Climate Transparency

MAKING TRANSPORT PARIS-COMPATIBLE:
A CONTRIBUTION TO THE DEBATE ON ELECTROMOBILITY IN THE AUTOMOTIVE SUB-SECTOR OF MEXICO

POLICY PAPER

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EXECUTIVE SUMMARY

Because of greenhouse gas (GHG) emissions, climate change mitigation requires the deep and accelerated decarbonisation of the transport sector. Yet this area has received little political attention, particularly in emerging economies like Mexico. This policy paper examines the GHG emissions of Mexico's transport sector and its medium-term trends, providing a critical perspective on the sector's mitigation policies based on a national and sectoral carbon budget (of, respectively, 22.2 and 6.6 gigatonnes of equivalent carbon dioxide ($GtCO_2e$) on a 2°C pathway by 2030). In addition, the literature indicates that accelerated electromobility in the automotive sector should be complemented with improved connectivity and access to public transport – both essential measures for achieving domestic mitigation targets. Although these measures face significant challenges (e.g., budget allocation, reducing fossil fuel dependency, overcoming institutional fragmentation, long-term urban planning), they could generate coeffects such as improving air quality in large cities and economic savings. Mexico, therefore, needs to improve institutional and policy coordination towards the transport sector, which will not only help to meet climate change mitigation targets, but will also have the potential to deliver significant socio-environmental benefits for its citizens. As a contribution to that goal, this policy paper provides technical and policy inputs to inform both public debate and policy-making in the sector. It provides an input to the growing debate in Mexico on how mitigation action in the transport sector could be enhanced and adds to the ongoing debates carried out by different stakeholders.

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This paper is part of the efforts of the Climate Transparency Initiative, an international partnership of 14 research organisations and non-governmental organisations (NGOs) analysing G20 climate actions. It is part of a series examining the status, opportunities and challenges in decarbonising the transport sector in G20 countries. Other papers on this topic can be downloaded from the Climate Transparency's website:
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INTRODUCTION

Worldwide, the transport sector is one of the primary greenhouse gas (GHG) emitters. This trend is partly due to the increase in urbanisation and the motorisation rate in emerging economies like Mexico. To achieve the sector's mitigation targets, a better understanding is needed of the issue including the political and technological alternatives available. To contribute to the debate, this paper analyses Mexico's automotive sector (light passenger and commercial vehicles) given that sector's share of national GHG emissions and its GHG emissions trends. The paper offers a critical perspective on Mexico's mitigation policy and includes a technical reference to identify the sectoral carbon budget.

The first section reviews the GHG emissions of the transport sector and its relevance to Mexico's compliance with the Paris Agreement. Among the various possibilities for decarbonising the transport sector, the second section focuses on use of an electromobility strategy aligned to mitigation targets for the automotive sub-sector in Mexico. It examines the specificities of Mexico's transport sector and bases its overview on a national carbon budget.[i] The third section analyses the implications of introducing electric vehicles of as well as the diverse environmental, economic and social coeffects associated with this goal. Next, the fourth section presents some of the main challenges that Mexico faces in moving towards the sector's decarbonisation by implementing an electromobility strategy. The fifth section reviews the main policies and actions that can address the sector's mitigation challenges. Finally, the conclusion presents the policy implications of this paper.

1. THE IMPORTANCE OF DECARBONISING THE TRANSPORT SECTOR

Decarbonising transport is critical to prevent global warming from exceeding 1.5°C at the end of this century.[1] Although 65 countries and many of the largest subnational economies have pledged to reach net-zero emissions by 2050, the Emissions Gap Report (2019) by the United Nations Environment Programme estimates that even with the compliance of the Nationally Determined Contributions (NDCs) committed to under the Paris Agreement, the average temperature of the planet would still increase by 3.2°C. Moreover, global GHG emissions continue to increase due to the slow implementation of climate policy (UNEP, 2019).[2] The transport sector accounts for 20% of energy-related GHG emissions from the G20 countries.[3] It is therefore necessary to accelerate the implementation of mitigation policies for the transport sector, which in emerging economies such as Mexico can also deliver significant environmental, economic and health benefits.[4]

Since 1970, GHG emissions from the transport sector have increased at a higher rate than for any other end-use energy sector, and have more than doubled globally, mainly due to the increased use of road vehicles.[5] The sector accounted for 23% of global GHG emissions in 2014; between 2010 and 2015, the sector's emissions had an annual increase of 2.5%.[6] For instance, in Latin America, total transport CO^2 emissions between 2000 and 2016 increased 49%, while in Africa and Asia emissions increased even further (82% and 92%, respectively).[7] Both the national commitments and mitigation policies of this sector have been particularly weak.

An analysis of the 166 NDCs submitted, representing 193 countries, shows that 76% emphasise the transport sector as a crucial mitigation source – yet only 8% of NDCs have established mitigation targets for that sector. Twenty NDCs have indirect targets (e.g., targeting public transport modal share, renewable energy, fuel consumption reduction, fuel efficiency); and in some cases, NDCs do not reflect transport targets included in national plans (e.g., Germany). The NDCs have been primarily focused on improving vehicle efficiency of transport modes and on the shift to more environmentally responsible modes. However, there has been only limited action on avoiding and reducing the need for motorised travel.[8]

Only five members (Canada, Mexico, United Kingdom, France, Japan) of the G20 countries have announced emission reduction targets related to new motorcycles, cars, and buses, and only three members (China, India, Indonesia) have aimed for a transformational change in the transport sector. Moreover, none of the members have acquired a legally binding commitment on heavy road transport, ships and aviation, which account for 40% of the sector's GHG emissions.[9, 10]

i. Further research needs to be developed to analyse the impact on GHG emission reduction targets of other mid- and long-term strategies, for instance, promoting modal shift and transit-oriented development.

