



# Decarbonising Transport in Latin American Cities

Assessing scenarios to 2050

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The DTLA project is part of the IDB's Regional Public Good programme 'Support to the planning of low-carbon transportation systems (RG-T3102)<sup>2</sup> and the ITF's Decarbonising Transport (DT)<sup>3</sup> initiative. More specifically, the project is part of the DT initiative's work stream on the development of transport decarbonisation pathways for regions, countries or metropolitan areas.

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1. Decarbonising Transport in Latin American cities: A review of policies and key challenges.  
2. To learn more about this initiative, please see: <https://www.iadb.org/en/project/rg-t3102>  
3. To learn more about this initiative, please see: <https://www.itf-oecd.org/decarbonising-transport>





## Chapter 1: Introduction and conclusions



Greenhouse gas (GHG) emissions from the transport sector have more than doubled since 1970 and are the largest and fastest growing source of energy-related emissions in Latin America and the Caribbean (LAC). As a result, all LAC countries have defined specific contributions to reduce the CO<sub>2</sub> emissions generated by the transport sector. The IDB has reinforced its commitment to address this shared challenge, by supporting the adoption of sustainable and clean urban mobility. In fact, the IDB Vision 2025: Reinvest in the Americas highlights the need for supporting LAC countries in their efforts to develop and implement mitigation measures for the transport sector.

In line with those objectives, this report assesses the impact of policies on passenger transport activity and related CO<sub>2</sub> emissions for three Latin American cities, Bogota, Buenos Aires and Mexico City. For each city, policy scenarios have been designed with local authorities that help draw conclusions on the degree to which a set of policy and infrastructure measures may reduce urban transport CO<sub>2</sub> emissions by 2050. The ITF, in close cooperation with the IDB and the respective city authorities, has developed tailored transport and CO<sub>2</sub> assessment tools for each city to carry out the analysis and assess the impact of the different scenarios.

### Global urban passenger transport demand is set to grow – especially in Latin America

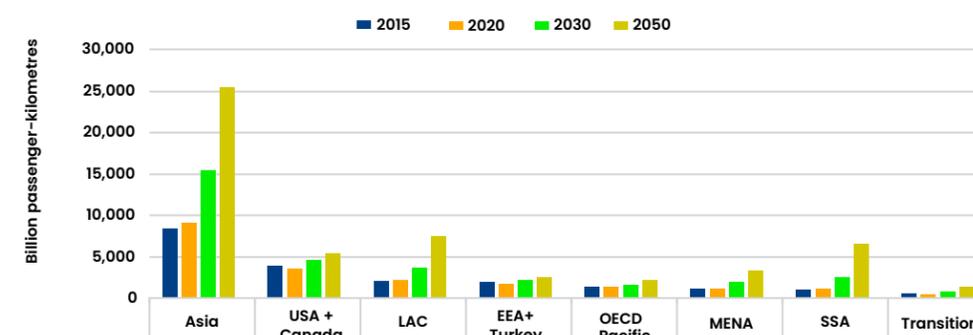
Global transport demand and related emissions are set to grow. Notably, after a temporary reduction in 2020, global passenger transport demand will double between 2015 and 2050 under the so-called Recover scenario – a scenario developed by the ITF for its Transport Outlook 2021 (ITF, 2021), see Box 1. Global urban passenger transport demand will grow by a factor of 2.6 over the same time period. This urban transport demand growth is driven by urbanisation, GDP and population growth – factors that develop differently across the world regions.

### Box 1: Definition of the ITF Recover scenario

The *Recover scenario* assumes that governments prioritise economic recovery from the years of the pandemic by reinforcing established economic activities. They continue to pursue existing (or imminent) commitments to decarbonise the transport sector. Alongside these, governments take action with policies that ensure some of the transport trends that hinder decarbonisation observed during Covid-19 revert back to previous patterns by 2030. These trends include a shift to greater private car use, and reduction in public transport ridership, for example. Changes in behaviour such as reduced business travel or greater shifts to active mobility which have lowered CO<sub>2</sub> emissions, also revert back to pre-pandemic norms by 2030. Due to limited policy action on technology innovation, cost reduction in clean energy and transport technologies do not take place to the extent they could. The Recover scenario is an updated version of the *Current Ambition* scenario in the *ITF Transport Outlook 2019*, accounting for Covid-19 related changes and policies announced since.

In Latin America and the Caribbean, urban transport demand grows by a factor of 3.5 (see Figure 1). This growth is the second highest growth rate around the globe, only surpassed by the six-fold urban transport demand growth for sub-Saharan Africa. Given the environmental impact of transport activity, and on CO<sub>2</sub> emissions in particular, such developments are concerning in the context of climate change.

Figure 1. Demand for passenger transport in urban areas by region, 2015–2050



Note: EEA refers to the European Economic Area. LAC refers to Latin America and the Caribbean. MENA refers to the Middle East and North African countries. OECD Pacific countries include Australia, Japan, New Zealand and South Korea. SSA refers to Sub Saharan Africa. Transition economies include countries that were part of the Former Soviet Union and non-EU south-eastern European countries. Source: ITF (2021)

However, increased transport activity does not necessarily need to translate into CO<sub>2</sub> emissions. Especially urban transport has the potential to decarbonise if the right measures are put in place. Measures can encourage the shift of travel away from private cars to other modes, stimulate the adoption of low-emission vehicles, and tilt fuel demand towards low-carbon sources of energy such as electricity from renewable sources. Densification of cities through land use policies and increased teleworking can reduce demand for transport and directly tackle the very source of emissions from the sector.

