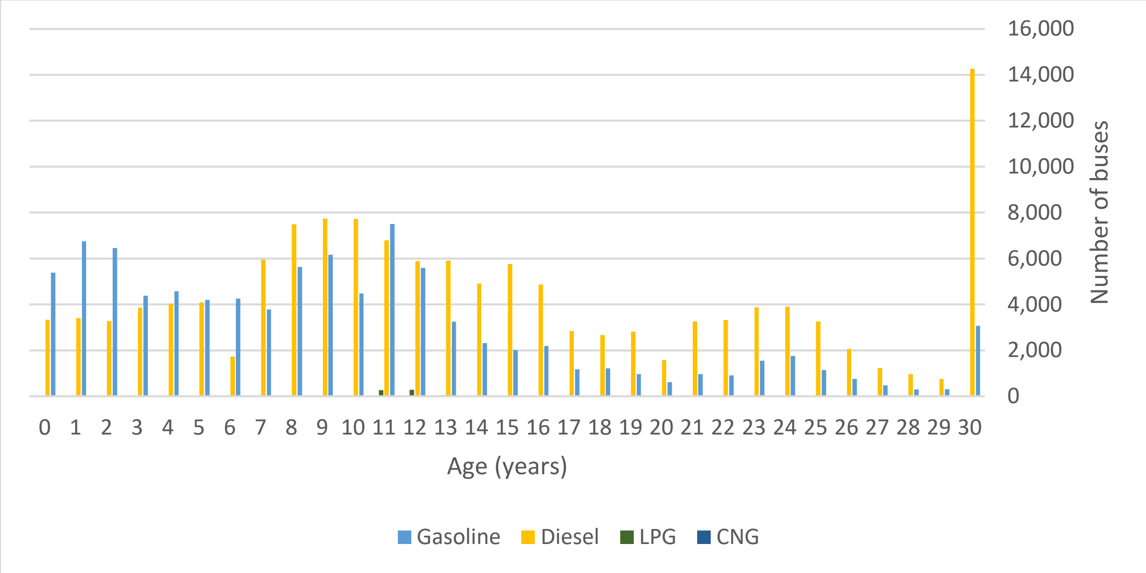
Figure 4: Financial Scheme of the Corridors in Mexico City



Source: (Dalberg, 2020)

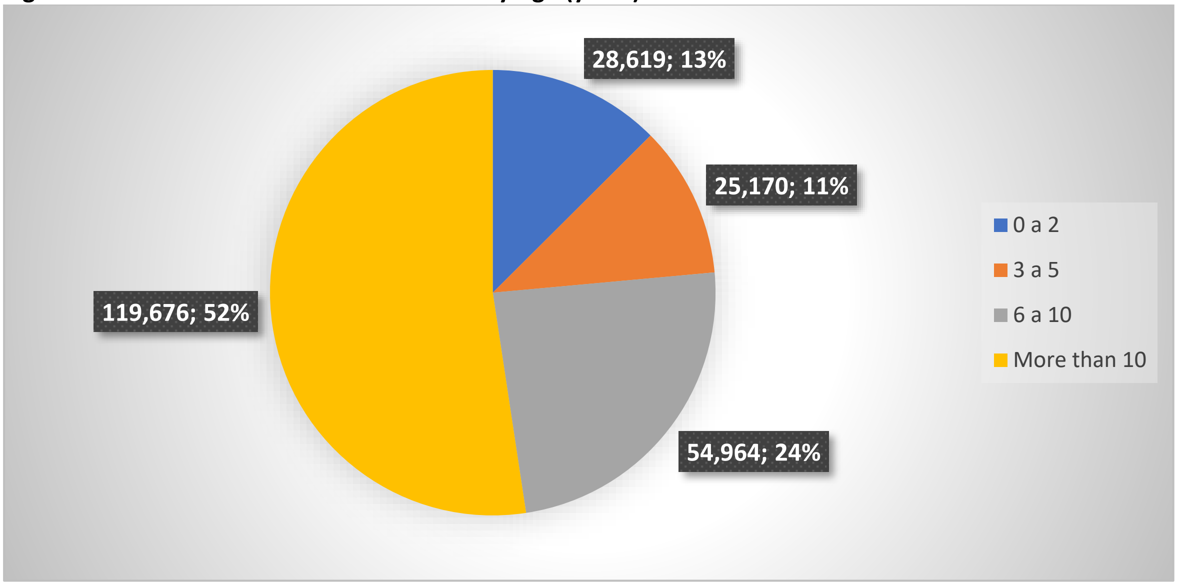
In accordance with Article 97 of Mexico City's *Mobility Law*, units used for public passenger and cargo transportation services must be replaced every 10 years, with the exception of electric and sustainable technology vehicles, which will be governed by their reference manual. The estimate of the number of buses in circulation for 2016 by fuel and age at the national level is shown in the Figure 5, from which it can be seen that 52% of the buses exceeded the 10-year age limit, clearly showing that the law is not enforced. In particular, for Mexico City in 2015, the public transportation vehicle fleet under concession, "individual bus" and "route-enterprise", had 28,960 units, of which more than 15,000 were more than 20 years old. (CTSEMBARQ México, 2015). The vehicle fleet with renewal potential in some metropolitan areas and the characteristics of the average public transport fleet in the country are summarized in the following figures. Metrobus is developing the implementation of Line 8 Circuito Interior, which will be the longest in the system and has an extension of 46.1 km, 144 stations, 3 terminals and will be operated by 4 companies that will transport approximately 258,000 passengers (Metrobús, 2020). This corridor is expected to absorb the traditional concessions operating on these routes with with 260 12-metre buses.

Figure 5: Age of the Bus Fleet in Mexico for 2016



Source: (Instituto Nacional de Ecología y Cambio Climático, 2018)

Figure 6: Distribution of Mexico's Bus Fleet by Age (years) for 2016



Source: (Instituto Nacional de Ecología y Cambio Climático, 2018)

Photo 1: Buses in Mexico City

Source: (Secretaría de Transportes y Vialidad, 2012) (Secretaría de Movilidad, 2020)

Photo 2: (a) Microbuses (most used system) and (b) "combis" operating in Mexico

(a)

(b)

Source: (CTSEMBARQ México, 2015)

Table 9: Public Transportation Vehicle Fleet to be Renovated by Age in Some Metropolitan Areas of Mexico

Metropolitan Zone	Maximum vehicle age	Fleet that exceeds the maximum age
Cancun	15	8.1%
Ciudad Juarez	12	97.4%
Chihuahua	12	75.5%
Guadalajara	10	69.0%
Mexicali	10	43.5%
Monterrey	10	25.7%
Morelia	12	33.5%
Tijuana	7	79.6%
Veracruz	15	23.7%

Source: (Instituto Nacional de Ecología y Cambio Climático - INECC, 2018)

Table 10: Characteristics of the average public transport vehicle fleet operating in Mexico by 2020

Parameter	Bi-articulated	Articulated	Buses	Microbuses	Van or "combi"
Vehicle length (m)	24	18	12	6.0 - 7-5	5
Passenger capacity	240	160	100	30	10
Technology	Euro V	Euro V	Euro V	-	-
Fuel	Diesel	Diesel	Diesel	Gasoline / LPG	Gasoline
Fuel efficiency (km/l)	1.33	1.74	1.47	1.95 / 1.40	7.12
Daily mileage	250	250	229	223	200
Average life span (years)	12	12	8	8	6
CAPEX (USD)	570,000	370,000	120,000	20,300	15,000
Maintenance cost (USD/km)	0.55	0.336	0.20	0.20	0.23

Source: (Metrobús, 2012), (SEDEMA, 2016), (Instituto Mexicano del Transporte, 2008), (C40 Cities Finance Facility & Grütter Consulting, 2018), (LOGIT, 2016), (LOGIT, 2016) (Transcolsult, 2011).

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. The following table summarizes the electromobility projects that have been developed at the national level. The trolley bus system in Mexico City, which is run by the Electric Transport System (STE), has a target of 500 units by 2024.

Table 11: Electromobility Projects in Mexico

City	Modes of transport/project	Status
Metropolitan Zone of the Valley of Mexico	Metro	In operation since 1969
	Trolley	In operation since 1951
	Zero Emissions Corridor (trolley)	In operation since 2009
	Light Train	In operation since 1986
	Project L3 Metrobus: 10 fully electric articulated buses[1]	In operation since 2020
	Project L4 Metrobus: 10 fully electric buses (12 m)	In operation by 2021
	Mexicable	In operation since 2016
	Electric cabs: 20 fully electric vehicles	In operation since 2011
	Project: Eje 8 Sur	Studies published in 2018
	Cablebus L1 and L2	In operation by 2021
Guadalajara	Trolley	In operation since 1976
	Light Train	In operation since 1994
	Project: Electric buses	Published in July 2019
Monterrey	Light Train	In operation since 1991
	Project: Electric buses	Published in July 2019
Hermosillo	Project: Electric buses	Published in July 2019

[1] Metrobus Line 3 is currently undergoing extension works on the Ethiopia - Zapata section, due to come into operation in March 2021. On this line Metrobus included 10 electric articulated units, which are part of its Electromobility Pilot Project 2020-2021 together with 10 12-metre units operating on Line 4 (Metrobús, 2020).

Source: Adapted from (Carrillo, de los Santos Gómez, & Briones, 2020), (Metrobús, 2020)

The BRT system has been accepted nationwide and has been extended to different states. The following table summarizes the next BRT projects to come into operation nationwide, as well as the new fleet required in these projects.

Table 12: Future BRT projects to be built in Mexico

BRT Project	Status	New vehicles	Vehicle type	Entry into operation
Mexibús V Naucalpan – Texcoco	State of Mexico	118	“Padron” (12.3 m)	2022
Integral Transport System Merida 1st Stage	Yucatan	187	40 Buses (12 m) 147 Buses (9 m)	2021
Zacatecas-Guadalupe Integrated Transport System 1st Stage	Zacatecas	154	Buses (12 m)	2021
Integral Transportation System in the Metropolitan Area of Aguascalientes	Aguascalientes	228	127 Buses (12 m) 101 Buses (10 m)	2021
Integrated Transportation System Ciudad Juárez Technological Corridor	Chihuahua	262	Buses (12 m)	2021
Peribús Integrated Transport System, Stage 1 Guadalajara	Jalisco	289	105 Articulated Buses (18 m) 184 “Padron” (12.3 m)	2021
Corridor 1 West of the Integrated System of Oaxaca Metropolitan Zone of Oaxaca	Oaxaca	117	Buses (12 m)	2022
Two Rapid Transport Corridors in the San Luis Potosi M.Z.	San Luis Potosi	21	Buses (12 m)	2021
Rapid Transport Corridor Metropolitan Area of La Laguna	Coahuila and Durango	215	41 “Padron” (12.3 m) 174 Buses (12 m)	2021
SIT Chihuahua 1st Stage Extension of Corridor 1	Chihuahua	54	Buses (9 m)	2021

Source: (González Zozaya, 2018), (Fondo Nacional de Infraestructura, 2020)

4.3. Taxi and Ride-Hailing Services

There are four classifications of the cab service:

1. Site service: the service is provided without a fixed route, through authorized physical spaces in bases, modal transfer centers, terminals and other places determined by the authority;
2. Free: operating without a fixed route or permanent assignment to any service base and which is the most common;
3. Radio cab, which can be site or free and also have a communication service accessible to users for hiring the service;
4. Tourist: which is exclusive for transportation in a tourist attraction center such as hotels, restaurants, museums and other recreational places (Jiménez Bautista, 2009).

As in some urban public transport services by bus, the cab service operates under the individual concession modality, which is granted by the relevant local authority with exception of the airport cab service, which is concessioned by the Ministry of Communications and Transportation and for which a contract or agreement must also be signed with the respective airport administrator (Comisión Federal de Competencia Económica, 2019). The local authorities establish the characteristics of the vehicles and the operation rates. The final cost paid by users depends on the distance traveled, waiting time, transit delay, charge or initial flag (Jiménez Bautista, 2009).

As requirements for access to the concession, the technical, administrative and financial capacities to provide the service must be accredited, experience and economic solvency must be guaranteed, and training, maintenance and vehicle replacement programs must be presented. Prior to the concession process, a declaration of necessity must be issued by the local authority and the maximum duration of the concession varies depending on the state[2]. For Mexico City it is 20 years, although it can be extended for an equal period of time. Among the obligations of the concessionaire are to provide auxiliary transportation equipment for the provision of the service, to exercise control over the driving licenses of its drivers, as well as to have insurance policies for damages to third parties. Also, the concessionary must have 20% of the units conditioned to provide the service to persons in a condition of disability, among others (Jiménez Bautista, 2009).

The service of public transport concessioned individual, cab, in 2019 had 721,900 units in circulation, usually owned by a natural person, who can rent the vehicle to a driver for a daily payment. The organization of the sector, in most cities, is done through associations of individual owners, however, most of the sector is not associated with any of them. Individuals can form a company to process concessions, which is why the number of concessions per registered company can vary from 1 to 200 on average (Rocha, 2021). In Mexico City the number of active concessions is around 18,000 and in the State of Mexico 15,800 (Secretaría de Movilidad, 2018).

The most common models nationwide are the *Nissan Tsuru, Chevrolet Malibu* and *Nissan Urban* (Instituto Nacional de Ecología y Cambio Climático - INECC, 2018) (Instituto Nacional de Estadística y Geografía, 2020). Below the age of vehicles by fuel type for 2016, which shows the predominance of gasoline as the fuel.

[2] In general, the duration of the taxi concessions are the same as for buses, presented in the Table 8.