Mexico's NDCs set the unconditional target of reducing 18% (218 $MtCO_2$) of the transport sector emissions in relation to the baseline in 2030.[ii, 11] This baseline may vary significantly over time as a result of the sector's economic growth rates, for example. Furthermore, Mexico has announced the target of achieving zero emissions from new motorcycles, cars and buses by 2050.[12]

However, despite Mexico's international commitments, there are numerous inconsistencies and contradictory measures within the policy framework for decarbonising the transport sector. The actions taken in this sector not only contribute to the climate change mitigation agenda but can also provide significant economic, environmental and human health benefits. For instance, electric vehicles can generate savings to the national economy equivalent to 3.7% of 2018 GDP.[13] In this context, this policy paper analyses the implications of electrifying Mexico's automotive sub-sector and delivers critical policy orientations to achieve this target.

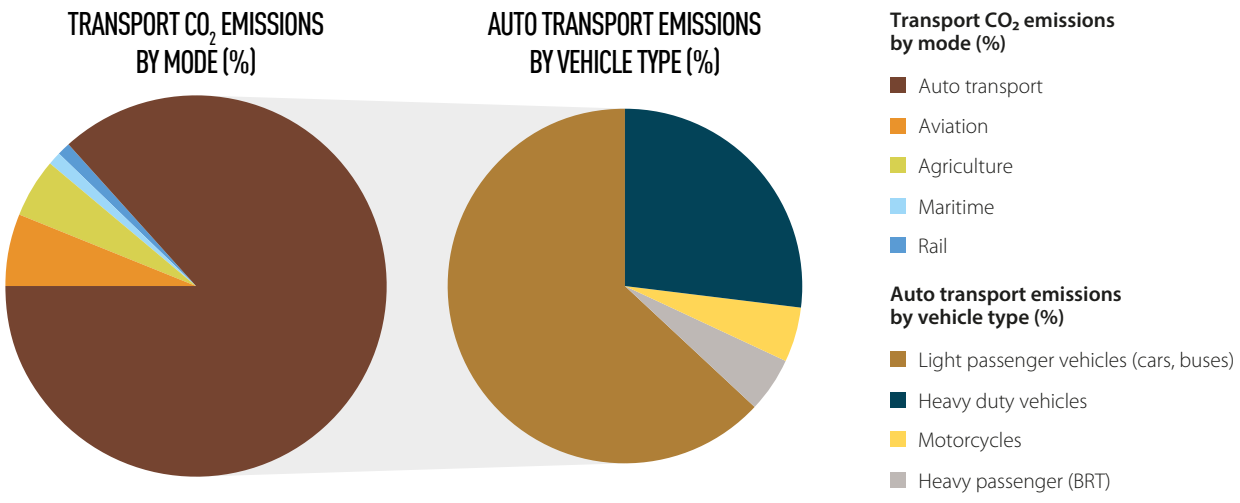
2. TRANSPORT EMISSIONS, PROJECTIONS AND MITIGATION OPTIONS

Despite Mexico's ambitious goals to reduce emissions from the transport sector, these targets have not been effectively translated into developing and implementing national climate regulatory frameworks and actions. This has helped to accelerate the increasing trend of GHG emissions from the sector over the past 30 years.[14]

According to official estimates, in Mexico, the transport sector represents 25.1% of the total domestic GHG emissions (171 $MtCO_2$ of a total 683 $MtCO_2$). In this sector, the automotive sub-sector represents 86% (149.01 $MtCO_2$), followed by aviation at 6% (10.13 $MtCO_2$), agricultural vehicles at 5% (8.84 $MtCO_2$) and other sub-sectors that contribute 3% of emissions (4.83 $MtCO_2$) (Figure 1a). Consequently, the automotive sub-sector alone accounts for 21.8% of total national GHG emissions. In this sub-sector, commercial and light passenger vehicles represent 63% of its emissions (54.1 $MtCO_2$ and 1.6 $MtCO_2$ respectively) followed by heavy freight and passenger vehicles that emit 32% (47.18 $MtCO_2$) and, finally, motorcycles with 5% (7.95 $MtCO_2$) (Figure 1b). All these vehicles depend on fossil fuels, mainly gasoline and diesel.[15, 16] The automotive sub-sector is a key area for mitigation action, with electromobility alternatives providing a promising route.

The critical contribution of commercial and light passenger vehicles to GHG emissions is due to their relatively old average age, deficient emission standards and lack of programmes to enhance their turnover rates and reduce emissions. To illustrate this, the average age of light passenger vehicles is 20 years, with

Figure 1: **Transport CO_2 emissions by mode and vehicle type**



Source: Authors' own, adapted from National Institute of Ecology and Climate Change (INECC), 2018

ii. The baseline for GHG emissions projects future national emissions within a specific time horizon, despite any mitigation action being implemented. It is a mechanism that aims to identify potential mitigation actions. It considers emission factors by economic activity, estimated from economic growth forecasts and available official data.

more than 50% of road passenger vehicles being 11 years or older, and less than a quarter being under five years old. In the case of heavy vehicles on the road, 70% are more than 11 years old.[17]

Additionally, the national standards set only low requirements to speed up fleet turnover. These lax national standards also have a negative impact on reducing GHG emissions and local air pollutants. As a consequence, light passenger and heavy duty vehicles are not only key contributors of GHG emissions but are also the primary source of outdoor air pollution in Mexican cities. These emissions are expected to grow in the coming years due to increasing motorisation rates.