ITF's recover scenario shows that the 3.5-fold increase of urban transport activity in the Latin America and the Caribbean may 'only' result in a 1.7-fold increase in tailpipe CO<sub>2</sub> emissions. While this may sound encouraging, such an increase is not in line with the global objective of reducing CO<sub>2</sub> emissions

to a level that will limit global warming to below 1.5 degrees, as set out in the Paris Climate Agreement. Rather, urban transport emissions have to fall significantly by 2050, if not reduce to zero entirely, irrespective of any potential transport demand increases in that period. These estimations urge a decisive action from many LAC cities, where decarbonization goals for the transport sector have not yet been operationalized, and are limited to small scale decarbonization pilots.

### Developing CO<sub>2</sub> reduction strategies requires predictive models and scenario assessments

The work presented in this report helps to better understand what actions will help make a significant contribution to transport CO<sub>2</sub> reduction in urban areas in Latin America, based on the assessment of different policy scenarios. For this purpose, two different policy scenarios have been defined with three case study cities, Bogota, Buenos Aires, and Mexico City, and assessed with a quantitative assessment framework. The scenarios built for each city are the result of participatory workshops conducted with local and national authorities from the transport and environment sectors, as well as ITF and IDB staff. These workshops allowed a discussion and analysis of the investments planned for urban transport, as well as an review of the main assumptions incorporated in the models.

The assessment framework developed for each city follows the traditional transport modelling approach to determine travel demand in passenger kilometres, covering the steps of trip generation (how many trips are carried out on an average day?), trip distribution (where do these trips start and end within the study area?) and mode choice (what modes are used to reach a destination?). The trip generation step relies on a regression model that uses information on population, income and/or job developments for different city zones as inputs. The trip distribution step relies on a so-called gravity model that provides the likelihood of a specific trip being carried out to certain destination (zone), based on the ease (or difficulty) to reach that destination. This ease (or difficulty) is expressed via a so-called generalised cost function that accounts for the time and costs it takes to reach that destination. The mode choice of a trip-maker is determined by a mode choice model, a discrete choice model, where the different mode alternatives are weighed against each other based on their 'utility'. The higher the utility of an alternative, the more likely the user is to choose that alternative. The utility of a mode is determined by characteristics of the mode itself (such as waiting, access and egress time, and costs) but also by characteristics of the user (e.g. to reflect that women may prefer specific transport modes or that some users may not have access to a certain mode of transport). Resulting passenger kilometre estimates are then converted to vehicle kilometres by taking assumptions on vehicle load factors and their developments over time. A vehicle stock model derives the number of vehicles required to meet the vehicle kilometre demand, and traces their life in the total vehicle fleet. This allows to estimate the fuel and age composition of the vehicle fleet and its CO<sub>2</sub> emissions over time.

Detailed specifications of each model developed for the three cities vary due to data availability and the specifics of each city. In general, the main data sources that were used can be classified into three categories: data from mobility or national household travel surveys (connecting individuals and their sociodemographic and geographic characteristics with their travel choices) and national census and local statistics to scale results of survey data to the whole population of a city; the transport models of the cities (where available); and data coming from ITF's own data repository, such as road network information from OpenStreetMaps or OECD forecasts for future GDP growth.

More information on the methodology and data behind the modelling tools that were developed for each city has been made available to the city authorities. City authorities were also provided with more detailed assessments on the impact of each individual policy measure in separate project delivera-

bles. The modelling tools have been provided to the city authorities for their further use and updates over time.

Finally, it is noteworthy to highlight this methodology has an enormous potential to be replicated in other LAC cities, subject to the availability of urban mobility information. This tool could be very helpful to guide the investments of intermediate or medium cities -defined as those between 100,000 and two million inhabitants-, which may face greater mobility and urban planning challenges along with lower fiscal space for investing in the transport sector.

### The cities' growth perspective raise enormous challenges for transport

The three case study cities (i.e. the corresponding study areas) face similar growth perspectives to 2050. GDP forecasts by the OECD expect a doubling of economic activity in all three areas by 2050. Population growth is projected to be comparatively modest, resulting in important GDP per capita increases. These developments are alarming and will result in enormous challenges for the cities. If cities do not achieve to decouple GDP from transport activity growth, transport systems and their (economic, social, and environmental) externalities will be increasingly difficult to manage.

The study area for each city goes beyond the administrative boundaries of the cities. For Mexico City, this work analysis future transport scenarios for the Metropolitan Zone of the Valley of Mexico, with around 21 million inhabitants. For Buenos Aires, the study area covers the Región Metropolitana de Buenos Aires (RMBA), with around 15 million inhabitants. The study area for Bogota comprises the Bogota Capital District (Bogota D.C.) and the surrounding department of Cundinamarca, inhabited in total by around 10.5 million people. The delimitation for Bogota does not refer to any existing legal, administrative of planning area.

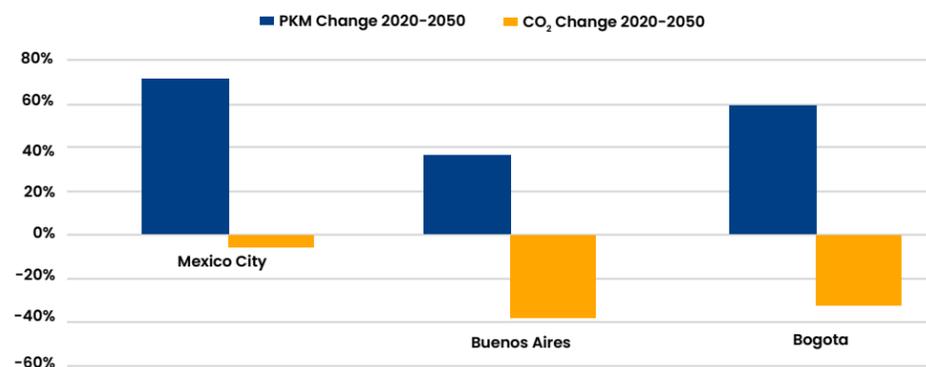
### Cities will decouple transport activity from CO<sub>2</sub> growth with heavy reliance on clean vehicles

As the three case study cities devised their own scenario definitions, definitions are naturally not coherent across the three cities. However, the baseline scenarios do represent in all cities a future where many or all already stated policies and plans are followed through. Mainly, these refer to measures in the timeframe to the year 2030, after which policy measures are less clear from today's point of view. Buenos Aires' definition of the baseline scenario is more ambitious and more forward-looking in terms of the policy measures that may also happen beyond 2030.