Photo 3: (a) Electric cab service in Mexico City and (b) Traditional cab vehicle

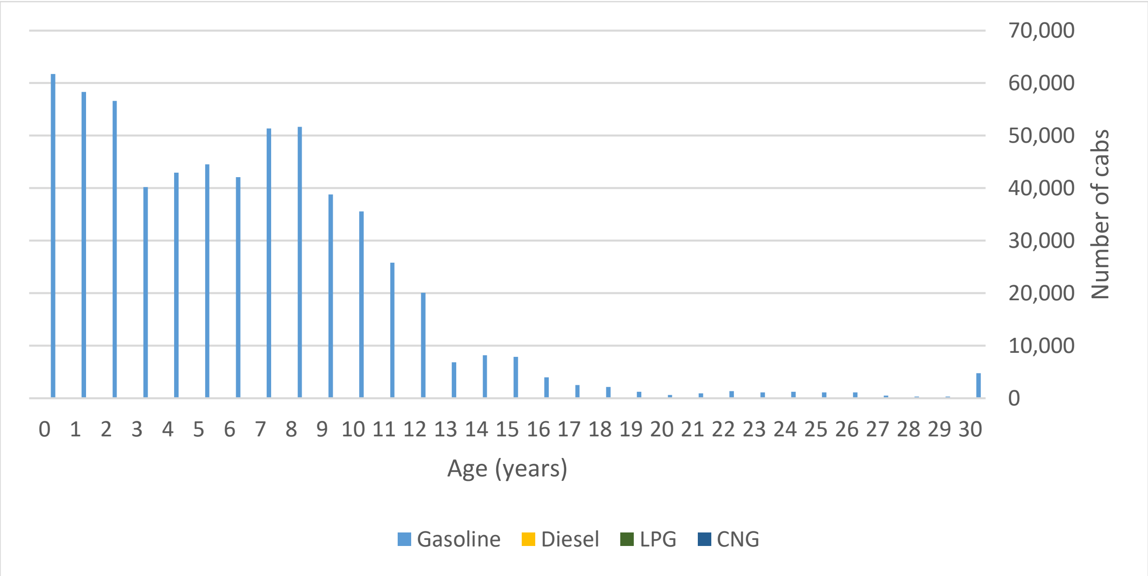
Source: (Secretaría de Movilidad, 2017), (Secretaría de Movilidad, 2019)

Table 13: Characteristics of the average cab vehicle fleet operating in Mexico by 2020

Parameter	Value
Technology	Euro IV
Fuel	Gasoline
Fuel efficiency (km/l)	12.50
Annual mileage	65,520
Average life span (years)	10
CAPEX (USD)	15,754
Maintenance cost (USD/year)	1,509

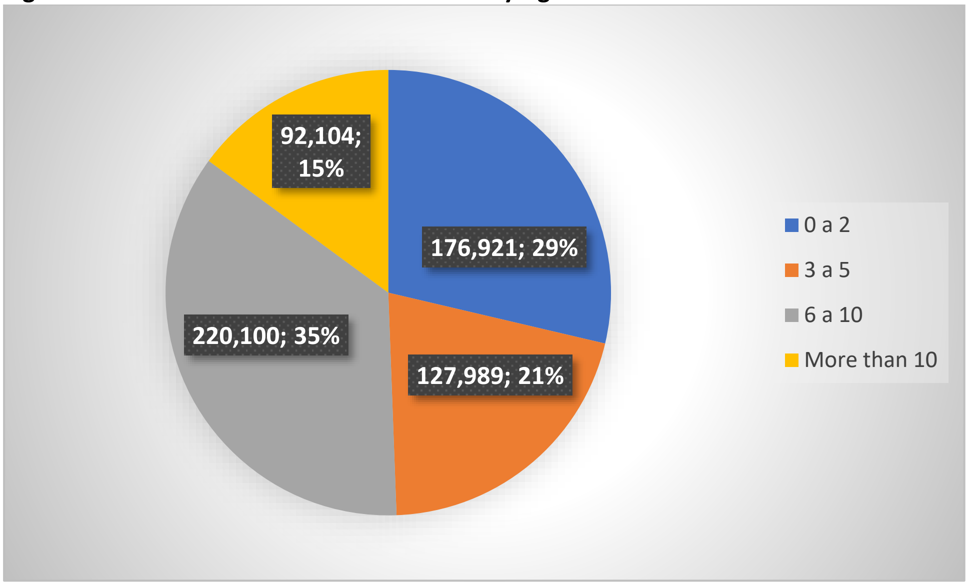
Source: (Instituto Nacional de Ecología y Cambio Climático - INECC, 2018), (Rodríguez, 2013)

Figure 7: Age of Mexico's Taxi Fleet for 2016



Source: (Instituto Nacional de Ecología y Cambio Climático, 2018)

Figure 8: Distribution of Mexico's Taxi Fleet by Age for 2016



Source: (Instituto Nacional de Ecología y Cambio Climático, 2018).

In Mexico City, the *Mobility Law* establishes the renewal of cab type vehicles every 10 years. This city has 133,628 street cabs, of which 1,022 are more than 20 years old, 29,496 are between 10 and 20 years old and 103,110 are less than 10 years old i.e. the law is not enforced. 99% of vehicles (132,921) use gasoline, 481 are hybrids, 51 are diesel, 48 use LPG, 30 are electric and 17 use natural gas. (Secretaría de Movilidad, 2020). The potential for fleet renewal for some metropolitan areas of Mexico is summarized below.

Table 14: Vehicle fleet of cabs to be renewed by age in some metropolitan areas of Mexico

Metropolitan Zone	Maximum vehicle age	Fleet that exceeds the maximum age
Cancun	10	50.9%
Ciudad Juarez	10	97.2%
Chihuahua	10	81.6%
Guadalajara	10	98.3%
Mexicali	10	5.4%
Monterrey	8	9.2%
Morelia	12	65.2%
Tijuana	7	67.9%
Veracruz	8	15.3%
Mexico City	10	22.8%

Source: (Instituto Nacional de Ecología y Cambio Climático - INECC, 2018), (Secretaría de Movilidad, 2020)

Since 2002, Mexico City has implemented the *Taxi Replacement Program*, which seeks to encourage the renewal of the vehicle fleet under a financial scheme that seeks 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. In 2020 it is expected to finance 610 units (Secretaría de Movilidad, 2020). For this purpose, 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 with the possibility of an additional MXN $10,000 if they include inclusion measures for the elderly or people with disabilities. In addition, financing is facilitated by means of a support through financial entities of the Nacional Financiera (NAFIN) with a maximum interest rate of 16.5% and a loan term of up to 72 months (Instituto Mexicano del Transporte, 2012) (Nacional Financiera, 2020).

In this same city, the *Zero Emissions Taxi Pilot Program* was carried out, which in 2012 allowed the entry into operation of 20 electric units; in this scheme, the administration and operation of the units was in charge of the *Historical Center Trust Fund, which* granted the service to the Taxi-4000 company (Gobierno de la Ciudad de México, 2012). A year later, the pilot program was completed and the cabs were placed under the responsibility of the decentralized public agency, *Servicio de Transportes Eléctricos del Distrito Federal*.

In Mexico there are different Transportation Network Companies (TNS) or shared transport platforms, the most popular being Uber, Cabify and DiDi. The most used models are Nissan Versa, Chevrolet Aveo, Volkswagen Vento, Ford Figo and Chevrolet Spark (KAYUM, 2019). Its regulation is different throughout the country. The states of Aguascalientes, Coahuila, Estado de México, Querétaro, San Luis de Potosí and Mexico City have issued some type of regulation for its operation; similarly the state of Hidalgo has prohibited its operation in its territory (Ramos, 2020). In Mexico City, the E1 license was created, exclusively for platform drivers and whose requirements make it equal to the type B license required for cab service. In addition, the vehicle magazine was included as a requirement and the minimum value of vehicles in operation was established at MXN $250,000 (USD 12,600) (Seretaría de Movilidad, 2018). In this city, the drivers must contribute 1.5% of the income of each trip, destined to the Fund for Taxi, Mobility and Pedestrian, whose objective is to improve the transportation infrastructure and train cab drivers. The regulation conditions vary for other states, for example, in Oaxaca an alliance was generated with the DiDi platform through which the regulated operation is allowed through the concessioned service. In addition, this company makes its application available to traditional cab drivers in order to obtain the benefits (COPARMEX, 2020).

4.4. Light Commercial Vehicles for Urban Freight

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. With respect to electric vehicles, this sector has realized some initial pilot projects, such as 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. The energy company ENGIE acquired part of this delivery company and included in its operations for Mexico City 14 electric vans in 2019, with the capacity to transport 500 kg of cargo and a range of 150 to 200 km, together with a network of chargers (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 and* the energy is obtained from the generation of the Piedra Larga Wind Farm in Oaxaca, which is owned by the same group. The company has 400 EVs in operation and expects to introduce 4,000 more by 2024 (Grupo BIMBO, 2020). Danone, dairy products producer has designed together with BYD, *Thermoking,* Industrias Zubiría and *Element* a refrigerated electric vehicle, of which they expect to incorporate 10 units in 2021 (Lastiri, 2020). In 2019, Grupo Modelo imported its first electric truck for distribution. Its goal is to reduce emissions by adding 2,000 units and reach a 100% sustainable fleet by 2025 (Sánchez Fermín, 2019). Similarly, DHL announced in 2020 the acquisition of 20 electric vehicles in a partnership with Renault.

5. E-Mobility System

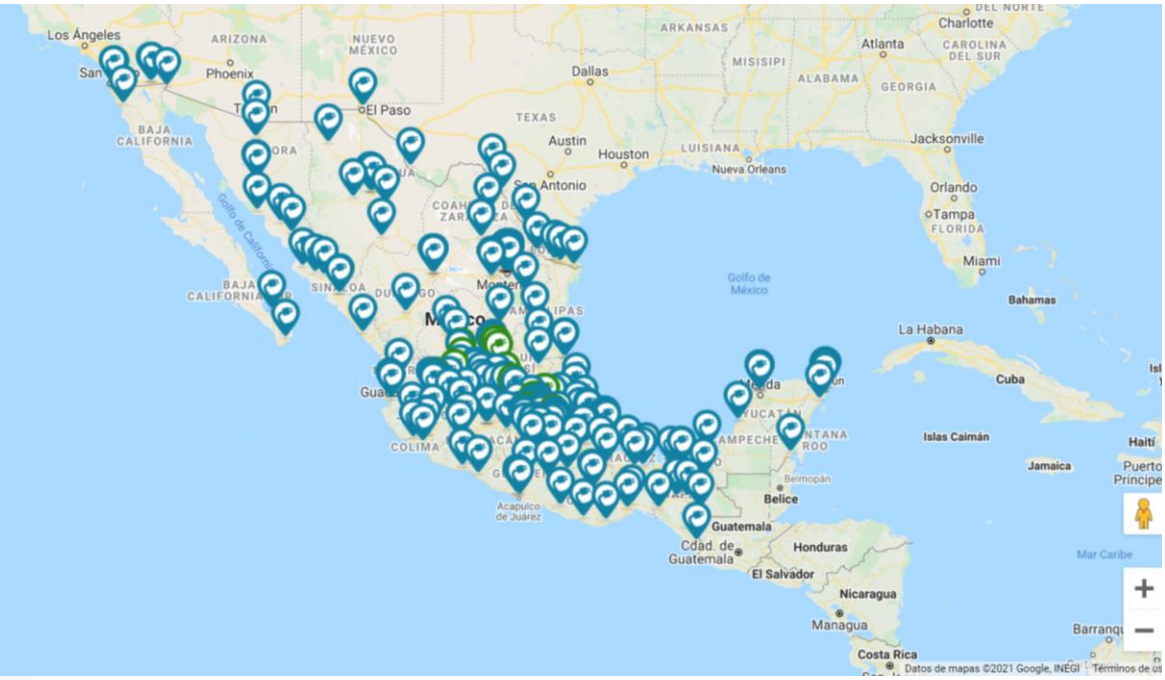
With regard to the electromobility system in public transport, decentralized public entities such as Metrobus play an important role, where structured models predominate and which, given their institutional nature, facilitate the conditions for promoting this technology. Furthermore, in order to overcome some of the barriers in unstructured or semi-structured schemes such as "individual", "route-enterprise" and individual cab owners, the participation of development banks such as NAFIN and local authorities is indispensable, so that together they develop strategies that allow access to credit, training and strengthen institutional support for the operator, who must acquire the vehicle. On the energy supply side, the Federal Electricity Commission is in charge of establishing policies that facilitate operations such as differential rates, coordinating and expanding infrastructure.

The country's public charging network began with the installation of the first fast charging station[3] in 2011 in Mexico City. Since this year, various states have made efforts to install charging infrastructure in their territories, in addition to the efforts of vehicle marketers such as BMW, Nissan and Tesla. In association with the Federal Electricity Commission, the Mexican Association of the Automotive Industry (AMIA), the Government of Mexico City and the Ministry of Energy (SENER) generated the Program for the *Promotion of Electromobility through Investment in Charging Infrastructure (*PEII). This program aims at connecting 10 states with fast chargers and to strengthen the existing interurban infrastructure in Mexico City, Monterrey and Guadalajara, which are operated by the CFE (Comisión Federal de Electricidad, 2017). A total of 100 stations are expected to be installed, of which 84 are level 2 (7 kW) and 16 are level 3 (50 kWh). The manufacturer Tesla has installed an ultra-fast charging center in Cuernavaca (UN Environment, 2018).

By 2018 the total number of charge points was 1,528; most of them located in Mexico City (21%), Nuevo Leon (11%) and Jalisco (9%), the figure below**Error! Reference source not found.** shows the distribution of them in the country (Instituto Mexicano del Transporte, 2020).

[3] 50 kW

Figure 9: Charge points for vehicles in Mexico



Estación de carga 7kW

Estaciones de carga rápida 50kW

Source: (ChargeNow, 2021)

Figure 10: National network of fast chargers in Mexico

Source: (Instituto Mexicano del Transporte, 2020)

The following table summarizes the number of hybrid and electric vehicles registered in Mexico since 2016. By 2019, 52% of the units were sold in Mexico City and the State of Mexico. The figures show not only that the number of EVs in Mexico is marginal (200-300 units per year) but also that there is no trend towards increasing EV numbers.