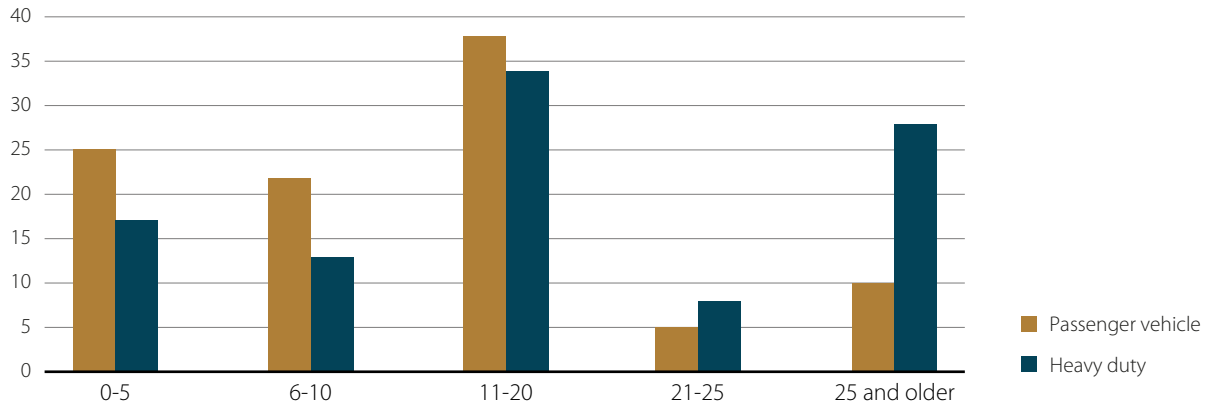
To meet Mexico's international climate commitments, the transport sector requires transformational changes within the next decade. For instance, it should look to carry out the following measures:

1. The national regulatory framework needs to be strengthened. Under a "business-as-usual" scenario, total transport emissions in Mexico will reach 266 $MtCO_2e$ by 2030,[18] which would put the global temperature on a pathway to an increase of 4ºC to 6ºC.[19] This trend is inconsistent with the urgent goal of limiting the global temperature increase to 1.5°C or 2°C. Furthermore, this trend implies non-compliance with the climate mitigation targets established by Mexico's General Law on Climate Change.
2. An open and transparent discussion is needed on the best methodologies to decarbonise the transport sector so that it meets international mitigation goals. The design of national mitigation targets in the transport sector is hampered by methodological inconsistencies and a lack of certainty, which puts limitations on stakeholder consensus. Mexico's NDCs were estimated from the 'business-as-usual' scenario of GHG emissions by 2030. Therefore, mitigation targets are relative to future expected emissions, which implies a growth in real emissions in the medium term even in a reduction scenario. Moreover, there are discrepancies between official and independent estimates, indicating a potential underestimate of national GHG emissions.[20, 21, 22]

The UK Partnering for Accelerated Climate Transitions (PACT) consortium, led by Iniciativa Climática de México (ICM) in coordination with the Carbon Trust and the World Resources Institute-Mexico, estimated Mexico's national carbon budget as well as the decarbonisation pathway of the transport sector. According to Mexico's historical contribution to cumulative GHG emissions (1.39%), its carbon budget by the end of this century will total 22.2 $GtCO_2e$, with 6.16 $GtCO_2e$ of this due to the transport sector.[23] The carbon budget would allow climate policy planning to ensure that the country makes the necessary mitigation contributions to meet the objectives set out in the Paris Agreement.

According to the assessment of Daniel Chacón et al. (2019), aligning transport emissions to the 6.16 $GtCO_2e$ sectoral budget estimated by the UK PACT consortium, requires an ambitious electromobility strategy to be implemented in the next decade (Figure 3). In the business-as-usual scenario, emissions from this sector would reach 240 $MtCO_2$ in 2050. Therefore, to keep emissions from the transport sector on the 2°C pathway, a 140 $MtCO_2e$ reduction in emissions is required by 2030, and a 130 MtCO2e reduction for a 1.5°C pathway. To achieve this, 60% of the 64.4 million light and heavy vehicles estimated to be in circulation by 2030 should be electric, which would require a 50% annual electric vehicles (EV) growth rate. In addition, the number of internal combustion engines (ICEs) needs to be significantly reduced (26 million units) by the same year. As well as the environmental benefits, this measure would generate an annual saving of 871 billion pesos (3.81% of GDP).[iii, 24]

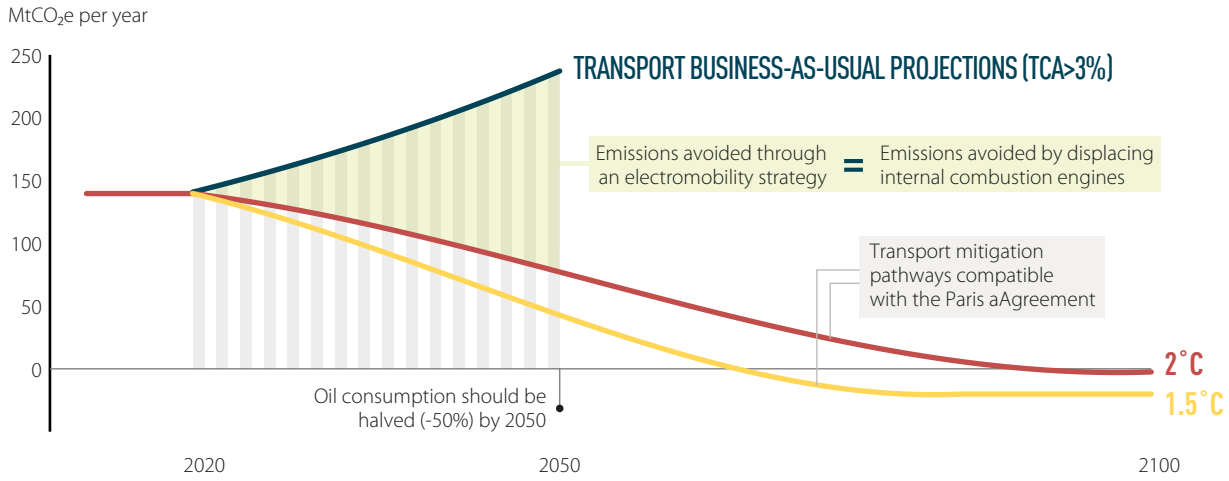
Figure 2: **The average age of passenger and heavy duty vehicles**



Source: Authors' own, adapted from AMIA (2018)

iii. ICM estimates 38 million EVs are needed to align national GHG emissions to a 2°C pathway. Substituting ICES with an average fuel efficiency of 10 km/l, implies a significant reduction in the consumption of gasoline and diesel.