If the plans as reflected in the cities' baseline scenarios materialise, cities will have successfully ensured that transport activity does not directly translate into CO<sub>2</sub> emissions increases. Passenger kilometres will increase significantly across all three cities, while CO<sub>2</sub> emissions can be held in check or even successfully, and substantially, reduced (Figure 1). In the case of Mexico City and Buenos Aires, further growth in transport demand is held in check by comparatively optimistic assumptions regarding the uptake of teleworking also beyond 2020, the year when the COVID-19 pandemic initially hit the world (i.e. by 2050, total trip reductions of around 15% are assumed, compared to a scenario where teleworking would follow pre-pandemic trends).

CO<sub>2</sub> reductions in the cities' baseline scenarios rely almost exclusively on the uptake of clean vehicle technologies, with Mexico City having the most modest assumption of what will be achieved by 2050.

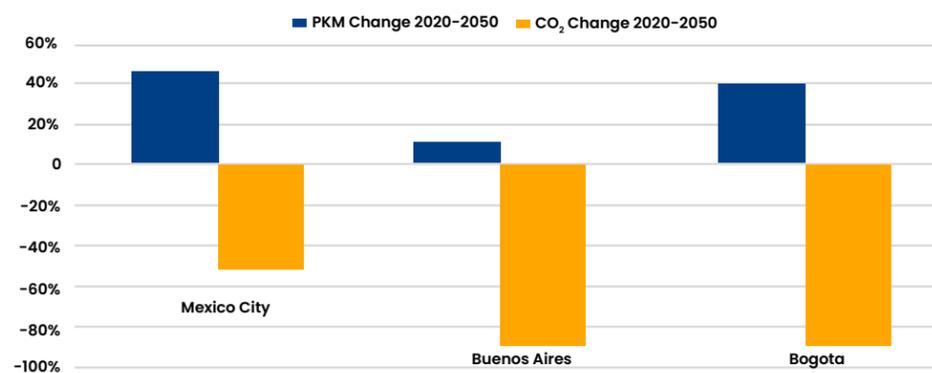
Figure 2. Change in transport indicators for the three cities, baseline scenarios as defined by each city, 2020–2050



None of the cities achieves any noticeable mode shift away from the use of private vehicles to more sustainable modes. This is concerning in the broader context of devising a sustainable transport system. Without significant mode shifts, economic and social externalities of the transport system, such as congestion and unequal access to opportunities for different population and income groups is likely to prevail and intensify over time.

Alternative policy scenarios assume greater ambition towards transport CO<sub>2</sub> mitigation. They reflect ‘what-if’ scenarios and go beyond currently planned measures. Case study cities provided again their specific definitions; as a result, a direct comparison between the scenarios across the three cities is not meaningful. Figure 3 shows that Buenos Aires and Bogota come close to a complete decarbonisation of their transport system by 2050 in their ‘what-if’ scenarios. Transport demand reductions stem from a further intensification of teleworking trends and scattered land-use measures. CO<sub>2</sub> outcomes rely again on the success of clean vehicle uptake. However, in the alternative scenarios, there is also a noticeable mode shift to more sustainable modes, which contributes to further emissions reductions. This would likely also result in more efficient, equitable and hence sustainable transport systems when compared to the baseline scenarios.

Figure 3. Change in transport indicators for the three cities, alternative scenarios as defined by each city, 2020–2050



### Ensuring sustainable transport systems by 2050 requires longer-term and more holistic strategies

Scenario results allow for the following recommendations applicable to the three case studies and beyond:

- Authorities should develop long-term strategies (to 2050 or beyond) for decarbonising their transport systems. Currently existing plans often do not go beyond 2030. Ensuring objectives are met, and that the right measures are put in place on time, requires long term planning and quantitative assessments of future measures. A step-wise approach to CO<sub>2</sub> reduction strategies risks that targets are not met on time, and that reduction efforts are put off to the future.
- Urban areas, and especially those with significant (GDP) growth forecasts, should strive to implement land-use measures that contribute to limit transport activity growth as quickly as possible. Land-use changes take time. If action is not taken now, reaping the benefits of such measures will not be possible on time to adhere to global commitments with regards to climate change mitigation. Relevant measures include the development of local centres and mixed use developments to reduce travel distances and to encourage the use of sustainable modes on resulting shorter trip distances, all while keeping urban sprawl in check.
- Urban areas should consider all levers, from regulatory to financial measures, to restrict the use of private motorised vehicles. Such measures require the provision of adequate alternatives. Investments in the enhancement of infrastructure and/or services of more sustainable modes (i.e. walking, cycling and public transport) is therefore essential and should go hand-in-hand with measures restricting private vehicle use.
- To achieve CO<sub>2</sub> reductions on time, much will unavoidably rely on the uptake of zero-emission vehicles. Considering vehicle turnover rates, zero-emission vehicle sales should reach significant levels rather sooner than later to ensure clean public and private vehicle fleets. Urban areas will need to ensure that they follow through on their zero-emission vehicle incentive schemes; and should prioritise here a transition in public vehicle fleets. Supporting private vehicle users to take up new technologies will require careful assessments to ensure any incentives to do not encourage private vehicle usage, especially where alternatives are available. They also need to be carefully designed to help address equity concerns (or at least not raise new ones) across differently population groups. At a very minimum, efforts should be put into communicating the clear benefits of clean vehicle fleets to the wider population. Early private adopters will need to overcome uncertainties with regards to the financial and operational sustainability of zero-emission vehicles. Authorities will need to step in here with financial support to achieve significant uptake levels early on, and, more importantly, recharge/refuel infrastructure needs to be made available in sufficient density, to the benefit of both public and private vehicle fleets. Finally, authorities need to ensure that zero-emission vehicles are ‘fuelled’ by clean energy sources, to avoid a sole shift of transport CO<sub>2</sub> emissions to the energy sector.
- Urban areas should, however, avoid relying solely on the uptake of clean vehicles for decarbonising their transport systems. Such a strategy will bear risks in case clean vehicle developments or availability do not materialise as planned, and will contribute to more equitable and economically efficient transport systems only to a limited degree. Authorities should strive to use the momentum to truly ‘build back better’ after the pandemic, and implement measures that foster holistically sustainable systems – systems that rely on efficient, shared and sustainable transport services.