Table 15: Sales of electric vehicles in Mexico in relation to total vehicle sales

Year	HEV	PHEV	EV	Total	% of total vehicles
2016	7,490	521	254	8,265	0.5%
2017	9,349	968	237	10,554	0.7%
2018	16,022	1,584	201	17,807	1.2%
2019	23,964	1,339	305	25,608	1.9%
2020[1]	6,717	779	119	7,615	1.7%

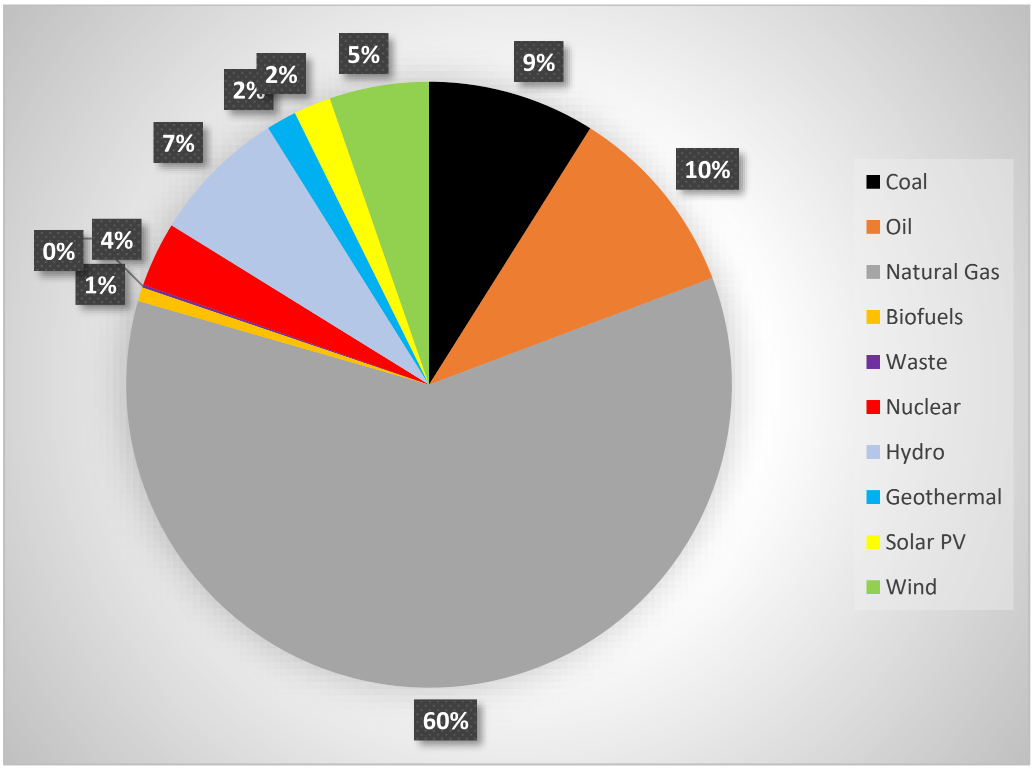
HEV: Hybrid Electric Vehicle
PHEV: Plug-in hybrid electric vehicle
EV: Electric Vehicle
[1] Values for 2020 are likely to be lower due to the COVID 19 health contingency. Overall, new car sales declined by 28% (Instituto Nacional de Estadística y Geografía, 2021)
Source: (Instituto Mexicano del Transporte, 2020)

6. Power Sector

6.1. Electricity Generation

2019 Mexico produced 17% of electricity based on renewables[4]. Natural gas is by far the largest source of electricity production, followed by oil and coal (see following figure).

Figure 11: Electricity Generation Mexico 2019

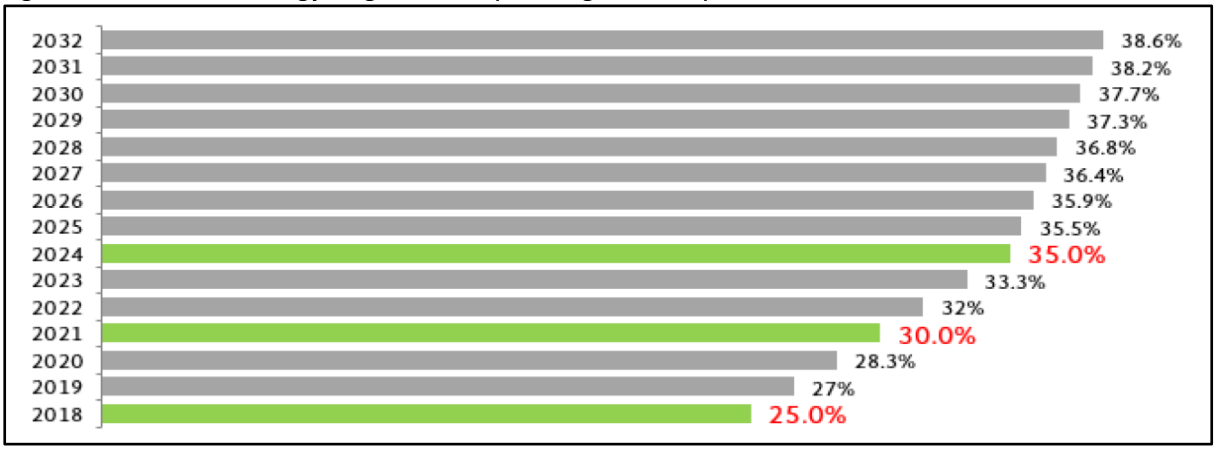


Source: IEA

[4] Including nuclear energy the share is 21%

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% (see figure below).

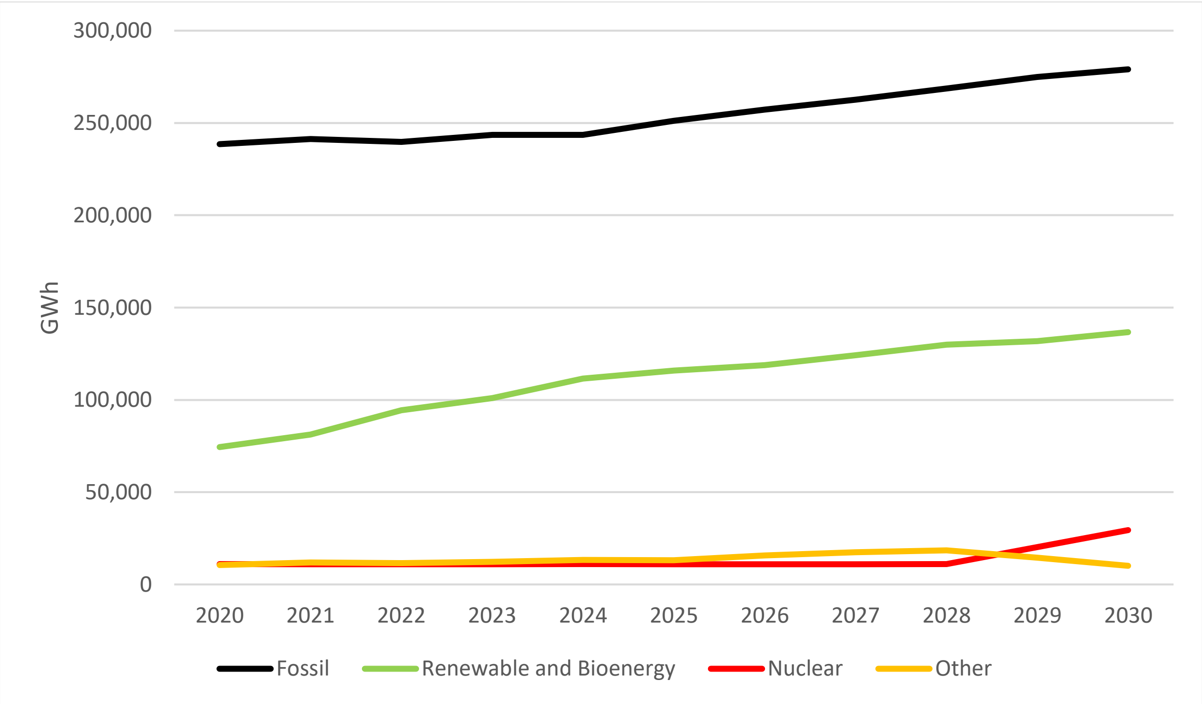
Figure 12: Renewable Energy Target Mexico (in % of generation)



Source: Elaborated by SENER and cited in (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). The following figure shows the projected electricity generation of Mexico to 2030 relative to the energy sources. Based on the projections of Sener the carbon grid factor should slightly decrease by 2030.

Figure 13: Projected Electricity Generation per Source 2020 to 2030 Mexico (GWh)



Source: (SENER, 2018)

Production as well as consumption are expected to grow on average annually around 3%.

6.2. Grid Factor

The carbon emission factor of the grid is calculated based on national data. The latest available grid factor is used. The actual grid factor is taken and not the grid factor used by UNFCCC methodologies based primarily on the Combined Margin (CM). The UNFCCC approach using the CM is not applied as former was designed primarily for renewable energy projects trying to capture what type of electricity would be displaced from more GHG intensive means[5]. It is a tool designed for energy supply and not energy demand projects. The CM does not reflect actual GHG emissions of the electric grid and in some cases can be far off actual emissions due (i) non-inclusion of low-cost/must-run (LCMR) resources defined as power plants with low marginal generation costs or dispatched independently of the daily or seasonal load of the grid including primarily hydro, geothermal, wind, low-cost biomass, nuclear and solar generation and (ii) the non-inclusion of CDM projects in the CM. Especially the non-inclusion of LCMR resources result in misleading results.

Following values are used for the grid factor of Mexico (all year 2018, IEA database):

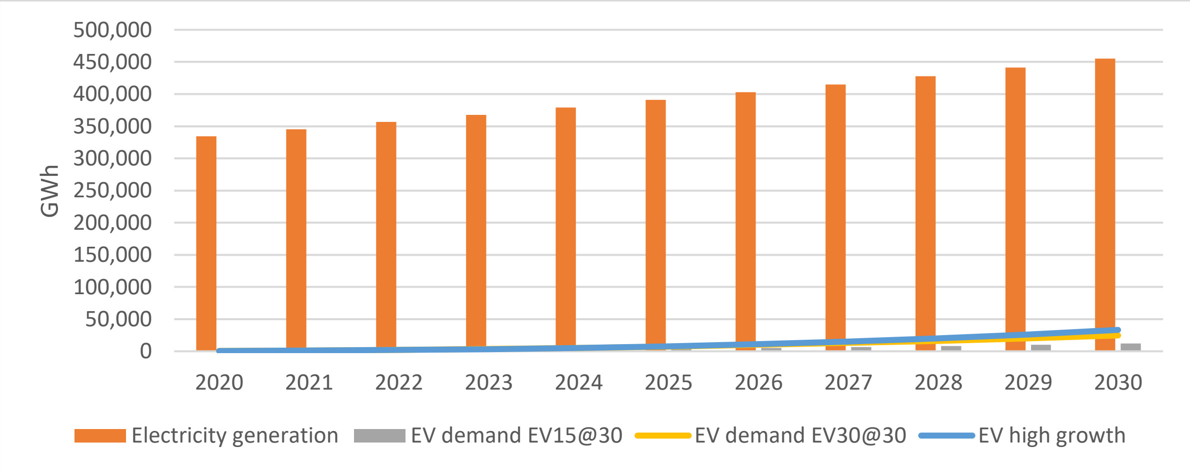
- Total electricity generation: 335,583 GWh
- Electricity losses: 46,940 GWh
- GHG emissions from electricity generation: 152,705 tCO_{2e}

The carbon factor of the electricity grid of Mexico is therefore: **0.529 $kgCO_2/kWh$**[6].

6.3. Electricity Demand from EVs

The following figure shows the projected electricity demand from EVs based on the three scenarios and the projected electricity generation of Mexico.

Figure 14: EV Electricity Demand vs Generation Mexico 2020-2030



Source: Grutter Consulting based on EV scenarios and generation based on (ICE, 2019)

The 2030 electricity demand of EVs represents 3% of projected electricity generation for the EV15@30, 5% for the EV30@30, and 7% for the highest potential scenario. In the highest scenario the EV demand would represent 27% of the additional demand expected by 2030 (compared to 2020).

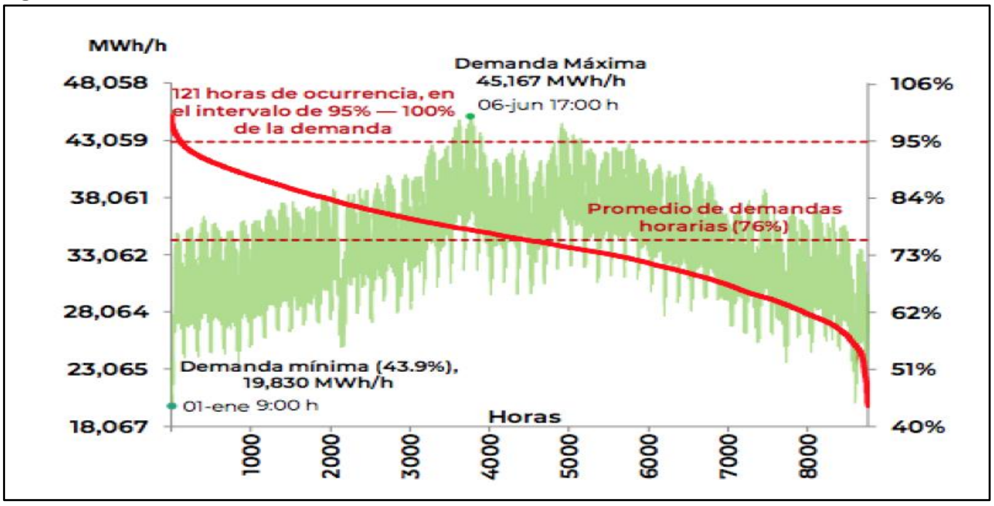
[5] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v6.pdf
[6] GHG emissions / net production

The demand increase is very gradual and thus leaves enough time to the country to plan a small production expansion required.