Figure 3: **Electromobility strategy for the transport sector**



Source: Chacón et al., 2019

The decarbonisation of the transport sector, and its significant environmental and economic benefits, require a robust political framework for the promulgation of new technologies. Conventional and electric vehicle prices are expected to reach price parity by 2025,[25] yet the domestic deployment of these technologies is currently minimal. For instance, in Mexico, electric cars only represent 0.14% of new vehicles sales, the lowest in the G20 (compare, for instance, to 4.5% in China and to the United States and Canada with 2.45 and 2.32%, respectively).[26] Moreover, the draft of the Electromobility Strategy of the Secretary of Environment and Natural Resources estimates that EVs only reach 10% of the vehicles sold by 2030. This scenario is not ambitious enough to meet the sector's required mitigation. Therefore, a policy that promotes and ensures a deep deployment of EVs is needed, along with a consistent plan to eliminate ICEs, even hybrid ones.

3. DRIVERS AND COEFFECTS OF AN ELECTROMOBILITY TRANSITION IN MEXICO

A radical transformation in the transportation sector is needed to align Mexico's emissions to the 2°C pathway. Moreover, climate targets need to be reviewed to comply with the Paris Agreement temperature limit. The focus in this section is on the electrification of light passenger and commercial vehicles given their major contribution to national GHG emissions. Further analysis is needed regarding the electrification of public transport, in light of the undisputed benefits this would bring concerning space and efficiency.

Having identified electromobility as a key lever for decarbonising transport in Mexico, this section explores the topic of drivers and coeffects associated with an electromobility transition through two themes:

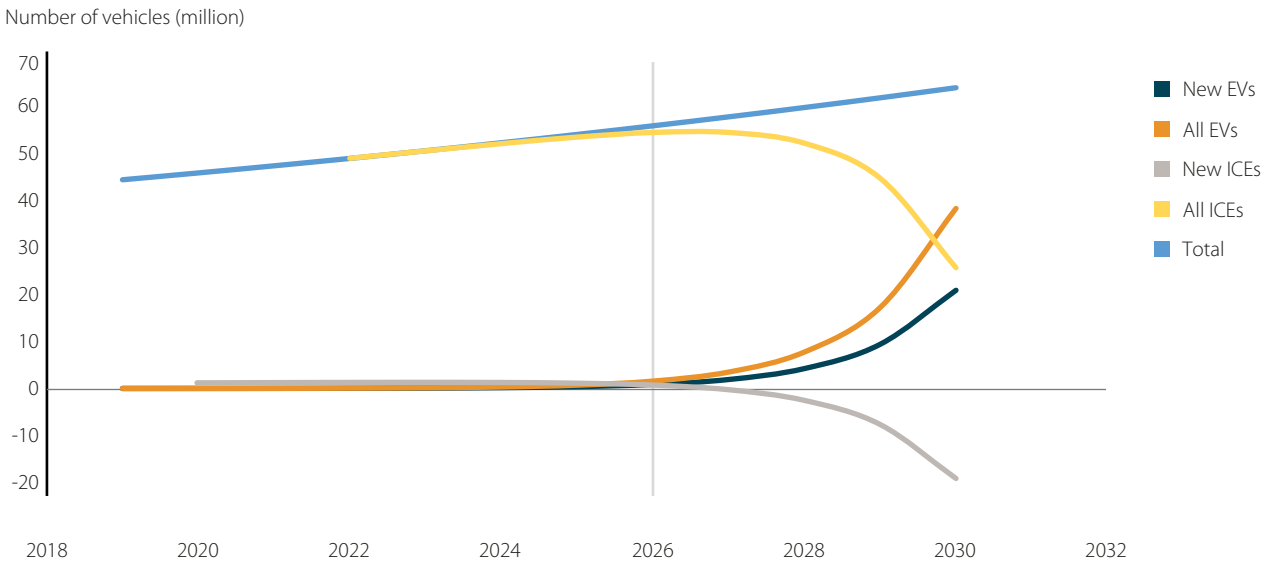
- **The convergence of energy and mobility to comply with mitigation targets:** While the cost-effectiveness of these technologies has improved, the transition from fossil fuels to other cleaner sources of energy is transforming energy and mobility systems around the world. Advancing electromobility is a necessary step to align national emissions to the Paris Agreement's temperature pathways of 2°C and 1.5°C.
- **Leveraging the associated coeffects of reducing GHG emissions and promoting electromobility:** In Mexico, vehicles are a significant contributor to outdoor air pollution, especially in cities where the population is projected to grow most rapidly. Approximately 78% of the Mexican population live in urban areas,[27] and it is expected that this share will reach 86% by 2050.[28] Immediate public health benefits are gained by reducing GHG emissions. Moreover, electromobility provides the opportunity to transform infrastructure, promote job creation and develop business models to promote EVs as affordable and sustainable means of transport. Also, ending dependence on fossil fuels reduces political tensions around oil.[29]

The convergence of energy and mobility to comply with climate change mitigation targets

According to official estimates, between 2013 and 2018, vehicles registered indicated an annual increase of 4% in the rate of motorisation.[30] If this rate is maintained, the vehicle fleet (including both light and heavy vehicles) will hit 64.4 million units by 2030. Considering each vehicle emits 5,044 kgCO_2e at current rates, the number of ICEs on the road should peak by 2026 and decrease after that to align emissions to the carbon budget. Based on the analysis elaborated by Daniel Chacón from ICM, achieving climate mitigation targets will require EVs to account for 60% of vehicles on the road (38.6 million units) and the number of ICEs need to be limited to 40% of vehicle fleet (25.7 million units) by 2030.[31]