The following chapters provide more insights in the key results for each city. After highlighted key findings for each city, the first part of each chapter provides brief background information to the transport system of the respective city, introduces the key data sources and the city zoning approach that was determined for adequate model transport activity and its impacts. The chapters then provide insights into the scenario definitions that were elaborated by the city authorities, before turning to the more detailed results of each scenario in terms of passenger transport activity, related CO<sub>2</sub> emissions and other relevant transport indicators. The background information on each city is based on the policy report that was elaborated in the context of the same project (ITF/IDB, 2022).

## Chapter 2: Mexico City



### Summary of findings

Mexico City will experience significant growth in passenger transport demand. In the next decades, the anticipated economic growth, coupled with the increasing population (mostly in the State of Mexico rather than in CDMX), will create a challenge for the transport system of the region. The number of trips will rise, with many of them going to the centre of CDMX; and the economic growth will mean that more people will have the option to purchase a private vehicle. If not properly managed through policies and other measures, this combination could prove a significant deterrent to the CO<sub>2</sub> mitigation ambitions of Mexico City.

Teleworking and decentralisation can be part of the solution. As in many other metropolitan areas in the world, the concentration of activity in the city centre draws increased transport flows. Increased uptake of teleworking – for professions that can telework – can reduce these flows and allow the city to grow organically. Research has shown that commuting trips avoided due to teleworking often lead to increased local activity for other purposes. If proper policies such as land use planning and increased density limits are put in place to support and encourage decentralisation, while keeping urban sprawl in check, many local “centres” could be created near residential locations. This would increase flows to these local centres, which would be shorter in distance and therefore easier to shift to more sustainable modes. This could also potentially counter urban sprawl, an issue facing Mexico City today.

Public transport plays and will continue to play a vital role in the transport environment of Mexico City. Public transport also bears a significant potential to reduce CO<sub>2</sub> emissions. More than 60% of motorised trips in 2017 used public transport. In the baseline scenarios defined by, and assessed for, Mexico City, this share will drop by 8 percentage points. The scenario assumes a number of short-term developments, which create benefits for the city in the short-term and medium-term. The benefits could be even greater on the long-term if further public transport enhancements can be put in place and the right policy measures

ensure their use. This is the case in the proposed alternative scenario, where the mode share of public transport remains the same over the study period. To increase the public transport share, even further improvements to the network and supportive measures that limit car use are needed in the longer term.

Car travel can decrease with proper policy instruments and measures. Private cars play a dominant role in Mexico City. In the past years, Mexico City has been ranked as one of the most congested cities in the world. Without proper policies addressing private car use, it could continue to grow and increase up to 50%, as seen in the baseline scenario. On the other side, if existing restriction policies are strengthened and are coupled with policies promoting the use of more sustainable modes, private car usage could decrease by as much as 20% in 2050. This could be further augmented by additional financial measures such as taxation on private vehicle travel (congestion charging). As long as high quality alternative travel options exist, such measures would further incentivise a switch from private vehicles.

Shared mobility, tested in this model as shared on-demand vans, can revolutionise Mexico City's transportation, but with a warning. Depending on the broader policies, this new mode could take trips from more, or less sustainable modes. In both scenarios, this mode provides 6% of all travelled PKM in 2050. In the baseline scenario, the majority of those PKM come from modes considered more sustainable, such as public transport or cycling. The policies of the alternative scenario, which create barriers in private car use and promote public transport and cycling, lead to sustainable modes maintaining a higher activity share. Shared on-demand vans would take most of their share from former car trips. This signifies the importance to couple the introduction of a new mode, such as shared vans, with other policy measures to ensure the right mode shifts across the different alternatives.

Policies supporting cycling have great potential in Mexico City. Expanding the existing Ecobici programme, coupled with enhancing cycling infrastructure could deliver great benefits for the inhabitants of Mexico City. In the scenarios tested, cycling increased a lot in the zones where these policies were applied. In the Alternative scenario, such policies are assumed to be implemented in half the zones, including big parts of CDMX and some parts of the State of Mexico. This led to a tripling of bike trips in the study area, a much bigger growth than other modes. Measures such as dedicated and protected bike-lanes, clear signalling and pavement maintenance can also have additional benefits. Cycling is a mode that is favoured more by men, as women may consider it to be less safe to navigate through traffic. Such measures can increase confidence and safety for bike users, which would increase the number of women cycling in the city.

Emissions in Mexico City are in a descending trajectory, but the end target will depend on the adopted policies. The current trend of transport CO<sub>2</sub> emissions in the region is downward, a result of the various policies and measures already implemented or planned for by local and regional authorities. The lack of long-term plans, however, limits the potential reduction. In the baseline scenario, transport CO<sub>2</sub> emissions will only reduce by 18% in 2050 compared to 2017. Under the more ambitious plans and targets of the alternative scenario, emissions reduce further. In 2050 they will reduce to 40% of 2017 levels. This drawdown is pushed primarily by the more restrictive medium-term policies and, more so, the vehicle fleet assumptions.