Running 100% EVs not only stresses the grid in terms of electricity production but also in terms of power demand. EV charging can have a sizeable impact on the loads applied to the grid at certain times and locations. The rise in the number of EVs can be accommodated fairly easily by power generation facilities as long as the vehicles are charged off peak. Faster charging during peak demand, however, can have a significant impact[7]. The extent on which EVs will impact the electricity networks will depend highly on technologies and charging modes used with the bulk of charging expected to occur in low-voltage distribution grids in residential or commercial areas (IEA, 2017). The management of the grid is considered critical rather than absolute capacities. Problems which can occur are increased peak loads and charging hotspots resulting in local network overloading. EV charging can have a sizeable impact on the loads applied to the grid at certain times and locations.

The following figure shows the typical demand curve in Mexico.

Figure 15: Demand Curve Mexico



Source: (SENER, 2019)

The 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. Intermediate fast-charged buses are charged 1-2x per day during off-peak transport hours which also coincide with low demand times of the power sector and opportunity charged buses can easily be equipped with large-enough battery sets to run 2-3 hours without charging.

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 in the evening may however result in this additional demand coinciding with the

[7] Peak demand from a single EV using a top-of-the-range fast charger can be 80 times higher than the expected peak demand of a single typical household.

evening peak electricity demand resulting in a higher risk of overloading of the power distribution network ultimately requiring additional generation capacity and network upgrades. Solutions being proposed for these problems involve controlled charging and smart charging using Demand Side Management (DSM).

Mexico has not established special tariffs for electricity consumption for EVs. For home chargers a separate electricity counter is installed. This avoids households from moving up into higher price levels due to increasing consumption levels.

7. Transport Emissions

7.1. Introduction

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[8]. Euro 6 standards are under discussions and are compulsory for Heavy Duty Vehicles (HDVs) since 01/2021[9]. 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). The ethanol share in gasoline is currently 0.4% and the biodiesel share in diesel 0.02% (Centro de Estudios para el Desarrollo Rural Sustentable y la Soberanía Alimentaria, 2020). GHG calculations are thus not influenced by this low biofuel share. The following table shows the median age of vehicles per category and the resultant average vehicle emission category for 2019 calculations and for 2030 projections.

Table 16: Vehicle Median Age and Emission Category

Vehicle Category	Median year in 2019	average emission standard 2019	Median year in 2030	average emission standard 2030
Passenger car	2008	Euro 3	2019	Euro 4
Motorcycle	2015	Euro 3	2026	Euro 4
Taxi	2013	Euro 3	2024	Euro 4
Small bus	2010	Euro 4	2021	Euro 4
Urban bus	2006	Euro 4	2017	Euro 4
LCV	2005	Euro 4	2016	Euro 4
Coach	2006	Euro 4	2017	Euro 4
Truck	2003	Euro 4	2014	Euro 4

Source: Based on data of INE and Coordinación General de Contaminación y Salud Ambiental

7.2. Transport Emissions 2019

The following table shows registered vehicles of Mexico in 2019.

[8] 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

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

Table 17: Vehicles Registered Mexico 2019

Vehicle category	Gasoline	Diesel	Total
Passenger car incl. pick-up	37,528,703	765,892	38,294,595
Taxi	721,900	0	721,900
Motorcycle	4,806,740	0	4,806,740
small bus	94,569	4,977	99,546
standard urban bus	0	128,832	128,832
Coach	0	50,670	50,670
LCV	2,676,173	1,784,116	4,460,289
Truck < 7.5t	0	1,115,861	1,115,861
Truck 7.5-16t	0	260,748	260,748
Truck 16-32t	0	204,873	204,873
Truck >32t	0	351,124	351,124

Source: (Instituto Nacional de Estadística y Geografía, 2020); Share per vehicle type based on INE, 2016 for city of Mexico for cars and taxis and Secretaría de Comunicaciones y Transportes, 2020 for buses and trucks. Estadística Básica del Autotransporte Federal, (if share <1% not included except for cars); small buses include minibuses and pick-ups used for passenger transport; share of LCVs diesel adjusted for total fuel consumed; passenger cars incl. pick-ups;

Compressed Natural Gas (CNG) or Liquefied Petroleum Gas (LPG) is only used in very small numbers. Urban buses include basically standard 12m units. However also medium sized buses as well as articulated and bi-articulated units operate in Mexico.

Air quality in Mexico is monitored through the National Air Quality Report. According to the latest report corresponding to 2018, permissible limits were exceeded by 32 cities for PM10 (75 µg/m^3/day), 25 cities for $PM_{2.5}$ (45 µg/m^3/day), 30 cities for O_3 (0.095 ppm/hour), 1 city for CO (11 ppm/8 hours) and none for NO_2 and SO_2. The Metropolitan Zone of the Valley of Mexico has the highest frequency of occurrence in exceeding current air quality standards, followed by the Metropolitan Zone of Guadalajara and the Metropolitan Area of Monterrey (National Institute of Ecology and Climate Change INECC, 2018).

The following table summarizes core assumptions on milage and fuel consumption[10].

Table 18: Main Parameters Used for Emission Calculations 2019

Vehicle Category	Fuel Used	Specific fuel consumption (l/100km)	Annual mileage (km)
Passenger car	Gasoline	7.6	11,500
	Diesel	6.5	11,500
Taxi	Gasoline	7.6	55,000
	Diesel	6.5	55,000
Motorcycles	Gasoline	2.7	10,000
small bus	Diesel	18	40,000
standard urban bus	Diesel	47	58,000
Coach	Diesel	29	40,000
LCV	Gasoline	9.4	16,700
	Diesel	9.5	16,700
Truck < 7.5t	Diesel	12	29,000
Truck 7.5-16t	Diesel	18.4	29,000
Truck 16-32t	Diesel	24.9	29,000
Truck >32t	Diesel	29.7	29,000

[10] Fuel consumption is the base for calculation of GHG emissions using for tank-to-wheel (TTW) calculations the fuel consumed, Net Calorific Value and the CO_2 Emissions factor and for well-to-wheel (WTW) calculations an upstream mark-up for fuel extraction, refinery and transport plus the GHG emissions caused by Black Carbon.

Source: Distance driven based on weighted averages per vehicle category (based on distance per vehicle year); source: Instituto Nacional de Ecología y Cambio Climático. Elementos de inventario de fuentes móviles: Inventario de emisiones de fuentes móviles carreteras, 2016. Coordinación General de Contaminación y Salud Ambiental. Ciudad de México. 2018 (for cars, taxis, motorcycles, small buses, urban buses, LCVs: other categories estimated and calibrated with fuel consumed); Fuel consumption: Passenger car size small; all fuel consumption values from (EEA, 2020) Tier 2 approach for vehicles > Euro 1/I;

The following table shows estimated 2019 transport emissions for Mexico. The model has been calibrated with actual transport fuel consumed by Mexico in 2019 based on PEMEX with a difference between top-down actual gasoline and diesel consumption and the modelled bottom-up consumption of 0.3% for gasoline and 0.4% for diesel.

Table 19: Estimated 2019 Road Transport Emissions

Vehicle category	NO_x	$PM_{2.5}$	CO_2 TTW	CO_2 WTW	Energy in TJ
Passenger car	45,651	819	75,740,535	90,520,521	1,091,494
Taxi	3,573	44	6,825,975	8,128,807	98,499
Motorcycles	9,325	168	2,988,220	3,593,835	43,120
small bus	1,014	8	1,817,419	2,171,959	26,135
standard urban bus	40,500	345	8,841,654	11,108,257	119,321
Coach	9,161	72	1,595,124	2,010,433	21,527
LCV	27,620	1,268	17,199,096	21,731,520	241,084
Truck < 7.5t	53,070	343	10,413,965	13,040,713	140,539
Truck 7.5-16t	20,038	122	3,734,539	4,675,659	50,399
Truck 16-32t	22,755	142	3,975,477	4,985,685	53,650
Truck >32t	46,942	273	8,143,646	10,200,888	109,901
Total	279,649	3,603	141,275,652	172,168,278	1,995,669

Source: Grutter Consulting; for details of modelling data see Annex 1

Road transport GHG emissions of Mexico TTW in 2019 were 141.3 million tCO_{2e}. Based on fuel sales the emissions are 140.8 million tCO_{2e} i.e. the modelled values reflect well the monitored top-down calculation. WTW GHG emissions of 172 million tCO_{2e} reflect the GHG emissions caused directly and indirectly by the transportation sector of Mexico: these emissions occur basically within the country due to fuel extraction, refinery and transport.

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.

7.3. Projected 2030 Transport Emissions

For 2030 projections an elasticity or growth factor per vehicle category was determined.

Table 20: Parameters for Projection of Vehicle Numbers and Emissions

Parameter	Value	Source/Explanation
CAGR population growth 2019-2030	0.5%[11]	OECD: https://stats.oecd.org/Index.aspx?DataSetCode=POPPROJ
CAGR GDP real growth 2019-2030	1.1%	World Economic Outlook (October 2020) - Real GDP growth (imf.org)
CAGR GDP per capita growth 2019-2030	0.6%	Calculated from GDP and population growth rate
CAGR freight transport growth rate	1.1%	Freight intensity of 0.98[12] based on income per capita 2030 of 11,200 USD using 2019 data from the World Bank and the real GDP growth rate
CAGR passenger transport growth rate	3.7%	Based on a projected vehicle ownership per tsd inhabitants of 491 by 2030 (Sommer, 2007) and the resultant vehicle number growth

Vehicle growth rates per vehicle category are used to model vehicle numbers for 2030. The mileage of vehicles is kept constant. The following table shows projected 2030 transport emissions of Mexico.

Table 21: 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; for details of modelling data see Annex 1

TTW emission from the transport sector are expected to grow under a BAU scenario by nearly 40% reaching 195 million tCO_2 by 2030 (237 million tCO_{2e} with a WTW approach).

8. EV Scenarios

3 different EV scenarios have been constructed which are contrasted with the BAU scenario:

- EV30@30: The EV30@30 scenario of IEA has as target that 30% of all vehicles sold in 2030 are electric. The scenario is built on newly purchased vehicles (and not the stock of vehicles) in line with IEA scenarios (IEA, 2019). In addition to the IEA also motorcycles and trucks <7.5t are included with the same EV penetration rates.
- EV15@30: The moderate EV scenario is based on the "EV new policies scenario" which has as target for 2030 15% instead of 30% EV share. The same approach is used as for EV30@30.

[11] Population 2019: 124 million; 2030: 131 million
[12] Freight intensity rates based on groupings realized by **Invalid source specified.**, table 2-4

- 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 number of vehicles to be newly registered per annum is the sum of additional vehicles (due to vehicle growth) and replacement vehicles. The following table shows the average lifespan of vehicles and the average annual replacement rate of the fleet as used for projections.

Table 22: Average Lifespan and Replacement Rate per Vehicle Category Mexico

Vehicle category	lifespan in years	% replaced per annum
Passenger car	20	5%
Taxi	11	9%
Motorcycles	5	20%
small bus	7	14%
standard urban bus	16	6%
Coach	23	4%
LCV	23	4%
Truck < 7.5t	25	4%
Truck 7.5-16t	29	4%
Truck 16-32t	29	4%
Truck >32t	29	4%

Source: Grutter Consulting based on Instituto Nacional de Estadística y Geografía, 2020

EV 15@30 and 30@30 Scenarios

The following table shows the modelled share of EVs as total of new registered vehicles from 2019 to 2030.

Table 23: EV Rates of Newly registered Vehicles

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
EV15@30	3%	3%	4%	5%	7%	9%	10%	11%	12%	14%	15%
EV30@30	5%	6%	8%	11%	14%	18%	20%	22%	24%	27%	30%

Source: Grutter Consulting based on IEA scenarios

EV High Growth Scenario

The share of newly registered EVs for the selected vehicle categories in the high growth scenario is shown below.

Table 24: Share of EVs of Newly Registered Vehicles "High Growth Scenario"

Vehicle Category	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Taxis	0%	0.2%	3.8%	7.9%	13.9%	21.9%	32.3%	45.3%	60.9%	79.5%	100.0%
Urban Buses	0%	0.5%	4%	8%	14%	22%	32%	45%	61%	79%	100%
Small buses	0%	0.5%	4%	8%	14%	22%	32%	45%	61%	79%	100%
LCVs	0%	0.0%	4%	8%	14%	22%	32%	45%	61%	79%	100%

Source: For urban buses, taxis and LCVs the target is that 100% of new registered buses/taxis/LCVs in 2030 are electric; This takes into consideration that EVs in this segment should be cost-competitive by 2030. No early replacement of vehicles is made i.e. conventional vehicles could still be used until ending their lifespan. The growth curve towards 2030 is based on a power curve with the function $y=0.0024*n^{2.52}$ based on the curve of Norway for the last 10 years. Initial experiences are built and cost structures go down. Barriers are removed and financial equivalence will be achieved. The vehicle penetration rates increases then (for new vehicles)

For other vehicle categories no specific scenario is made but the value from EV30@30 is taken.

Scenario Results

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. Scenarios do not include electric trucks > 7.5t as no massive penetration of such trucks can be expected.