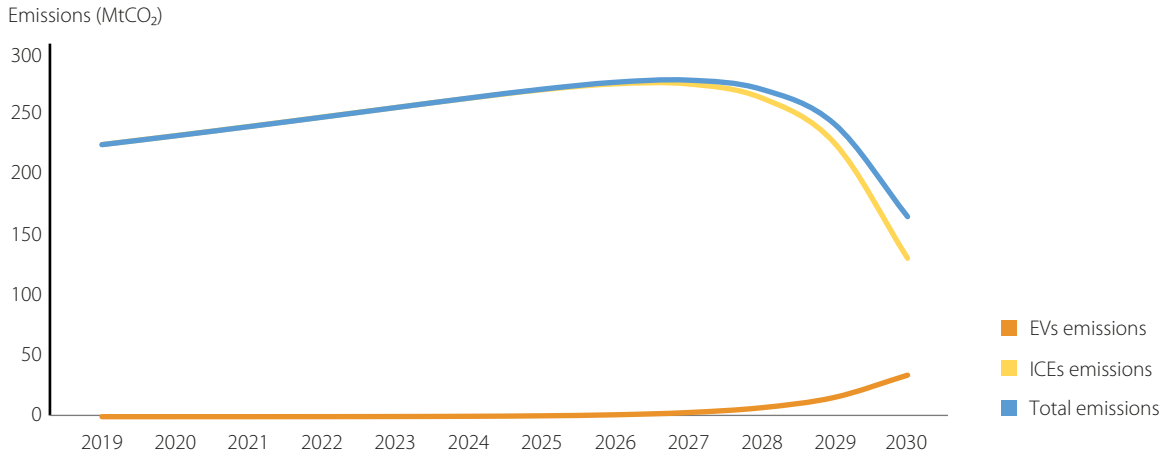
This decline is premised on reducing power system emission factors by 0.52 tCO_2e/MWh with a decreasing annual rate of 3% (see Figures 4 and 5). This decreasing trend assumes the energy mix will be cleaner by 2030, and energy-reduced emissions will reach 139 MtCO_2, according to the unconditional NDC. The strong participation of renewables is crucial to accelerate the energy transition in Mexico in the face of the growing urgency to limit the increase in global temperature to 1.5°C, based on the provisions of the Paris Agreement.

Figure 4: **Vehicle fleet composition to achieve the carbon budget**



Source: Chacón et al., 2019

Figure 5: **Emissions associated with electromobility**

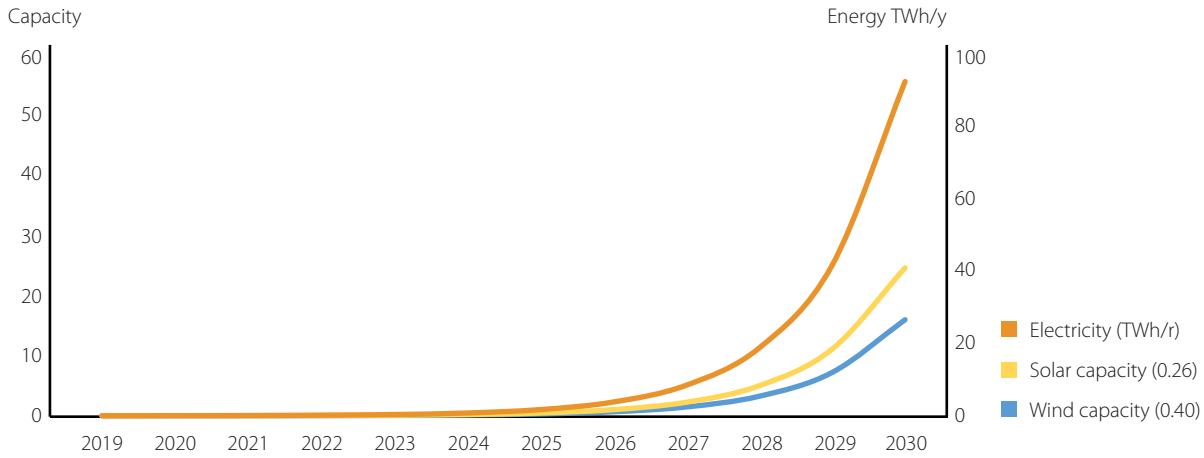


Source: Chacón et al., 2019

Given the current characteristics of the transport sector in Mexico and the pre-eminence of ICEs in comparison with EVs, it will take high ambition to transform the vehicle fleet to a 2°C pathway. For instance, it is estimated that the number of EVs required by 2030 (38.5 million units) for the 2°C pathway, will lead to additional electricity demand (see Figure 6). Moreover, if Mexico aims to align national emissions to a 1.5°C scenario, a more extensive EV strategy would be required.

Advancing electromobility requires an increase of 20% in electricity generation to reach 450,000 TWh by 2030 and 92.5 TWh each year.[iv, 32] The increasing demand could lead to increased peak-energy demand. However, this could be solved by defining hourly tariffs and incentivising users to recharge their vehicles during off-peak hours. To address the energy demand and reduce the power system emission factor, the capacity from solar and wind power needs to reach 0.4 and 0.26 TWh respectively by 2030. Electromobility, coupled with the deployment of renewables in the energy generation mix, becomes key to leveraging the social, economic and environmental benefits of EVs rather than using ICE vehicles.

Figure 6: **Electricity demand from EVs**



Source: Chacón et al., 2019

iv. Additional coeffects could be gained by accelerating modal shift and implementing transit-oriented development, enhancing the use of other responsible modes of transport like public transport, biking and walking. Further research needs to be developed on modal shift and electricity demand.

Leveraging the associated coeffects of reducing GHG emissions and promoting electromobility

The electrification of transport generates benefits that transcend decarbonisation goals. In Mexico, the externalities associated with the transport sector – like air pollution from particulate matter (PM) emissions (PM10 and PM2.5) and GHGs – cost around 1.17% and 0.7% of Mexico's GDP respectively.[33] These amounts exceed the budget allocated to the health sector and the budget allocated to the Fund for Adaptation and Mitigation.[34]

Furthermore, reducing emissions in the transport sector may lead to reducing economic impacts associated with the severity of climate change. Mexico is among the five highest-ranked G20 countries in terms of economic losses, with an annual average financial loss of US$2,955 million (36.2 billion Mexican pesos) from extreme weather events.[35] This amount exceeds the budget of the Ministry for Environment and Natural Resources in 2019 (30 billion Mexican pesos).[36]

Likewise, electromobility can lead to substantial economic benefits and promote value chain changes. The life-span of batteries is 10 years at least with 60% capacity remaining at the end of that period.[37] Improved manufacturing processes and innovations, recycling and utilising batteries to charge electric distribution networks all offer opportunities to develop new markets and jobs.[v, 38, 39] The use, access and exploitation of fossil fuels have become a significant driver of national identity and energy security,[40, 41] creating geopolitical tensions at national and international levels. Using new energy sources like lithium-ion batteries, therefore, offer an opportunity to reduce political tensions around oil.[42]

4. CHALLENGES TO AN ACCELERATED ELECTROMOBILITY TRANSITION AND CONSIDERATIONS FOR SOCIAL JUSTICE

Despite the potential benefits from the electrification of the automotive sub-sector, different conditions should be considered ahead of EV proliferation in Mexico. This includes, for instance, the reduction in the price of batteries and having the energy infrastructure in place to address a possible increased demand. A cross-cutting policy strategy that integrates critical sectors of society is necessary to leverage the social, economic and environmental benefits of EV proliferation in Mexico.