A large part of the emission reduction between the two scenarios comes from the evolution and decarbonisation of the vehicle fleet. This concerns both car and public transport fleets. In the next decades, efficiency of ICE engines will bring significant benefits too, but the true revolution is seen to come with electric and other zero emission vehicle vehicles.

In public transport, the uptake of zero-emission buses can drastically reduce CO<sub>2</sub> emissions and local pollutants. This is evident in the two scenarios tested, where CO<sub>2</sub> emissions from public transport in the

alternative scenario in 2050 are one quarter of the base year. In the baseline scenario, CO<sub>2</sub> emissions in 2050 reduce by 50%. This happens despite the growth in public transport activity observed in both scenarios. Local pollutants, a significant amount of which comes from buses, are also much lower in both scenarios, and especially in the alternative. This is a direct side-effect of the increased uptake of electric buses. To properly integrate electric vehicles in the existing fleets, cities need to address several regulatory, normative, financial and infrastructure barriers that may limit the deployment of e-mobility. The results show the uptake of electric and other low- and zero-emission vehicles will have the biggest effect in CO<sub>2</sub> emissions. In 2017, two thirds of all CO<sub>2</sub> emissions in Mexico City came from private cars. In the alternative scenario, where 50% of new private vehicles sold in 2050 will be electric, emissions from private cars reduce by 62%. To achieve this sales target, however, many policies and measures need to be taken. These range from fiscal and financial, to infrastructure and regulatory measures. As long as electric vehicles have a higher upfront costs than conventional ICE vehicles, governments could use financial or fiscal benefits to encourage the purchase of electric vehicles. Preferential parking policies for clean vehicles can be another policy to encourage the use of these vehicles. Provision of charging infrastructure can be another relevant factor in the enabling environment for clean mobility. The adoption of low-emission-zones can also contribute to the uptake of clean vehicles. Any policies supporting the uptake of clean vehicles should be duly assessed with regards to their impact on equity. They will only be justified where people without access to private vehicles are sure to benefit from enhancements of the transport system overall as well. Communicating the broad benefits of clean vehicle uptake, having an effect on the liveability of the city as a whole, will help in bringing the broad public on board for the support of clean vehicle uptake.

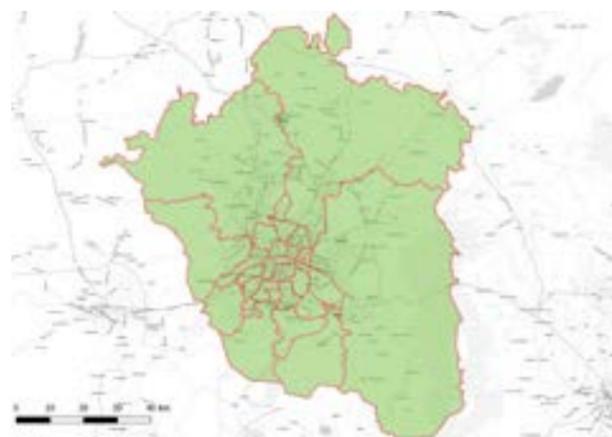
### Mexico City's passenger transport system, related key challenges and policy plans

#### The conurbation of Mexico City spreads over three States, with a total population of over 21 million.

The City of Mexico (CDMX) itself has a population of 8.9 million people. The Metropolitan Zone of the Valley of Mexico (Zona Metropolitana del Valle de Mexico, ZMVM) comprises CDMX, 59 municipalities in the eastern arm of the State of Mexico that surrounds CDMX to the east and northwest, and one municipality in the State of Hidalgo in the north. Around 16% of the country's population live in the ZMVM.

A mobility survey for the ZMVM conducted in 2017 forms the basis of the geographical region. This survey has 194 zones, which for the purposes of the current project are aggregated to 30 ITF zones (Figure 4). Out of these, 26 cover the area of CDMX, while the remaining four cover the area of the states of Mexico and Hidalgo. The total extent of the model, as well as the exact zones used in the model were decided in coordination with the CDMX's Secretary of Mobility.

Figure 4. Zoning system used for ZVMV



Inhabitants of the metropolitan area make around 57 million trips every day, an estimate that includes walking trips of less than 15 minutes. Public transport with its many modes is the most common mode of transport in the study area, walking, private car, taxis, motorcycles and biking, in descending order. Within public transport, the majority of trips happen with buses, followed by metro, BRT, rail and trolleybus.

#### Public transport

The public transport system in ZMVM serves more than 60% of all motorised trips. Within the mode of public transport, CDMX's buses and minibuses serve more than 60% of those trips, with minibuses doing the great majority of those (80–90%). Minibuses vary greatly in condition. Operators hold individual concessions that set loosely regulated routes. In practice, drivers deviate from the set routes to search out additional passengers. Minibus stations, often adjacent to RTP bus stations and metro stations, can be chaotic and severely congested. Together, these factors, driven by the overriding incentive to maximise passengers carried per vehicle trip, greatly lengthen journey times and the vehicles are frequently severely overloaded. Nevertheless, the system is the basis for mobility in the city. City authorities have negotiated with traditional operators the operation of bus corridors, replacing minibuses with standard buses. As a result, around 2000 standard buses run on 23 corridors, with more regular schedules, and at more direct routes, with partially protected bus priority lanes. Regular buses operate on 98 routes; trolleybuses operate on eight lines.

The city's mass rapid transit system carries 20% of passenger motorised traffic, and consists of a Bus Rapid Transit (BRT) system and a metro. The BRT has seven lines, known as Metrobus. These carry around 1.5 million passengers a day. The State of Mexico has three BRT lines, known as Mexibus, totalling 32 km with 95 stations. The Metro is the busiest in Latin America and second largest in North America. The system totals 226 km and 195 stations. Coverage of the system is largely limited to the territory of CDMX, with only 11 stations along two lines (A and B) beyond its borders. The lines vary in quality and operational reliability. Generally, the system suffers from inadequate investment in maintenance and renewal.