Table 25: 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

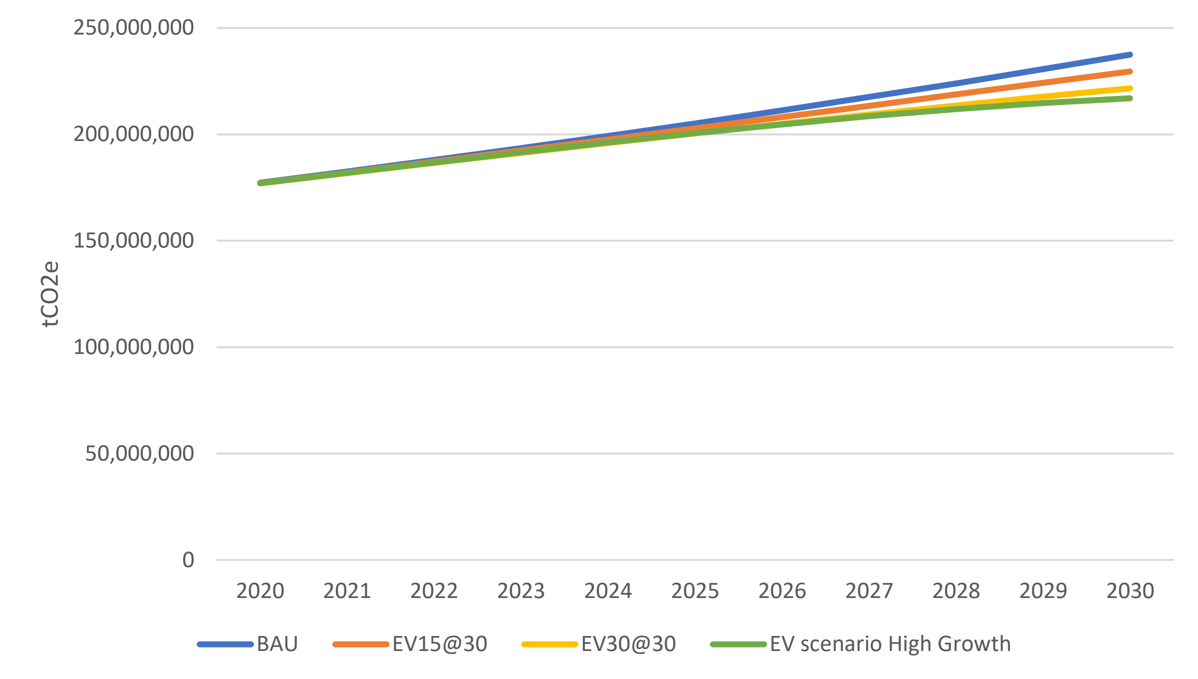
Source: Grutter Consulting, see Annex for further details

The growth of electricity demand is discussed in chapter 6.

The most ambitious scenario (EV high growth scenario) would result in a 9% reduction of GHGs relative to the baseline. None of the scenarios result in a trend change in this period i.e. they can reduce the growth of transport emissions and slowly shift the curve – however road transport emissions in 2030 will even with the ambitious EV scenario remain higher than the 2019 emissions. This is partially due to not including electric trucks > 7.5t in EV scenarios but basically due to the lag between new vehicles entering the market and the slow change of the vehicle stock in total.

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 16: Projected GHG Transport Emissions Mexico BAU and with EV Scenarios (WTW)



Source: Grutter Consulting

The following tables shows the potential GHG reduction which is possible to achieve for the targeted vehicle sectors.

Table 26: Projected GHG Reductions for Taxis "High Growth Scenario"

Taxis High Potential	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	748,905	776,920	805,984	836,134	867,413	899,861	933,523	968,445	1,004,673	1,042,256	1,081,245
Replacement taxis	66,843	69,343	71,937	74,628	77,420	80,316	83,320	86,437	89,671	93,025	96,505
Additional new taxis	27,005	28,015	29,063	30,151	31,278	32,448	33,662	34,922	36,228	37,583	38,989
EV taxi fleet new	0	200	3,863	8,273	15,060	24,736	37,843	54,963	76,723	103,796	135,494
EV taxi fleet stock	0	200	4,063	12,336	27,396	52,132	89,975	144,937	221,660	325,457	460,951
EV taxi as % of stock	0%	0%	1%	1%	3%	6%	10%	15%	22%	31%	43%
GHG reduction WTW in tons	0	1,205	24,468	74,296	165,001	313,979	541,896	872,925	1,335,008	1,960,150	2,776,200
Electricity demand GWh	0.0	2.0	40.2	122.1	271.2	516.1	890.7	1434.9	2194.4	3222.0	4563.4

Source: Grutter Consulting

Table 27: Projected GHG Reductions for LCVs "High Growth Scenario"

LCV Potential	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	4,508,371	4,556,971	4,606,095	4,655,749	4,705,938	4,756,668	4,807,945	4,859,775	4,912,163	4,965,116	5,018,640
Replacement vehicles	176,996	178,904	180,832	182,782	184,752	186,744	188,757	190,791	192,848	194,927	197,028
Additional new vehicles	48,082	48,600	49,124	49,654	50,189	50,730	51,277	51,830	52,388	52,953	53,524
EV vehicle fleet new	0	50	8,794	18,353	32,552	52,092	77,648	109,882	149,447	196,994	250,552
EV vehicle fleet stock	0	50	8,844	27,197	59,749	111,841	189,489	299,371	448,818	645,812	896,364
EV fleet as % of stock	0%	0%	0%	1%	1%	2%	4%	6%	9%	13%	18%
GHG reduction WTW in tons	0	125	22,165	68,161	149,741	280,291	474,890	750,273	1,124,813	1,618,514	2,246,441
Electricity demand GWh	0.0	0.2	29.5	90.8	199.6	373.5	632.9	999.9	1499.1	2157.0	2993.9

Source: Grutter Consulting

Table 28: Projected GHG Reductions for Small Buses "High Growth Scenario"

Small Bus Potential scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	103,270	107,133	111,141	115,298	119,611	124,086	128,728	133,543	138,539	143,721	149,098
Replacement vehicles	6,145	6,375	6,613	6,861	7,117	7,383	7,660	7,946	8,243	8,552	8,872
Additional new vehicles	3,724	3,863	4,008	4,158	4,313	4,474	4,642	4,815	4,996	5,183	5,376
EV vehicle fleet new	0	50	406	870	1,584	2,601	3,979	5,780	8,068	10,915	14,248
EV vehicle fleet stock	0	50	456	1,326	2,910	5,511	9,490	15,270	23,338	34,253	48,501
EV fleet as % of stock	0%	0%	0%	1%	2%	4%	7%	11%	17%	24%	33%
GHG reduction WTW in tons	0	490	4,473	13,004	28,534	54,041	93,064	149,740	228,855	335,887	475,605
Electricity demand GWh	0.0	1.1	10.2	29.7	65.2	123.4	212.6	342.0	522.8	767.3	1086.4

Source: Grutter Consulting

Table 29: Projected GHG Reductions for Urban Buses "High Growth Scenario"

Urban bus standard potential	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	133,651	138,651	143,838	149,219	154,801	160,591	166,599	172,831	179,296	186,004	192,962
Replacement vehicles	5,506	5,712	5,925	6,147	6,377	6,615	6,863	7,120	7,386	7,662	7,949
Additional new vehicles	4,819	5,000	5,187	5,381	5,582	5,791	6,007	6,232	6,465	6,707	6,958
EV vehicle fleet new	0	50	425	910	1,657	2,721	4,163	6,047	8,441	11,420	14,907
EV vehicle fleet stock	0	50	475	1,385	3,042	5,764	9,927	15,974	24,415	35,834	50,741
EV fleet as % of stock	0%	0%	0%	1%	2%	4%	6%	9%	14%	19%	26%
GHG reduction WTW in tons	0	2,777	26,378	76,930	168,954	320,096	551,324	887,162	1,355,959	1,990,184	2,818,091
Electricity demand GWh	0.0	2.9	27.5	80.3	176.4	334.3	575.8	926.5	1416.1	2078.4	2943.0

Source: Grutter Consulting

The following table shows key figures for the potential EV scenario in terms of number of electric vehicles, the GHG impact and the vehicle investment volume.

Table 30: Key Figures Commercial Vehicles EV "High Growth Scenario"

Parameter	Taxis	Small Buses	Urban Buses	LCVs	Total
EV stock 2025 (% of all vehicles)	52,000 (6%)	5,500 (4%)	5,800 (4%)	112,000 (2%)	175,000
EV Stock 2030 (% of all vehicles)	460,000 (43%)	49,000 (33%)	51,000 (26%)	896,000 (18%)	1,460,000
GHG impact in year 2025 (tons)	314,000	54,000	320,000	280,000	968,000
GHG impact in year 2030 (tons)	2,776,000	476,000	2,818,000	2,246,000	8,316,000
$PM_{2.5}$ reduction in year 2030 (tons)	28	4	136	255	423
NO_x reduction in year 2030 (tons)	1,420	494	15,951	5,551	23,415
Vehicle CAPEX 2025 (cumulative)	3,227 MUSD	413 MUSD	1,247 MUSD	2,550 MUSD	7,436 MUSD
Vehicle CAPEX 2030 (cumulative)	10,014 MUSD	3,060 MUSD	9,571 MUSD	18,763 MUSD	41,408 MUSD

Note: Constant real USD of 2020; vehicle values based on 2020 average values and annual reduction rate for each vehicle category based on market trends; see Annex for further details

Source: Grutter Consulting

By implementing this strategy Mexico would have around 1.5 million commercial EVs by 2030 reducing more than 8 million tons of CO_2 per annum. The impact is distributed between taxis, urban buses and LCVs. The estimated cumulative vehicle investment required by 2025 is around 7 billion USD and 41 billion USD by 2030. This excludes the investment required for chargers, grid upgrades or other investments e.g. in depot facilities. This is not the incremental investment for EVs relative to the BAU investment for fossil vehicles but the total required vehicle investment i.e. also in absence of an EV strategy a large part of this investment will take place, but in fossil units and not in EVs.

9. Enablers and Barriers

Enablers

- **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 as Metrobus, have evolved and allow for a distribution of responsibilities and greater institutional capacity in regulation, which is conducive to the transition to electrical technologies. In these schemes, the figure of trust and ownership unbundling is common, in addition to state intervention in tariff stabilization. This reduces the risk with financial institutions and facilitates the conditions for access to credit.
- **Interest of electric vehicle manufacturers in the national market:** different manufacturers have launched electric vehicles that have supported the installation of charging infrastructure, which brings this technology closer to the citizens and promotes cultural change. In addition, they have developed strategic alliances with government entities (CFE, Charge Now) and private sector companies to develop vehicles that are adapted to business needs, for example, in the LCV segment (Moldex, Danone). It is also important to mention that the impact of international announcements of electric vehicle production, such as the case of General Motors, which expects to produce only electric vehicles from 2035[13], is still unknown. The impact in Mexico will depend on the effects of the import tariff reductions for electric vehicles recently implemented by the Ministry of Economy, and on the negotiations between the U.S. and Mexican governments within the framework of the Free Trade Agreement. It should also be mentioned that some manufacturers are beginning to negotiate with Mexican states, such as the case of Zhong Tong Bu's investment (US$350 million)[14] for the construction of a bus assembly plant to be located in the municipality of El Carmen, Nuevo León, for natural gas, electric and hydrogen bus technologies.
- **Government initiatives in the generation of charging infrastructure:** entities such as CFE have managed to establish alliances with manufacturers, especially in passenger vehicles, which have allowed the generation of a considerable charging infrastructure. Although the existing infrastructure does not meet the characteristics to support electromobility in public transport systems, it is evidence of the national interest in promoting new technologies and generates a learning path related to technical factors such as the correct installation of chargers according to the particularities of the distribution network.
- **Tax benefits:** import benefits, purchase tax, property tax, among others are factors that together favors 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

[13] https://www.cnbc.com/2021/01/28/general-motors-plans-to-exclusively-offer-electric-vehicles-by-2035.html

[14] https://www.metalmecanica.com/temas/Mexico-tendra-una-planta-de-ensamble-de-autobuses-ecologicos+132939

contracts with more favorable 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, which 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. In addition, the lack of knowledge about the technology and its maintenance, together with the lack of charging infrastructure is a barrier.
- **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.
- **Reduced demand due to COVID 19:** Globally, the pandemic situation has considerably reduced mass transport systems and has highlighted the need for minimum guarantees for the financial stability of services, especially those that support their operation solely on user fee income. As a result, some fleet owners are in a state of bankruptcy, which is likely to delay the technological transition.
- **Lack of national policies and commitment to electric mobility:** The National Electromobility Strategy has been under development for several years, however, it has been affected by the change of government and political interests, to date the final document has not been published. Consequently, the country has not (yet) issued meaningful EV targets. Both local governments and the national government continue to favor gas powered vehicles. In 2020 the NDC update mentions the National Electromobility Strategy and it is expected to be published in the coming years. It should be noted that the adoption of electromobility requires the involvement of different actors, generating jobs, as well as traditional investments in the transport sector.
- **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. Only the Federation, through the Ministry of Finance and Public Credit (SHCP), can contract and manage public debt and grant guarantees. Therefore, access to these international resources by state governments is given through an explicit request for participation and adhesion to the Federal Government's programmes. sometimes, the resources that are finally allocated to the federal entities offer higher interest rates than those offered by local banks.

Some of the strategies identified to overcome barriers and facilitate the electrification of commercial vehicles are:

- To provide technical assistance for concessionaires with emphasis on small operators, allowing them to expand their knowledge of the technology, operating conditions and financial scheme.

- Provide financial mechanisms that facilitate the acquisition of fleet and recharging infrastructure, through loans and subsidies. As an example, a structure similar to that of the *Taxi Replacement Program in Mexico City* can be used, with the intervention of a development bank.
- Generation and promotion of investment in public charging infrastructure exclusively for the transport system (for the different categories of public transport).
- To generate an industrial policy to achieve the federal government's goal of reaching the new vehicle inclusion targets through domestic production.