In Mexico, mobility patterns are strongly related to the deep-rooted inequality that characterises Latin American countries.[43] Increasing rates of motorisation in cities are consistently related to substantial rises in per capita income and are perceived as a symbol of social status. However, increased motorisation that is dependent on ICEs causes traffic and perpetuates a vicious cycle that spurs road construction, urban sprawl and air pollution. Displacing ICEs by EVs is a concrete step to avert this vicious cycle and reduce environmental impacts.

Affordability is one obstacle to substituting ICEs by EVs. In the case of EVs, the lithium-ion batteries are vital components that influence EVs' price according to their storage capacity, with a relatively high cost. Nevertheless, due to the massive production of batteries, their price has significantly reduced in the last years, varying from US$650/kW to US$176/kW between 2013 and 2018.[44] Global estimates foresee its price hitting US$62/kW by 2030. Following this trend, it is estimated that EVs will become more affordable than ICEs by 2025.[45]

In the state of Sonora, the Mexican government recently discovered one of the world's largest lithium mines, which is planned to be exploited after 2021. The domestic proven and probable reserves of lithium are estimated at 243.8 million tons,[46] which are larger compared with the lithium reserves in Nevada and Australia (179.4 million tons and 152 million tons respectively). The lithium reserves offer the possibility to guarantee synergies between energy and climate governmental agendas with national development goals of promoting economic growth as well as new manufacturing processes and innovations. In this regard, Victor Toledo, the Head of the Ministry of Environment and Natural Resources of Mexico announced that lithium would replace oil shortly, turning Mexico into a key player in the international lithium industry, similarly to Bolivia and Chile.[47]

These recent lithium mine discoveries could add a new political tension for lithium- producing countries like Argentina,[48] and now, Mexico. In this process, the justice and social implications of extracting new materials required for ongoing energy transition

v. China is leading a pilot regional recycling system as well as a national standard for electric car batteries, setting an example of a circular economy for other EV manufacturing countries.

should have a central role in energy planning to guarantee the adequate distribution of costs and benefits of such a shift. Similarly, the social implications of extracting the materials required for EVs should be at the centre of the sector's planning and policies to deliver a fair energy transition. Switching from fossil fuel technologies to new and cleaner energy resources will lead to a reconfiguration of social and political structures.[49]

To mitigate risk and ensure a socially just transition, a clear and shared vision is needed. There is no shared or clear vision among different levels of government in how the electrification of transport will transform mobility patterns, urban development and planning in the medium and long term. Developing a participatory and inclusive plan that integrates interests, needs and motivations of the various stakeholders from the national, state and local levels, is critical to creating a framework of justice.

In sum, the EV revolution is growing at a rapid pace globally, with EVs becoming a viable alternative to ICEs. The Mexican government should take advantage of this global revolution to leverage the benefits of EVs as an effective alternative to achieve climate targets. As discussed in the following section, the federal and subnational governments must develop the sectoral political framework to drive the massive adoption of EVs as sustainable alternatives for transport.

5. IMPLEMENTATION STRATEGY FOR AN ACCELERATED ELECTROMOBILITY TRANSITION

The slow progress in achieving mitigation objectives is related to the lack of policy coordination in Mexico, among other factors. Currently, each sector defines its own sectoral goals, leading to inconsistencies and duplication in policy-making. The lack of institutional coordination also fragments the sector's decarbonisation policy and compromises the benefits of accelerating mitigation in Mexico.

The energy and climate agendas, for instance, need to be coordinated and with other critical sectors such as urban planning, mobility, employment and infrastructure planning at large to guarantee a robust institutional and legal framework and policy conditions to achieve decarbonisation. In this process, the federal and subnational governments have a crucial role to play in addressing several economic, institutional and social challenges that the decarbonisation of the transport sector faces.

As discussed in Section 1, to achieve Mexico's international climate targets will entail transparent and accountable methodologies and policy processes. When defining mitigation commitments and a national emissions reduction strategy, integrating decisions across different sectors of policy will be fundamental. For instance, updating and upgrading national climate commitments involves collaboration and dialogue among policy-makers within the Ministry of Environment and Natural Resources (SEMARNAT), with the National Institute of Ecology and Climate Change (INECC), as well as with other ministries from the Federal Public Administration and other sectors of society such as the academic sector and NGOs in the field of climate change.

Policy integration would enable the achievement of practical outcomes that simultaneously fulfil the goals of more than one sector.[50] For example, a first concrete step towards defining an EV strategy requires collaboration and coordination between the urban, environmental and energy ministries to guarantee that the National Mobility Strategy integrates ambitious electromobility targets. At the same time, this sectoral interaction could promote a shared vision of how EV proliferation can positively transform mobility patterns.

Furthermore, a paradigm shift in policy-making is needed in order to transform mobility patterns and eradicate the entrenched inequalities that sustain dependence on ICEs and produce urban sprawl and air pollution. This shift should be

accompanied by a long-term vision that leverages the benefits of decarbonisation. A definite step towards this goal would be avoiding the construction of fossil-intensive infrastructure that perpetuates carbon lock-in and progressively eradicates subsidies to gasoline. To that end, the federal institutions, like the Ministries of Energy and of Finance and Public Credit, need closer interaction.