A suburban rail line began operation in 2008, running north 27 km from the Buenavista station in CDMX to Cuautitlán in the State of Mexico, with 7 stations. Ridership grew more slowly than projected but rea-

ched 184 000 a day in 2015, close to the planned 192 000 a day. A light train service operates also in the south of the city.

Transit vehicle fleets are relatively old and the performance of much of the metro and rail system infrastructure suffers from chronic underinvestment. This results in high levels of out-of-service vehicles and unplanned outages for maintenance, seriously undermining frequency of service on all the transit systems (except BRT) including the minibuses. This greatly reduces quality of service with severe overcrowding on many peak hour services.

**The government is investing in several upgrades of the public transport system.** These include investments in new buses, an expansion of the electric trolleybus system, two major metro extensions into the State of Mexico to the northeast, southeast and northwest (next to further shorter metro extensions), a new BRT line and four cable cars to serve peripheral areas affected by severance resulting from highway infrastructure or by steep gradients. These will link marginalised areas to the mass transit system and are expected to be completed by 2025. The limited availability of public funds limits the scale of these vital improvements to the overall public transport system.

#### Private cars and motorcycles

Private passenger cars and motorcycles make a fifth of all weekday trips. Vehicle numbers in each of these categories have grown strongly over the last 20 years, and growth continues. New vehicles sold in Mexico comply with either US or EU criteria pollutant emission standards. Both standards are valid and manufacturers can choose which to follow. Motorcycles are a small (5%) but growing proportion of the motorised vehicle fleet. Their relatively low cost makes them a ready substitute for poor quality public transport as soon as income permits purchase.

#### Walking and cycling

**Cycling accounted for 2–3% of trips in the ZMVM according to the 2017 travel survey but just 1.4% in CDMX.** The City government has promoted cycling over the last decade, establishing 332 km of designated cycle lanes by June 2020. The goal of the current administration is to implement 400 kilometres of bike lanes between 2019 and 2024, so the city will have a total of 600 kilometres by 2024. In addition, 100 junctions are expected to be treated every year until 2024 to improve walking and cycling safety over a wider area. Parking facilities for large numbers of bicycles at a small number of public transport transfer stations were built by the previous administration and the strategic plan includes construction of 16 more large parking facilities by 2024.

**Ecobici, a subsidised, docked bike share system, was established in 2010** and operates under concession in the central western part of the city. The system currently operates 6 500 bikes, of which 340 are electric, with docking stations at 480 locations. The expansion plan for the system foresees that by 2021 Ecobici will have a fleet of 10 000 bicycles.

**Walking is fundamental to mobility and a component of most trips, with 25–30% of trips made exclusively on foot** (according to an Origin-Destination Survey of 2017). Pedestrianisation of the city's historic centre has improved accessibility, and is seen as supporting local businesses as well as taking cars off the road. Pedestrian environments have been improved by small scale interventions across the city to calm traffic, particularly in dangerous road intersections. The goal of the current administration is to intervene at 600 of these crossings by 2024. There are also investments to remodel some Metro, Metrobús and Light Rail stations to improve access and create a more secure environment.

### Informal transport and micromobility

Informal mototaxis, three wheeled auto-rickshaws, account for 1% of public transport trips in the ZMVM. These are unregulated services and operate mainly in the more peripheral areas. Micro-mobility services have been introduced by private operators over the last three years, but are restricted to the same central western zone as Ecobici operations under licence conditions. There are dockless bikes and e-bikes and electric push-scooters.

### Challenges across the different modes

Congestion on the roads and crowding on public transport are severe in peak hours. This reflects sprawling urban development with weak transport planning and underinvestment in transit systems. Expansion of the road system has tended to induce demand rather than relieve congestion, with average speeds on central roads estimated at 11 km/h (IDB 2018). CDMX aims to contain urban sprawl through urban planning instruments to improve the management of real estate development and public infrastructure investment. Without intervention to link urban development to investment in mass transit, through planning controls and fiscal mechanisms, the share of trips made by public transport will inevitably decline.

Mexico City experiences regular episodes of ozone and particulate matter concentrations in the air that exceed health limits even though air quality has improved substantially in since the 1980's. The transport sector contributes the largest share of criteria air pollutants today; one third of particulate matter emissions, 82% of NOx emissions, 19% of volatile organic compounds and 90% of carbon monoxide emissions (SEMOVI, 2019).

### Key policy plans with regards to transport decarbonisation

**The City began to develop climate change policy in 2000, adopting its first Climate Action Strategy in 2004.** An emissions inventory was established in 2006 and a Climate Action Program adopted for the period 2008–2012. Programs were renewed in 2014 with a Local Climate Action Strategy and Mexico City's Climate Action Programme (PACCM) 2014–2020. This focussed on the energy transition, containing urban sprawl, sustainable management of natural resources and biodiversity, and building resilience. A progress report was issued in 2016 reviewing measures that in the transport sector covered modernisation of the metro system, establishing a fleet of 20 electric taxis, low energy consumption lighting in public transport, expansion of the Ecobici docked shared bike system, improvement of public transport transfer stations including investment in bike parking facilities, expansion of BRT corridors, and replacement of 30 old diesel buses with CNG buses.

Mexico City has developed a Mandatory Vehicle Inspection Programme (Programa de Verificación Vehicular Obligatorio, PVVO) and a No-driving Day Programme (Hoy No Circula, HNC) to limit air pollution. These are linked and create incentives to renew vehicle fleets. Combined with the 2013 fuel economy standards this drives a moderate degree of mitigation of CO<sub>2</sub> emissions.

**The Secretariat for Mobility of CDMX published its Strategic plan for mobility – One city one system in December 2018.** Its objective is to improve quality of life, reduce social inequalities, cut emissions of air pollutants and greenhouse gases, and increase productivity through creation of an integrated mobility system that will improve accessibility with services that are decent, safe and secure. It also aims to optimize the efficiency of freight transport. The Strategic Mobility Plan will be translated into a Mobility Programme (Programa Integral de Movilidad – PIM) for 2020–2024 following evaluation of progress in implementing the PIM for 2013–2018.