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Annex

Vehicle Data

Vehicle category	gasoline	diesel	CNG	total
Passenger car incl. pick-up	37,528,703	765,892	0	38,294,595
Taxi	721,900	0	0	721,900
Motorcycle	4,806,740	0	0	4,806,740
small bus	94,569	4,977	0	99,546
standard urban bus	0	128,832	0	128,832
coach	0	50,670	0	50,670
LCV	2,676,173	1,784,116	0	4,460,289
Truck < 7.5t	0	1,115,861	0	1,115,861
Truck 7.5-16t	0	260,748	0	260,748
Truck 16-32t	0	204,873	0	204,873
Truck >32t	0	351,124	0	351,124
total				50,495,178

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Year of data	2019
Country	Mexico
GDP growth rate	1.1%

take from country values

Carbon grid factor	0.529

take from country values

Growth rate freight transport	1.1%

See below

passenger transport growth rate	3.7%

Total fuel consumed (million liters)

Diesel	17,016
Gasoline	41,797
Ethanol share	0.41%
Biodiesel share	0.02%

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vehicle category	average	Median	Estimated replacement age	Median year in 2019	average emission standard 2019	Median year in 2030	average emission standard 2030
cars	11	11	20	2008	Euro 3	2019	Euro 4
motorcycles	6	4	7	2015	Euro 3	2026	Euro 4
taxis	6	6	11	2013	Euro 3	2024	Euro 4
small bus	10	9	16	2010	Euro 4	2021	Euro 4
urban bus	15	13	23	2006	Euro 4	2017	Euro 4
LCV	15	14	25	2005	Euro 4	2016	Euro 4
coach	14	13	23	2006	Euro 4	2017	Euro 4
trucks	16	16	29	2003	Euro 4	2014	Euro 4

Source: Instituto Nacional de Ecología y Cambio Climático. Elementos de inventario de fuentes móviles:
Inventario de emisiones de fuentes móviles carreteras, 2016.
Coordinación General de Contaminación y
Salud Ambiental. Ciudad de México. 2018.

Replacement age based on 1.8x median age

Projected freight growth	
GDP growth rate	1.1%
take from country values	
GDP per capita 2019	9946
GDP per capita (current US$) - Mexico | Data (worldbank.org)	
Projected GDP per capita 203(	11217.8897

Income Group USD/Capita	Freight Intensity
< 5,000	1.18
5,000-25,000	**0.98**
25,000-50,000	0.87
> 50,000	0.82

	2019	2030		vehicles per
Population Mexico	124,270,000	131,479,000		
CAGR population		0.5%		projected ve
CAGR GDP/capita		0.6%		
GDP per capita ppp	9,946	11,218		

GDP 2019 based on World Bank: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=MX; Population based on OECD: https://stats.oecd.org/Index.aspx?DataSetCode=POPPROJ

Saturation level vehicles		590

Japan pattern; Tian Wu et. Al (2014), Vehicle Onwership Analysis Based on GDP per capita in China: 1963-2050; Sustainability 2014; 6, 4877-4899: doi:

vehicles per tsd inhabitants 2019 (cars + MC)	347
projected vehicles per tsd in 2030	491
Growth rate per capita	3.2%
Total growth rate	3.7%

Emissions

All data in tons per annum

2019

Vehicle category	NO_x	$PM_{2.5}$	CO_2 TTW	CO_2 WTW	Energy in TJ
Passenger car	45,651	819	75,740,535	90,520,521	1,091,494
Taxi	3,573	44	6,825,975	8,128,807	98,499
Motorcycles	9,325	168	2,988,220	3,593,835	43,120
small bus	1,014	8	1,817,419	2,171,959	26,135
standard urban bus	40,500	345	8,841,654	11,108,257	119,321
coach	9,161	72	1,595,124	2,010,433	21,527
LCV	27,620	1,268	17,199,096	21,731,520	241,084
Truck < 7.5t	53,070	343	10,413,965	13,040,713	140,539
Truck 7.5-16t	20,038	122	3,734,539	4,675,659	50,399
Truck 16-32t	22,755	142	3,975,477	4,985,685	53,650
Truck >32t	46,942	273	8,143,646	10,200,888	109,901
Total	**279,649**	**3,603**	**141,275,652**	**172,168,278**	**1,995,669**

2030

Vehicle category	NO_x	$PM_{2.5}$	CO_2 TTW	CO_2 WTW	Energy in MJ
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**

Emission costs	2019	2030
Pollutants	1,538	2,335
GHG	6,887	9,498
Total	**8,425**	**11,832**

in MUSD of 2019

Fuel Usage	Modelled	Top-down	as percentage	Modelled
	2019	2019	2019	2030
Gasoline	41,909	41,797	100.3%	47,268
Diesel	17,083	17,016	100.4%	19,267
CNG	0			0

in million liters for diesel and gasoline

EV Scenarios

Rate of EVs of newly registered vehicles

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
S1 EV 15@30	3%	3%	4%	5%	7%	9%	10%	11%	12%	14%	15%
S2 EV30@30	5%	6%	8%	11%	14%	18%	20%	22%	24%	27%	30%

High Potential Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Taxis	0%	0.2%	3.8%	7.9%	13.9%	21.9%	32.3%	45.3%	60.9%	79.5%	100.0%
Urban Buses	0%	0.5%	4%	8%	14%	22%	32%	45%	61%	79%	100%
Small buses	0%	0.5%	4%	8%	14%	22%	32%	45%	61%	79%	100%
LCVs	0%	0.0%	4%	8%	14%	22%	32%	45%	61%	79%	100%

This scenario is only made for the vehicle categories of the program i.e. urban buses, small buses, taxis and LCVs

For urban buses, taxis and LCVs the target is 100% of new registered buses/taxis/LCVs in 2030 are electric; This takes into consideration that Evs in this segment should be cost-competitive by 2030. No early replacement of vehicles is made i.e. conventional vehicles could still be used till ending their lifespan.

The growth curve towards 2030 is based on a power curve with the function y=0.0024*n^2.52 based on the curve of Norway for the last 10 years). Initial experiences are built and cost structures go down. Barriers are removed and financial equivalence will be achieved. The vehicle penetration rates increases then (for new vehicles)

Passenger cars S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all cars	39,727,133	41,213,260	42,754,980	44,354,373	46,013,598	47,734,891	49,520,575	51,373,058	53,294,840	55,288,512	57,356,764
Replacement cars	1,934,070	2,006,421	2,081,478	2,159,342	2,240,120	2,323,919	2,410,853	2,501,039	2,594,599	2,691,659	2,792,349
Additional new cars	1,432,538	1,486,127	1,541,720	1,599,394	1,659,224	1,721,293	1,785,684	1,852,483	1,921,782	1,993,672	2,068,252
EV car fleet new	84,899	113,378	151,410	202,199	270,026	360,604	415,126	477,893	550,150	633,331	729,090
EV car fleet stock	84,899	198,277	349,687	551,886	821,912	1,182,515	1,597,642	2,075,535	2,625,685	3,259,016	3,988,106
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	5%	6%	7%
GHG reduction WTW in tons	106,914	249,692	440,363	694,993	1,035,038	1,489,149	2,011,920	2,613,734	3,306,540	4,104,098	5,022,246
Electricity demand GWh	175.7	410.4	723.9	1142.4	1701.4	2447.8	3307.1	4296.4	5435.2	6746.2	8255.4

Passenger cars S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all cars	39,727,133	41,213,260	42,754,980	44,354,373	46,013,598	47,734,891	49,520,575	51,373,058	53,294,840	55,288,512	57,356,764
Replacement cars	1,934,070	2,006,421	2,081,478	2,159,342	2,240,120	2,323,919	2,410,853	2,501,039	2,594,599	2,691,659	2,792,349
Additional new cars	1,432,538	1,486,127	1,541,720	1,599,394	1,659,224	1,721,293	1,785,684	1,852,483	1,921,782	1,993,672	2,068,252
EV car fleet new	169,798	226,756	302,820	404,398	540,051	721,208	830,253	955,786	1,100,299	1,266,663	1,458,180
EV car fleet stock	169,798	396,554	699,374	1,103,772	1,643,823	2,365,031	3,195,284	4,151,070	5,251,369	6,518,032	7,976,213
EV fleet as % of stock	0%	1%	2%	2%	4%	5%	6%	8%	10%	12%	14%
GHG reduction WTW in tons	213,828	499,383	880,726	1,389,987	2,070,077	2,978,297	4,023,840	5,227,467	6,613,081	8,208,197	10,044,492
Electricity demand GWh	351.5	820.9	1447.7	2284.8	3402.7	4895.6	6614.2	8592.7	10870.3	13492.3	16510.8

Taxis S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	748,905	776,920	805,984	836,134	867,413	899,861	933,523	968,445	1,004,673	1,042,256	1,081,245
Replacement taxis	66,843	69,343	71,937	74,628	77,420	80,316	83,320	86,437	89,671	93,025	96,505
Additional new taxis	27,005	28,015	29,063	30,151	31,278	32,448	33,662	34,922	36,228	37,583	38,989
EV taxi fleet new	2,367	3,161	4,221	5,637	7,527	10,052	11,572	13,322	15,336	17,655	20,324
EV taxi fleet stock	2,367	5,527	9,748	15,384	22,912	32,964	44,536	57,858	73,194	90,848	111,173
EV taxi as % of stock	0%	1%	1%	2%	3%	4%	5%	6%	7%	9%	10%
GHG reduction WTW in tons	14,254	33,289	58,709	92,657	137,991	198,534	268,229	348,463	440,828	547,159	669,567
Electricity demand GWh	23.4	54.7	96.5	152.3	226.8	326.3	440.9	572.8	724.6	899.4	1100.6

Taxis S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	748,905	776,920	805,984	836,134	867,413	899,861	933,523	968,445	1,004,673	1,042,256	1,081,245
Replacement taxis	66,843	69,343	71,937	74,628	77,420	80,316	83,320	86,437	89,671	93,025	96,505
Additional new taxis	27,005	28,015	29,063	30,151	31,278	32,448	33,662	34,922	36,228	37,583	38,989
EV taxi fleet new	4,733	6,321	8,441	11,273	15,054	20,104	23,144	26,644	30,672	35,310	40,648
EV taxi fleet stock	4,733	11,054	19,496	30,769	45,823	65,928	89,072	115,715	146,387	181,697	222,345
EV taxi as % of stock	1%	1%	2%	4%	5%	7%	10%	12%	15%	17%	21%
GHG reduction WTW in tons	28,508	66,578	117,418	185,313	275,983	397,067	536,459	696,927	881,657	1,094,318	1,339,133
Electricity demand GWh	46.9	109.4	193.0	304.6	453.7	652.7	881.8	1145.6	1449.2	1798.8	2201.2

Taxis High Potential	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all taxis	748,905	776,920	805,984	836,134	867,413	899,861	933,523	968,445	1,004,673	1,042,256	1,081,245
Replacement taxis	66,843	69,343	71,937	74,628	77,420	80,316	83,320	86,437	89,671	93,025	96,505
Additional new taxis	27,005	28,015	29,063	30,151	31,278	32,448	33,662	34,922	36,228	37,583	38,989
EV taxi fleet new	0	200	3,863	8,273	15,060	24,736	37,843	54,963	76,723	103,796	135,494
EV taxi fleet stock	0	200	4,063	12,336	27,396	52,132	89,975	144,937	221,660	325,457	460,951
EV taxi as % of stock	0%	0%	1%	1%	3%	6%	10%	15%	22%	31%	43%
GHG reduction WTW in tons	0	1,205	24,468	74,296	165,001	313,979	541,896	872,925	1,335,008	1,960,150	2,776,200
Electricity demand GWh	0.0	2.0	40.2	122.1	271.2	516.1	890.7	1434.9	2194.4	3222.0	4563.4

Motorcycle S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all MC	4,986,552	5,173,091	5,366,608	5,567,364	5,775,630	5,991,687	6,215,826	6,448,349	6,689,572	6,939,818	7,199,425
Replacement MC	667,603	692,577	718,485	745,362	773,245	802,171	832,179	863,309	895,604	929,107	963,864
Additional new MC	179,812	186,539	193,517	200,756	208,266	216,057	224,139	232,524	241,222	250,246	259,607
EV MC fleet new	21,370	28,539	38,112	50,896	67,969	90,768	104,492	120,291	138,479	159,417	183,521
EV MC fleet stock	21,370	49,909	88,020	138,916	206,885	297,653	402,145	522,437	660,916	820,333	1,003,853
EV fleet as % of stock	0%	1%	2%	2%	4%	5%	6%	8%	10%	12%	14%
GHG reduction WTW in tons	13,151	30,714	54,168	85,490	127,318	183,177	247,482	321,510	406,731	504,837	617,776
Electricity demand GWh	5.3	12.5	22.0	34.7	51.7	74.4	100.5	130.6	165.2	205.1	251.0

Motorcycle S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all MC	4,986,552	5,173,091	5,366,608	5,567,364	5,775,630	5,991,687	6,215,826	6,448,349	6,689,572	6,939,818	7,199,425
Replacement MC	667,603	692,577	718,485	745,362	773,245	802,171	832,179	863,309	895,604	929,107	963,864
Additional new MC	179,812	186,539	193,517	200,756	208,266	216,057	224,139	232,524	241,222	250,246	259,607
EV MC fleet new	42,740	57,077	76,223	101,792	135,937	181,536	208,984	240,583	276,958	318,834	367,041
EV MC fleet stock	42,740	99,817	176,041	277,832	413,770	595,306	804,291	1,044,873	1,321,832	1,640,666	2,007,707
EV fleet as % of stock	1%	2%	3%	5%	7%	10%	13%	16%	20%	24%	28%
GHG reduction WTW in tons	26,303	61,428	108,336	170,980	254,636	366,354	494,965	643,020	813,462	1,009,674	1,235,553
Electricity demand GWh	10.7	25.0	44.0	69.5	103.4	148.8	201.1	261.2	330.5	410.2	501.9

Small Bus S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	103,270	107,133	111,141	115,298	119,611	124,086	128,728	133,543	138,539	143,721	149,098
Replacement vehicles	6,145	6,375	6,613	6,861	7,117	7,383	7,660	7,946	8,243	8,552	8,872
Additional new vehicles	3,724	3,863	4,008	4,158	4,313	4,474	4,642	4,815	4,996	5,183	5,376
EV vehicle fleet new	249	332	444	593	792	1,057	1,217	1,401	1,613	1,857	2,137
EV vehicle fleet stock	249	581	1,025	1,618	2,409	3,466	4,683	6,084	7,697	9,553	11,690
EV fleet as % of stock	0%	1%	1%	1%	2%	3%	4%	5%	6%	7%	8%
GHG reduction WTW in tons	2,440	5,699	10,052	15,864	23,626	33,991	45,924	59,661	75,475	93,681	114,638
Electricity demand GWh	5.6	13.0	23.0	36.2	54.0	77.6	104.9	136.3	172.4	214.0	261.9