To improve EV affordability in order to substitute ICEs, a shift in public expenditure is required. Currently, the federal government subsidises gasoline, promoting the use of ICEs and increasing the negative externalities associated. It should end these contradictory incentives and communicate the benefits of electromobility. Phasing out subsidies in gasoline requires coordination among different levels of government and actors.

The potential social implications associated with decarbonising the transport sector require a significant redesign of the energy governance structure. In this regard, policy alignment across the Energy, Urban Planning, Economic and Social Development Ministries is essential.

The aforementioned policy recommendations and others are included in Table 1. This policy package could contribute to the decarbonisation of automotive sub-sector – and possibly the transport sector as a whole – in the medium and long term. The recommendation therefore is to implement these priority measures at the same time as an electromobility strategy is developed.

Alongside those policy recommendations, Table 2 details three types of policy measures (on vehicle restrictions, influencing user behaviour and economic incentives) to accelerate EV proliferation in Mexican cities in the short term. The measures are classified under the "push-and-pull policies" approach. The "push" policies disincentivise the use of ICEs by setting higher tariffs and vehicle restrictions on ICEs and other inefficient vehicles. The "pull" policies promote using EVs, public transport, walking or biking by improving infrastructure, access and affordability of sustainable ways of transport (see Table 2).

Table 1: **Policy recommendations to decarbonise the transport sector**

Policy areas	Policy recommendation	Actors involved*
Environment and climate change	Make climate change central to the sectoral regulatory and policy frameworks related to urban development (housing, transport, employment, infrastructure).	SEMARNAT and other sectoral ministries
	Develop more accountable and transparent mechanisms to define climate mitigation goals and sectoral planning instruments to reduce national GHG emissions.	SEMARNAT, INECC
	Update and upgrade regulatory emission standards and efficiency for vehicles (new and on the road) according to international criteria.	SEMARNAT, SENER, SE, CONAMER, AMIA, ANPACT
	Upgrade and reinforce air quality monitoring systems and local programmes as well as the regulatory standards for criteria pollutants.	SEMARNAT and SS Ministries
	Make emissions inspection programmes mandatory and develop vehicle scrappage programmes to get rid of polluting and inefficient ICEs.	SEMARNAT, SCT Ministries
	Enhance the elaboration of local programmes to improve air quality and provide updated information on air quality and preventive actions that citizens can take.	SEMARNAT, SS and, SCHP Ministries, COFEPRIS, CONAMER
	Create the regulatory and policy framework to recycle, reutilise and properly dispose of batteries.	SEMARNAT, SENER, SE
Energy	Avoid the construction of fossil intensive-infrastructure that perpetuates carbon lock-in and deploys renewable energies.	SENER, PEMEX, BANOBRAS, CRE
	Set targets for electric motorisation (including motorcycles, scooters and others) and heavy duty vehicles.	SENER, SCT, SEMARNAT, CONAMER
	Promote and communicate the economic benefits of EV proliferation and develop the regulatory framework to set preferential tariffs in EV charging stations.	SENER, CFE, SCT, SEMARNAT, SEDATU.
	Improve distribution networks to support charging station load.	SENER, CFE
Urban, Housing and Transport Planning	Articulate transport planning with housing policy and contain urban sprawl.	SEDATU, CONAVI
	Develop and implement a longer-term strategy to promote modal shift; and promote and create integrated transport systems.	SEDATU, SCT, BANOBRAS
	Develop a National Mobility Strategy coordinated with a National Electric Mobility Plan.	SEDATU, SENER, SEMARNAT, CONAMER
	Adopt a strategy to phase out ICEs and fossil-fuel light duty vehicles.	SCT, SEMARNAT, SENER, SE, CONAMER
	Guarantee that building codes include EV charging stations.	SENER, BANOBRAS
Budget allocation and finance	Plan for the creation of EVs charging infrastructure in strategic locations like roads, cities (buildings, supermarkets), public spaces.	SEDATU, SENER, BANOBRAS, CONAMER
	Allocate funds to implement the Sustainable Urban Mobility Strategy and implement urban integrated transport systems instead of incentivising dependence on ICEs.	SCHP, SEMARNAT, House of representatives
	Progressively eradicate subsidies to gasoline and disincentivise the use of fossil fuels.	SCHP, SENER, CONAMER

Source: Authors' own adapted from CTS Embarq, IMCO, et al. (2013)[51]

* The acronyms stand for: Ministry of Environment and Natural Resources (SEMARNAT); National Institute of Ecology and Climate Change (INECC); Ministry of Energy (SENER); Ministry of the Economy (SE); National Regulatory Improvement Commission (CONAMER); Ministry of Health (SS); Ministry of Communications and Transport (SCT); Ministry of Finance and Public Credit (SCHP); Federal Commission for the Protection against Sanitary Risk (COFEPRIS); Regulatory Energy Commission (CRE); National Association of Bus, Truck and Tractor Truck Producers (ANPACT); Mexican Oil Company Petroleos Mexicanos (PEMEX); National Bank of Public Works and Services (BANOBRAS); Ministry of Agrarian, Land and Urban Development; National Housing Commission (CONAVI).

Table 2: **Incentives and disincentives to accelerate EV proliferation**

	Push policies: disincentivise ICEs (higher tariffs, taxes, restrictions) and polluting, inefficient vehicles	**Pull policies:** incentivise the use, production and commercialisation of EVs
Vehicle restrictions according to efficiency and emission	Create low emission zones that prohibit the entrance of ICEs and inefficient vehicles.	Preference in federal auto transport concessions for EVs.
	Prohibit diesel vehicles not aligned to Euro IV standard.	Set increasing EV rates for automobile manufacturers with bonus, incentives and sanctions.
	Higher tariffs in congestion charge for ICEs and inefficient vehicles.	Fiscal stimuli for EVs.
		Exemptions on vehicle ownership tax, privileges in parking tariffs and special driving privileges and parking lots for EVs.
Influencing user behaviour by providing information about costs and benefits	Make development platforms mandatory with information about charging infrastructure and other matters related to EVs.	Vehicle efficiency labelling, providing information on emissions and savings for users.
	Create informative programmes about EV benefits.	Federal, state and local government setting the example with EV fleets.
	Develop campaigns to raise citizens' awareness about environmental matters.	Tax incentives for the purchase of EVs.
Economic instruments	Introduce an emission tax mainly for polluting vehicles and inefficient ICEs.	Incentivise vehicle fleet renovation.
	Define stringent standards and tariffs on importing ICEs.	Set guaranteed loan agreements for EVs with special privileges.
	Higher tariffs for inefficient ICEs in highways.	Quota exemption for EVs on highways.