### Assessing scenarios for Mexico City's passenger transport system

The transport assessment model for Mexico City mainly relies on data coming from a mobility survey that was carried out in the metropolitan area of Mexico City in 2017 and from other inputs provided by SEMOVI. Like for the other case study cities, other key sources of information were OpenStreetMaps (OpenStreetMap) for road network information, GTFS data<sup>1</sup> to describe the public transport system and OECD forecasts of future GDP growth.

### Scenario definition

The model that the ITF built for the authorities of CDMX allows assessing the impact of future scenarios of transport policies and transport infrastructure developments on key passenger transport indicators for the city (such as transport activity and transport-related CO<sub>2</sub> emissions). For the purpose of this report, the ITF, together with CDMX authorities, designed two distinct scenarios, named Baseline and Alternative. Both scenarios are focused on the short-term ambitions of the current administration, with few elements going beyond 2030. The first scenario represents the currently envisaged path of policies and infrastructure developments under construction/planning. The second scenario assumes increased ambition of the implemented policies for CO<sub>2</sub> reduction and additional short/medium term infrastructure developments.

The two scenarios were defined during a series of virtual technical meetings that took place in July 2020. Participants included representatives of the mobility and environment secretaries of CDMX. The meetings allowed the ITF to present a beta version of the model, describing its workings and functionalities. Using a predefined template, the participants then defined the two scenarios for use in this report. The meeting participants then validated the scenario outputs after the ITF had made them available.

### Baseline (BL) scenario

The Baseline scenario includes many of the stated policy plans and ambitions of the current administration. As the administration has direct control of short-term targets, measures are clearly defined. A few longer-term policy goals are set.

CDMX has concrete and ambitious plans for multiple public transport infrastructure projects, and has partly already begun their construction. These projects are all included in the Baseline scenario. They cover the creation of a new metro line, several cable-car lines (Mexicable), multiple new BRT corridors and the expansion of the trolley network. These developments are planned until 2025, and will enhance and supplement the city's already robust public transport system.

There are also plans to improve infrastructure for non-motorised modes in the near-future. The developments included in the Baseline scenario target mainly CDMX, but also parts of the surrounding state of Mexico. The pedestrian environment will be improved in the city centre, while cycling infrastructure will be upgraded throughout the metropolitan area. Ecobici, the bike sharing system currently in place in the central parts of the city, will be expanded to a bigger part of CDMX.

In terms of fiscal policies, the Baseline scenario does not assume relevant changes in parking or public transport pricing. Such charges grow in line with inflation throughout the study period. No new regulations are assumed with regards to speed limits of motor vehicles. The fragmented public transport ticketing system does not become integrated beyond existing levels.

<sup>1</sup> GTFS data for the study area come from open source data and are complemented by a data collection exercise done by WhereIsMyTransport in 2019. This happened in the framework of another ITF/IDB project in ZMVM and created GTFS data for many Microbus routes that did not exist before

CDMX has been one of the first cities in the region to implement car restriction and low-emission zone schemes for parts of the city. The Baseline scenario considers a scaling up of these measures: the city centre becomes a zone where only low-emission vehicles are allowed to enter, prioritising non-motorised modes and public transport.

The Baseline scenario also assumes the introduction of a new transport service, a hybrid taxi-public transport mode. This new mode operates with shared on-demand vans, which have flexible routes based on the destination of the users. This service is assumed to begin in 2030 and to use a mix of diesel, diesel-hybrid, and electric vans. The aim of this service is to partly replace the semi-regulated Micro-buses, which currently dominate the metropolitan area of Mexico City.

Decarbonisation of vehicle fleets is an important long-term priority for CMDX. This concerns both private and public transport fleets. However, the Baseline scenario takes a more realistic approach. CNG/LPG are assumed to become a key component of the public transport fleets, particularly buses, with electrification only starting later in the study period. The BRT fleet becomes low/zero emission faster, with a majority of the fleet being electric in 2050. The use of diesel engines is largely discontinued towards 2050. Private car sales assumptions set for this scenario are 20% for 2020. This means that gasoline powered vehicles continue to dominate the vehicle fleet of CMDX throughout the study period.

Another trend that takes hold in the Baseline scenario is teleworking. Teleworking is assumed to reduce total trips in the study region by 15% by 2050. Teleworking is assumed to reduce primarily trips to the city centre, where most jobs are located, while slightly increasing local short-distance trips.

### Alternative (ALT) scenario

The Alternative scenario builds upon the policies of Baseline scenario and assumes a higher ambition for decarbonising transport in CMDX and the surrounding area. The Alternative scenario includes stronger policy levers, expanding the low-emission zone to more zones, and completing the integration of the public transport fare system. This scenario also has more infrastructure developments – both public transport and non-motorised – and more ambitious targets with regard to the uptake of clean vehicles. Nevertheless, most measures and policies are applied on the short-term.

The Alternative scenario adds to the infrastructure developments included in the baseline. Two new metro expansions are added, alongside several new BRT corridors. Light train and cable car systems are also installed in more locations, primarily areas in the borders between CDMX and state of Mexico.

There is increased emphasis of non-motorised infrastructure, with walking infrastructure being improved in more zones at CMDX. Similarly, cycling infrastructure and bike-sharing are put in place in more parts of the city, also expanding these developments to parts of the metropolitan region outside CDMX.

Pricing policies in the Alternative scenario penalise car usage, while public transport fares remain the same as in the Baseline scenario. Parking prices in this scenario increase by 20% in every 5-year interval throughout the study period. The public transport fare system is assumed to be integrated across the entire metropolitan area, without significant changes in fare levels. The integration and the widespread usage of smart cards reduce transfer times, which generates benefits especially for people taking long commutes.