Small Bus S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	103,270	107,133	111,141	115,298	119,611	124,086	128,728	133,543	138,539	143,721	149,098
Replacement vehicles	6,145	6,375	6,613	6,861	7,117	7,383	7,660	7,946	8,243	8,552	8,872
Additional new vehicles	3,724	3,863	4,008	4,158	4,313	4,474	4,642	4,815	4,996	5,183	5,376
EV vehicle fleet new	498	665	888	1,185	1,583	2,114	2,434	2,802	3,225	3,713	4,274
EV vehicle fleet stock	498	1,162	2,050	3,236	4,819	6,933	9,366	12,168	15,394	19,107	23,381
EV fleet as % of stock	0%	1%	2%	3%	4%	6%	7%	9%	11%	13%	16%
GHG reduction WTW in tons	4,881	11,399	20,104	31,728	47,252	67,983	91,849	119,323	150,951	187,361	229,277
Electricity demand GWh	11.1	26.0	45.9	72.5	107.9	155.3	209.8	272.6	344.8	428.0	523.7

Small Bus Potential scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	103,270	107,133	111,141	115,298	119,611	124,086	128,728	133,543	138,539	143,721	149,098
Replacement vehicles	6,145	6,375	6,613	6,861	7,117	7,383	7,660	7,946	8,243	8,552	8,872
Additional new vehicles	3,724	3,863	4,008	4,158	4,313	4,474	4,642	4,815	4,996	5,183	5,376
EV vehicle fleet new	0	50	406	870	1,584	2,601	3,979	5,780	8,068	10,915	14,248
EV vehicle fleet stock	0	50	456	1,326	2,910	5,511	9,490	15,270	23,338	34,253	48,501
EV fleet as % of stock	0%	0%	0%	1%	2%	4%	7%	11%	17%	24%	33%
GHG reduction WTW in tons	0	490	4,473	13,004	28,534	54,041	93,064	149,740	228,855	335,887	475,605
Electricity demand GWh	0.0	1.1	10.2	29.7	65.2	123.4	212.6	342.0	522.8	767.3	1086.4

Urban bus standard S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	133,651	138,651	143,838	149,219	154,801	160,591	166,599	172,831	179,296	186,004	192,962
Replacement vehicles	5,506	5,712	5,925	6,147	6,377	6,615	6,863	7,120	7,386	7,662	7,949
Additional new vehicles	4,819	5,000	5,187	5,381	5,582	5,791	6,007	6,232	6,465	6,707	6,958
EV vehicle fleet new	260	348	464	620	828	1,106	1,273	1,466	1,687	1,942	2,236
EV vehicle fleet stock	260	608	1,072	1,693	2,521	3,627	4,900	6,365	8,053	9,995	12,231
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	4%	5%	6%
GHG reduction WTW in tons	14,461	33,773	59,562	94,003	139,996	201,418	272,127	353,526	447,233	555,109	679,295
Electricity demand GWh	15.1	35.3	62.2	98.2	146.2	210.3	284.2	369.2	467.1	579.7	709.4

Urban bus standard S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	133,651	138,651	143,838	149,219	154,801	160,591	166,599	172,831	179,296	186,004	192,962
Replacement vehicles	5,506	5,712	5,925	6,147	6,377	6,615	6,863	7,120	7,386	7,662	7,949
Additional new vehicles	4,819	5,000	5,187	5,381	5,582	5,791	6,007	6,232	6,465	6,707	6,958
EV vehicle fleet new	521	695	929	1,240	1,656	2,212	2,546	2,931	3,375	3,885	4,472
EV vehicle fleet stock	521	1,216	2,145	3,385	5,041	7,253	9,800	12,731	16,105	19,990	24,462
EV fleet as % of stock	0%	1%	1%	2%	3%	5%	6%	7%	9%	11%	13%
GHG reduction WTW in tons	28,922	67,545	119,124	188,006	279,993	402,836	544,253	707,052	894,467	1,110,217	1,358,590
Electricity demand GWh	30.2	70.5	124.4	196.3	292.4	420.7	568.4	738.4	934.1	1159.4	1418.8

Urban bus standard potential	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	133,651	138,651	143,838	149,219	154,801	160,591	166,599	172,831	179,296	186,004	192,962
Replacement vehicles	5,506	5,712	5,925	6,147	6,377	6,615	6,863	7,120	7,386	7,662	7,949
Additional new vehicles	4,819	5,000	5,187	5,381	5,582	5,791	6,007	6,232	6,465	6,707	6,958
EV vehicle fleet new	0	50	425	910	1,657	2,721	4,163	6,047	8,441	11,420	14,907
EV vehicle fleet stock	0	50	475	1,385	3,042	5,764	9,927	15,974	24,415	35,834	50,741
EV fleet as % of stock	0%	0%	0%	1%	2%	4%	6%	9%	14%	19%	26%
GHG reduction WTW in tons	0	2,777	26,378	76,930	168,954	320,096	551,324	887,162	1,355,959	1,990,184	2,818,091
Electricity demand GWh	0.0	2.9	27.5	80.3	176.4	334.3	575.8	926.5	1416.1	2078.4	2943.0

Coach S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	52,565	54,532	56,572	58,688	60,884	63,161	65,524	67,975	70,518	73,156	75,892
Replacement vehicles	2,165	2,246	2,330	2,418	2,508	2,602	2,699	2,800	2,905	3,014	3,126
Additional new vehicles	1,895	1,966	2,040	2,116	2,195	2,278	2,363	2,451	2,543	2,638	2,737
EV vehicle fleet new	102	137	183	244	326	435	501	576	664	764	879
EV vehicle fleet stock	102	239	422	666	991	1,426	1,927	2,504	3,167	3,931	4,811
EV fleet as % of stock	0%	0%	1%	1%	2%	2%	3%	4%	4%	5%	6%
GHG reduction WTW in tons	1,896	4,428	7,810	12,326	18,356	26,410	35,681	46,354	58,641	72,785	89,068
Electricity demand GWh	4.1	9.6	16.9	26.6	39.7	57.1	77.1	100.1	126.7	157.2	192.4

Coach S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	52,565	54,532	56,572	58,688	60,884	63,161	65,524	67,975	70,518	73,156	75,892
Replacement vehicles	2,165	2,246	2,330	2,418	2,508	2,602	2,699	2,800	2,905	3,014	3,126
Additional new vehicles	1,895	1,966	2,040	2,116	2,195	2,278	2,363	2,451	2,543	2,638	2,737
EV vehicle fleet new	205	274	365	488	651	870	1,001	1,153	1,327	1,528	1,759
EV vehicle fleet stock	205	478	844	1,331	1,983	2,853	3,854	5,007	6,334	7,862	9,621
EV fleet as % of stock	0%	1%	1%	2%	3%	5%	6%	7%	9%	11%	13%
GHG reduction WTW in tons	3,792	8,856	15,619	24,651	36,712	52,819	71,362	92,708	117,281	145,570	178,136
Electricity demand GWh	8.2	19.1	33.7	53.3	79.3	114.1	154.2	200.3	253.4	314.5	384.8

LCV S1	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Stock all vehicles	4,508,371	4,556,971	4,606,095	4,655,749	4,705,938	4,756,668	4,807,945	4,859,775	4,912,163	4,965,116	5,018,640
Replacement vehicles	176,996	178,904	180,832	182,782	184,752	186,744	188,757	190,791	192,848	194,927	197,028
Additional new vehicles	48,082	48,600	49,124	49,654	50,189	50,730	51,277	51,830	52,388	52,953	53,524
EV vehicle fleet new	5,676	7,385	9,610	12,504	16,269	21,169	23,744	26,633	29,873	33,507	37,583
EV vehicle fleet stock	5,676	13,061	22,671	35,175	51,444	72,613	96,358	122,991	152,863	186,370	223,953
EV fleet as % of stock	0%	0%	0%	1%	1%	2%	2%	3%	3%	4%	4%
GHG reduction WTW in tons	14,225	32,734	56,818	88,154	128,928	181,982	241,489	308,236	383,102	467,076	561,265
Electricity demand GWh	19.0	43.6	75.7	117.5	171.8	242.5	321.8	410.8	510.6	622.5	748.0

LCV S2	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Stock all vehicles	4,508,371	4,556,971	4,606,095	4,655,749	4,705,938	4,756,668	4,807,945	4,859,775	4,912,163	4,965,116	5,018,640
Replacement vehicles	176,996	178,904	180,832	182,782	184,752	186,744	188,757	190,791	192,848	194,927	197,028
Additional new vehicles	48,082	48,600	49,124	49,654	50,189	50,730	51,277	51,830	52,388	52,953	53,524
EV vehicle fleet new	11,352	14,771	19,219	25,007	32,539	42,338	47,489	53,266	59,746	67,014	75,166
EV vehicle fleet stock	11,352	26,123	45,342	70,350	102,888	145,227	192,716	245,981	305,727	372,741	447,906
EV fleet as % of stock	0%	1%	1%	2%	2%	3%	4%	5%	6%	8%	9%
GHG reduction WTW in tons	28,450	65,468	113,635	176,308	257,856	363,963	482,978	616,471	766,204	934,151	1,122,529
Electricity demand GWh	37.9	87.3	151.4	235.0	343.6	485.1	643.7	821.6	1021.1	1245.0	1496.0

LCV Potential	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Stock all vehicles	4,508,371	4,556,971	4,606,095	4,655,749	4,705,938	4,756,668	4,807,945	4,859,775	4,912,163	4,965,116	5,018,640
Replacement vehicles	176,996	178,904	180,832	182,782	184,752	186,744	188,757	190,791	192,848	194,927	197,028
Additional new vehicles	48,082	48,600	49,124	49,654	50,189	50,730	51,277	51,830	52,388	52,953	53,524
EV vehicle fleet new	0	50	8,794	18,353	32,552	52,092	77,648	109,882	149,447	196,994	250,552
EV vehicle fleet stock	0	50	8,844	27,197	59,749	111,841	189,489	299,371	448,818	645,812	896,364
EV fleet as % of stock	0%	0%	0%	1%	1%	2%	4%	6%	9%	13%	18%
GHG reduction WTW in tons	0	125	22,165	68,161	149,741	280,291	474,890	750,273	1,124,813	1,618,514	2,246,441
Electricity demand GWh	0.0	0.2	29.5	90.8	199.6	373.5	632.9	999.9	1499.1	2157.0	2993.9

Truck <7.5t S1	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Stock all vehicles	1,127,890	1,140,049	1,152,338	1,164,761	1,177,317	1,190,008	1,202,836	1,215,803	1,228,909	1,242,157	1,255,547
Replacement vehicles	39,137	39,558	39,985	40,416	40,852	41,292	41,737	42,187	42,642	43,101	43,566
Additional new vehicles	12,029	12,159	12,290	12,422	12,556	12,691	12,828	12,967	13,106	13,248	13,390
EV vehicle fleet new	1,290	1,679	2,185	2,842	3,698	4,812	5,398	6,054	6,791	7,617	8,543
EV vehicle fleet stock	1,290	2,969	5,154	7,996	11,695	16,507	21,904	27,959	34,750	42,366	50,910
EV fleet as % of stock	0%	0%	0%	1%	1%	1%	2%	2%	3%	3%	4%
GHG reduction WTW in tons	3,993	9,190	15,951	24,748	36,195	51,089	67,795	86,533	107,551	131,125	157,567
Electricity demand GWh	21.0	48.2	83.7	129.9	189.9	268.1	355.7	454.0	564.3	688.0	826.8

Truck <7.5t S2	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Stock all vehicles	1,127,890	1,140,049	1,152,338	1,164,761	1,177,317	1,190,008	1,202,836	1,215,803	1,228,909	1,242,157	1,255,547
Replacement vehicles	39,137	39,558	39,985	40,416	40,852	41,292	41,737	42,187	42,642	43,101	43,566
Additional new vehicles	12,029	12,159	12,290	12,422	12,556	12,691	12,828	12,967	13,106	13,248	13,390
EV vehicle fleet new	2,581	3,358	4,369	5,685	7,397	9,625	10,795	12,109	13,582	15,234	17,087
EV vehicle fleet stock	2,581	5,938	10,307	15,992	23,389	33,014	43,809	55,917	69,499	84,733	101,820
EV fleet as % of stock	0%	1%	1%	1%	2%	3%	4%	5%	6%	7%	8%
GHG reduction WTW in tons	7,987	18,379	31,901	49,496	72,389	102,178	135,589	173,066	215,101	262,250	315,135
Electricity demand GWh	41.9	96.4	167.4	259.7	379.8	536.1	711.5	908.1	1128.7	1376.1	1653.6

Truck 7.5-16t S1	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Stock all vehicles	263,559	266,400	269,272	272,174	275,108	278,074	281,072	284,102	287,164	290,260	293,389
Replacement vehicles	9,145	9,244	9,343	9,444	9,546	9,649	9,753	9,858	9,964	10,072	10,180
Additional new vehicles	2,811	2,841	2,872	2,903	2,934	2,966	2,998	3,030	3,063	3,096	3,129
EV vehicle fleet new	302	392	510	664	864	1,125	1,261	1,415	1,587	1,780	1,996
EV vehicle fleet stock	302	694	1,204	1,868	2,733	3,857	5,119	6,533	8,120	9,900	11,896
EV fleet as % of stock	0%	0%	0%	1%	1%	1%	2%	2%	3%	3%	4%
GHG reduction WTW in tons	1,706	3,926	6,814	10,572	15,461	21,824	28,960	36,965	45,943	56,013	67,309
Electricity demand GWh	7.0	16.1	27.9	43.3	63.4	89.5	118.7	151.6	188.4	229.7	276.0