Source: Authors' own adapted from Chacón et al., 2019.

6. CONCLUSION

Global efforts to tackle climate change are insufficient to achieve compliance with the Paris Agreement, including in the transport sector. Even the G20 economies, which represent more than three-quarters of global GHG emissions, are failing to implement policies that have been effective in decarbonising this sector. The COP26, however, presents an opportunity to strengthen climate action in the area by presenting more ambitious NDCs as well as clear national plans to reduce emissions in the transport sector.

In Mexico, the transport sector contributes approximately one-quarter of the country's emissions. Light (passenger and commercial) vehicles are responsible for more than 80% of total emissions. Transport emissions stem from the burning of fossil fuels by ICEs, causing adverse social, economic, environmental and even political effects.

Given the estimates of the projected growth of the vehicle fleet (4% per year), continuing to burn fossil fuels will further aggravate the health problems associated with poor air quality, will add to the effects of climate change and will increase government spending while other development issues are left unattended. Every year, Mexicans lose plenty of resources due to the government's failure to implement ambitious, transparent policies that are aligned to the climate emergency.

Within the range of alternatives to reduce emissions from the transport sector and improve air quality in cities, electrification of automotive vehicles has become a necessary and economically viable alternative globally. To estimate the benefits of implementing an electromobility strategy at the national level, ICM analysed how ambitious such a policy would need to be by 2030, to reach an emissions scenario of 1.5ºC and 2°C.

Moreover, ICM estimated the electricity generation required for the supply of EVs, highlighting the importance of resuming the deployment of renewable energies in Mexico and enhancing the benefits of the energy transition. The results indicate that a radical transformation of the vehicle fleet is required, which implies an increasing penetration rate of EVs in years to come until ICEs are displaced.

In the face of the forces of global technological change, the Mexican government needs to anticipate such change and deploy the measures needed to accelerate the electrification of the automotive sector. However, there are structural challenges to boost the decarbonisation of the sector. For instance, the disarticulation between the sector's mitigation policy and urban development policies (e.g., housing and mobility), which affect the environment and health spheres, has led to a disorderly and inequitable growth of cities. This issue, coupled with a nationalist vision rooted in fossil fuel consumption, has produced a dependence on ICEs, increasing inequality and negative externalities in the transport sector. Therefore, a set of policies was identified that, if implemented in a coordinated manner across different sectors, would enable the faster decarbonisation of the sector.

However, reversing institutional and sectoral disarticulation will require long-term joint working. Although this should not be postponed, it must be accompanied by a series of restrictive measures, stimuli and economic instruments that can be implemented as of today to accelerate the transition to electromobility in Mexico.

This document concludes that it is feasible to accelerate the reduction of emissions through the electrification of the automotive sector. There are, however, several implications both for society and for decision-makers. In the social sphere, an adequate transformation of the transport sector requires a guarantee of spaces for dialogue and transparent mechanisms for citizen participation Dialogue spaces allow information to be distributed about the objectives, benefits, duration and processes of electrifying the transport sector. Citizen participation mechanisms are essential for the functioning of any democracy, as they help to include society in public affairs and encourage ownership and legitimacy in government decision-making.

Decision-makers, meanwhile, require a series of coordinated institutional and public policy processes that are aligned with each other and that foster shared political will. A decisive step in this direction is the strengthening of existing institutions responsible for ensuring collective and shared interests that slip through the different levels of government and legal faculties. It is essential to go beyond sectoral targets and instead prioritise the formulation of national targets and the policies needed to achieve them.

Further analysis needed:

The latest report from the UN scientific panel on climate change – *Special Report on Global Warming of 1.5°C* – advises that aligning emissions to a 2°C goal can no longer be considered a safe limit. Further analysis must consider the impact of combining an automotive electromobility strategy with other mid- and long-term strategies (for instance, accelerating vehicle turnover rates, promoting modal shift, transit-oriented development and other possibilities to decarbonise the transport sector), to achieve the 1.5°C pathway.

More specific information is needed on road vehicles. The official data regarding motorisation rates is provided by Mexico's National Institute of Statistics and Geography (INEGI by its acronym in Spanish). The database provides information about cumulative vehicles registered by Mexican states, excluding those vehicles that changed their subscription to another state. Therefore, the information may be overestimated as this database may not include specific data for all existing road vehicles.

The most updated and official information regarding public health impacts in Mexican cities needs to be included. Due to the lack of official estimates, the information included provides independent analysis on average estimates for 20 Mexican cities.

TERMS

The 2°C and 1.5°C targets: In 2015, countries reached a landmark agreement to hold the increase in global average temperatures to well below 2°C and to pursue efforts to limit the increase to 1.5°C. The estimates included in this document for the electromobility strategy in the automotive sub-sector are based on a 2°C pathway. Thus, achieving the 1.5°C pathway requires a more ambitious and extensive strategy.

Automotive sub-sector: This represents 86% of transport sector greenhouse gas emissions in Mexico; includes commercial and light passenger vehicles, heavy freight and passenger vehicles, and motorcycles.

Automotive electromobility strategy: This is primarily focused on commercial and light passenger vehicles. These vehicles currently depend on diesel and gasoline. Switching internal combustion engines (ICEs) to electric vehicles (EVs) is a concrete step to reduce emissions.

Carbon budget: This refers to the CO_2e accumulated emissions allowed during a certain period to maintain global temperature within a specific range.

Coeffects: Positive environmental, economic and social impacts derived from the decarbonisation of the transport sector by implementing an automotive electromobility strategy.

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