Truck 7.5-16t S2	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Stock all vehicles	263,559	266,400	269,272	272,174	275,108	278,074	281,072	284,102	287,164	290,260	293,389
Replacement vehicles	9,145	9,244	9,343	9,444	9,546	9,649	9,753	9,858	9,964	10,072	10,180
Additional new vehicles	2,811	2,841	2,872	2,903	2,934	2,966	2,998	3,030	3,063	3,096	3,129
EV vehicle fleet new	603	785	1,021	1,328	1,728	2,249	2,523	2,829	3,174	3,560	3,993
EV vehicle fleet stock	603	1,388	2,409	3,737	5,465	7,714	10,237	13,066	16,240	19,800	23,793
EV fleet as % of stock	0%	1%	1%	1%	2%	3%	4%	5%	6%	7%	8%
GHG reduction WTW in tons	3,412	7,851	13,627	21,143	30,923	43,648	57,920	73,929	91,886	112,026	134,617
Electricity demand GWh	14.0	32.2	55.9	86.7	126.8	179.0	237.5	303.1	376.8	459.4	552.0

Truck 16-32t S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	207,082	209,314	211,571	213,851	216,157	218,487	220,842	223,223	225,629	228,061	230,520
Replacement vehicles	7,186	7,263	7,341	7,420	7,500	7,581	7,663	7,746	7,829	7,913	7,999
Additional new vehicles	2,209	2,232	2,256	2,281	2,305	2,330	2,355	2,381	2,406	2,432	2,459
EV vehicle fleet new	237	308	401	522	679	884	991	1,112	1,247	1,398	1,569
EV vehicle fleet stock	237	545	946	1,468	2,147	3,031	4,022	5,133	6,380	7,779	9,347
EV fleet as % of stock	0%	0%	0%	1%	1%	1%	2%	2%	3%	3%	4%
GHG reduction WTW in tons	1,404	3,230	5,606	8,698	12,721	17,956	23,827	30,413	37,800	46,086	55,379
Electricity demand GWh	8.2	19.0	32.9	51.1	74.7	105.5	140.0	178.6	222.0	270.7	325.3

Truck 16-32t S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	207,082	209,314	211,571	213,851	216,157	218,487	220,842	223,223	225,629	228,061	230,520
Replacement vehicles	7,186	7,263	7,341	7,420	7,500	7,581	7,663	7,746	7,829	7,913	7,999
Additional new vehicles	2,209	2,232	2,256	2,281	2,305	2,330	2,355	2,381	2,406	2,432	2,459
EV vehicle fleet new	474	616	802	1,044	1,358	1,767	1,982	2,223	2,494	2,797	3,137
EV vehicle fleet stock	474	1,090	1,892	2,936	4,294	6,061	8,043	10,267	12,760	15,557	18,694
EV fleet as % of stock	0%	1%	1%	1%	2%	3%	4%	5%	6%	7%	8%
GHG reduction WTW in tons	2,807	6,460	11,212	17,396	25,442	35,912	47,655	60,827	75,601	92,172	110,759
Electricity demand GWh	16.5	37.9	65.9	102.2	149.4	210.9	279.9	357.3	444.1	541.4	650.6

Truck >32t S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	354,909	358,735	362,602	366,511	370,462	374,456	378,492	382,572	386,697	390,865	395,079
Replacement vehicles	12,315	12,448	12,582	12,718	12,855	12,993	13,133	13,275	13,418	13,563	13,709
Additional new vehicles	3,785	3,826	3,867	3,909	3,951	3,994	4,037	4,080	4,124	4,169	4,214
EV vehicle fleet new	406	528	687	894	1,164	1,514	1,698	1,905	2,137	2,397	2,688
EV vehicle fleet stock	406	934	1,622	2,516	3,680	5,194	6,893	8,798	10,935	13,331	16,020
EV fleet as % of stock	0%	0%	0%	1%	1%	1%	2%	2%	3%	3%	4%
GHG reduction WTW in tons	2,078	4,782	8,300	12,878	18,834	26,584	35,278	45,028	55,965	68,232	81,991
Electricity demand GWh	18.4	42.3	73.4	113.8	166.5	235.0	311.8	398.0	494.7	603.1	724.7

Truck >32t S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock all vehicles	354,909	358,735	362,602	366,511	370,462	374,456	378,492	382,572	386,697	390,865	395,079
Replacement vehicles	12,315	12,448	12,582	12,718	12,855	12,993	13,133	13,275	13,418	13,563	13,709
Additional new vehicles	3,785	3,826	3,867	3,909	3,951	3,994	4,037	4,080	4,124	4,169	4,214
EV vehicle fleet new	812	1,057	1,375	1,789	2,328	3,029	3,397	3,810	4,274	4,794	5,377
EV vehicle fleet stock	812	1,869	3,243	5,032	7,360	10,388	13,785	17,595	21,869	26,663	32,039
EV fleet as % of stock	0%	1%	1%	1%	2%	3%	4%	5%	6%	7%	8%
GHG reduction WTW in tons	4,156	9,564	16,600	25,756	37,668	53,169	70,555	90,056	111,930	136,464	163,983
Electricity demand GWh	36.7	84.5	146.7	227.7	333.0	470.0	623.6	796.0	989.4	1206.2	1449.5

Total excl. trucks >7.5t S1	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GHG reduction WTW in tons	171,335	399,519	703,432	1,108,234	1,647,449	2,365,749	3,190,647	4,138,017	5,226,101	6,475,869	7,911,422
Electricity demand GWh	269	627	1,104	1,738	2,581	3,704	4,992	6,470	8,166	10,112	12,345

Total excl. trucks >7.5t S2	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GHG reduction WTW in tons	342,670	799,037	1,406,864	2,216,469	3,294,898	4,731,498	6,381,295	8,276,034	10,452,203	12,951,739	15,822,845
Electricity demand GWh	538	1,255	2,208	3,476	5,163	7,408	9,985	12,940	16,332	20,224	24,691

GHG Transport Projections WTW

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BAU	177,273,820	182,530,763	187,943,598	193,516,947	199,255,570	205,164,368	211,248,388	217,512,826	223,963,032	230,604,514	237,442,946
EV15@30	177,102,485	182,131,244	187,240,165	192,408,712	197,608,121	202,798,619	208,057,741	213,374,809	218,736,930	224,128,645	229,531,524
GHG reduction EV15@30	171,335	399,519	703,432	1,108,234	1,647,449	2,365,749	3,190,647	4,138,017	5,226,101	6,475,869	7,911,422
EV30@30	176,931,150	181,731,726	186,536,733	191,300,478	195,960,672	200,432,870	204,867,093	209,236,792	213,510,829	217,652,776	221,620,101
GHG reduction EV30@30	342,670	799,037	1,406,864	2,216,469	3,294,898	4,731,498	6,381,295	8,276,034	10,452,203	12,951,739	15,822,845
EV scenario High Growth	177,011,535	181,914,244	186,788,090	191,585,146	196,215,491	200,563,583	204,685,328	208,491,653	211,880,057	214,733,428	216,943,934
GHG reduction Potential	262,285	616,519	1,155,508	1,931,800	3,040,079	4,600,785	6,563,060	9,021,173	12,082,975	15,871,087	20,499,012

GHG WTW emissions in tCO2e of selected 4 commercial vehicle sectors (LCVs, small and urban bus, taxis)

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BAU	44,175,686	45,243,313	46,344,573	47,480,656	48,652,795	49,862,271	51,110,410	52,398,588	53,728,229	55,100,813	56,517,874
EV15@30	44,130,306	45,137,818	46,159,432	47,189,978	48,222,254	49,246,347	50,282,641	51,328,701	52,381,590	53,437,789	54,493,109
EV30@30	44,084,926	45,032,323	45,974,291	46,899,300	47,791,712	48,630,422	49,454,871	50,258,814	51,034,951	51,774,765	52,468,345
Potential scenario	44,175,686	45,238,716	46,267,087	47,248,264	48,140,565	48,893,864	49,449,237	49,738,487	49,683,594	49,196,079	48,201,537

Potential scenario

Parameter	Taxis	Small Buses	Urban Buses	LCVs	Total
EV stock 2025	52,132	5,511	5,764	111,841	175,247
EV Stock 2030	460,951	48,501	50,741	896,364	1,456,557
GHG impact 2025 tCO2	313,979	54,041	320,096	280,291	968,407
GHG impact 2030 tCO2	2,776,200	475,605	2,818,091	2,246,441	8,316,336
PM2.5 reduction 2030 (tons)	28	4	136	255	423
NOx reduction 2030 (tons)	1,420	494	15,951	5,551	23,415
Savings emision costs 2030 (MUSD)	124	22	199	189	533
Emissions savings excl. GHG	13	3	86	99	200
Vehicle CAPEX 2025 cumulative MUSD	3,227	413	1,247	2,550	7,436
Vehicle CAPEX 2030 cumulative MUSD	10,014	3,060	9,571	18,763	41,408
Investment based on real 2020 USD					

Default Emissions

Euro 3 light vehicles/IV HDVs

Vehicle category	Fuel	Fuel consumption	NO_x	$PM_{2.5}$	CO_2 TTW	BC	CO_2 WTW incl. BC	Energy Usage MJ	Annual distance
Passenger Car	gasoline	56	0.090	0.001	172	0	205	2.5	11,500
Passenger Car	diesel	55	0.773	0.039	175	30	245	2.4	11,500
Passenger Car	CNG	63	0.056	0.001	189	0	264	3.0	11,500
Taxi	gasoline	56	0.090	0.001	172	0	205	2.5	55,000
Taxi	diesel	55	0.773	0.039	175	30	245	2.4	55,000
Taxi	CNG	63	0.056	0.001	189	0	264	3.0	55,000
3-wheeler	gasoline	24	0	0.000	75	0	89	1.1	20,000
3-wheeler	diesel	19	0.500	0.050	61	11	86	0.8	20,000
3-wheeler	CNG	32	0.5	0.000	96	0	134	1.5	20,000
Motorcycle	gasoline	20	0.194	0.004	62	1	75	0.9	10,000
Small bus	gasoline	148	0.000	0.000	455	0	541	6.6	40,000
Small bus	diesel	152	5.092	0.040	484	27	622	6.5	40,000
Urban standard bus	diesel	371	5.420	0.046	1183	31	1487	16.0	58,000
Urban standard bus	CNG	490	2.500	0.005	1470	0	2051	23.5	58,000
Coach bus	diesel	247	4.520	0.035	787	24	992	10.6	40,000
LCV	gasoline	70	0.064	0.001	215	0	256	3.1	16,700
LCV	diesel	80	0.831	0.041	255	32	346	3.4	16,700
Truck < 7.5t	diesel	101	1.640	0.011	322	7	403	4.3	29,000
Truck 7.5-16t	diesel	155	2.650	0.016	494	11	618	6.7	29,000
Truck 16-32t	diesel	210	3.830	0.024	669	16	839	9.0	29,000
Truck >32t	diesel	251	4.610	0.027	800	18	1002	10.8	29,000

Euro 4/IV

Vehicle category	Fuel	Fuel consumption	NO_x	$PM_{2.5}$	CO_2 TTW	BC	CO_2 WTW incl. BC	Energy Usage MJ	Annual distance
Passenger Car	gasoline	56	0.056	0.001	172	0	205	2.5	11,500
Passenger Car	diesel	55	0.580	0.031	175	25	240	2.4	11,500
Passenger Car	CNG	63	0.056	0.001	189	0	264	3.0	11,500
Taxi	gasoline	56	0.056	0.001	172	0	205	2.5	55,000
Taxi	diesel	55	0.580	0.031	175	25	240	2.4	55,000
Taxi	CNG	63	0.056	0.001	189	0	264	3.0	55,000
3-wheeler	gasoline	24	0.000	0.000	75	0	89	1.1	20,000
3-wheeler	diesel	19	0.500	0.050	61	11	86	0.8	20,000
3-wheeler	CNG	32	0.500	0.000	96	0	134	1.5	20,000
Motorcycle	gasoline	20	0.194	0.004	62	1	75	0.9	10,000
Small bus	gasoline	148	0.000	0.000	455	0	541	6.6	40,000
Small bus	diesel	152	5.092	0.040	484	27	622	6.5	40,000
Urban standard bus	diesel	371	5.420	0.046	1183	31	1,487	16.0	58,000
Urban standard bus	CNG	490	2.500	0.005	1,470	0	2,051	23.5	58,000
Coach bus	diesel	247	4.520	0.035	787	24	992	10.6	40,000
LCV	gasoline	70	0.064	0.001	215	0	256	3.1	16,700
LCV	diesel	80	0.831	0.041	255	32	346	3.4	16,700
Truck < 7.5t	diesel	101	1.640	0.011	322	7	403	4.3	29,000
Truck 7.5-16t	diesel	155	2.650	0.016	494	11	618	6.7	29,000
Truck 16-32t	diesel	210	3.830	0.024	669	16	839	9.0	29,000
Truck >32t	diesel	251	4.610	0.027	800	18	1,002	10.8	29,000

Source and Assumptions

Emission factors and fuel consumption EEA, (2020), COPERT Tier 2
car/taxi: small size gasline and medium size diesel
Motorcycle 4-strooke<250cm3, Euro 3
all units g/km
Distance driven based on weighted averages per vehicle category (based on distance per vehicle year); source: Instituto Nacional de Ecología y Cambio Climático. Elementos de inventario de fuentes móviles: Inventario de emisiones de fuentes móviles carreteras, 2016. Coordinación General de Contaminación y Salud Ambiental. Ciudad de México. 2018 (for cars, taxis, motorcycles, small buses, urban buses, LCVs: other categories estimated and calibrated with fuel consumed); adjustment in small buses;

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 3 gasoline passenger car and LCV	15%		EEA, 2020, tabla 3-92
BC fraction Euro 4 gasoline passenger car and LCV	15%		
BC fraction Euro 3 diesel passenger car and LCV	85%		
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