Teleworking becomes the norm in the Alternative scenario. More people begin teleworking, with the relative trip reduction reaching up to 35% by 2050.

The new mode – shared on-demand vans – appears at the same time in this scenario as in the baseline scenario (in 2030). However, the vehicles used for this new mode in the Alternative scenario have a lower CO<sub>2</sub> footprint. More than half of them are plug-in hybrids or electric.

Decarbonisation ambitions of vehicle fleets are much stronger in the Alternative scenario. A majority of the buses and BRTs in 2050 are electric. BRT vehicles in particular are 90% electric and hybrid-electric vehicles. This transition requires significant upfront developments, and, as such, 2030 public transport fleets are already much more electrified. Private vehicles sales follow the same trend. In 2050, electric vehicles constitute 50% of total sales.

Table 1 and Table 2 show the exact specifications for each scenario.

Table 1. Policies in the two scenarios				
Measure	Current Policies		Positive scenario	
	Year	Average fare change [%]	Year	Average fare change [%]
Integrated ticketing (regional)			2030-2040	0%
Speed limitations		Speed change [%]		Speed change [%]
		0		
Parking regulation/pricing		Parking cost change every 5 years [%]		Parking cost change every 5 years [%]
	2020	10%	2020	20%
Public transport pricing		Average fare change every 5 years [%]		Average fare change every 5 years [%]
	2020	10%	2025	10%
Transit Oriented Development		Zones affected		Zones affected
Enhanced walking infrastructure	2025	3 zones affected	2025	6 zones affected
Enhanced cycling infrastructure	2025	12 zones affected	2025-2030	19 zones in total
Bike-sharing	2025	7 zones affected	2025-2030	13 zones in total
Low Emission Zones	2025	3 zones in CDMX	2025	5 zones in CDMX
New BRT corridors	2020-2025	Planned corridors and extensions	2020-2035	Planned + 5 new corridors at 2025
New metro lines	2025	Planned metro line extensions	2025-2035	Planned + 2 new lines/extensions
New light train/ cable-car lines	2025	Planned light train/ cable-car lines	2025	Planned + 2 new cable car lines

Table 1. Policies in the two scenarios			
Measure	Current Policies		Positive scenario
Public transport express lanes		2025	2 new corridors
Teleworking	% of the total trips reduced due to teleworking in 2050		% of the total trips reduced due to teleworking in 2050
	15%		35%

Table 2. Vehicle stock/sales targets for the two scenarios						
Measure	Baseline			Alternative		
Vehicle stock targets	Bus fleet composition in [%]:	2030	2050	Bus fleet composition in [%]:	2030	2050
	Electric	10%	20%	Electric	20%	50%
	Hydrogen	0%	0%	Hydrogen	0%	0%
	CNG/LPG	10%	40%	CNG/LPG	20%	20%
	Hybrid	20%	30%	Hybrid	20%	30%
	Diesel	60%	10%	Diesel	40%	0%
	BRT fleet composition in [%]:	2030	2050	BRT fleet composition in [%]:	2030	2050
	Electric	25%	50%	Electric	40%	70%
	Hydrogen	0%	10%	Hydrogen	10%	20%
	CNG/LPG	40%	40%	CNG/LPG	40%	10%
	Hybrid	0%	0%	Hybrid	0%	0%
	Diesel	35%	0%	Diesel	10%	0%
	Car fleet	2050		Car fleet	2050	
	Vehicle sales target in [%]:			Vehicle sales target in [%]:		
		Electric	20%	Electric	50%	
	Hydrogen	0%	Hydrogen	0%		

**Results**

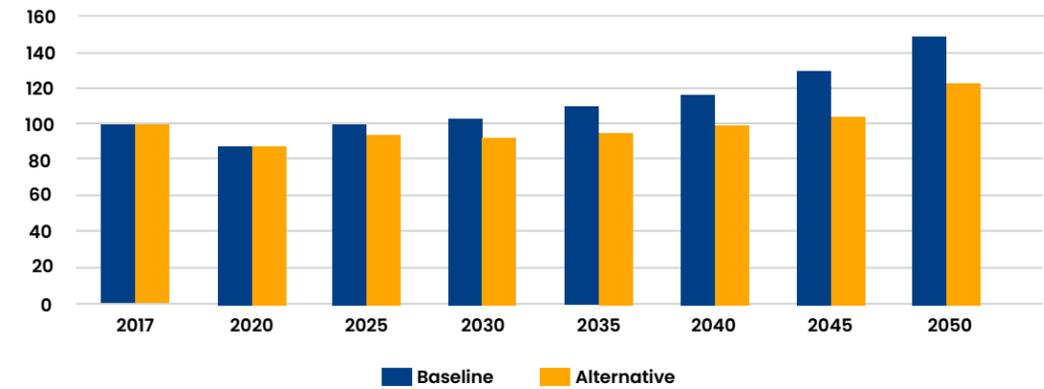
The different scenarios demonstrate two (out of many) possible futures for the metropolitan area of Mexico City's transport ecosystem and their impacts in terms of transport activity and emissions up to 2050.

**Teleworking reduces activity but doesn't change mode balance in Mexico City**

Trips in the study area have a U-shaped trajectory in both scenarios (Figure 5). The total number of

trips initially declines in 2020, and then picks up. The main reason behind this change is teleworking. As a large segment of the population works from home, fewer trips are taken. The drop is bigger in the Alternative scenario where teleworking affects up to 35% of total trips in 2050. Eventually, growing transport demand will lead to higher trip numbers than the base year. Characteristically, in the Alternative scenario, transport demand of 2017 will only be reached around 2040, compared to 2025 in the Baseline scenario. By 2050, both scenarios will lead to more trips than in the base year, 50% more trips in the Baseline scenario, and 23% more trips in the Alternative scenario.

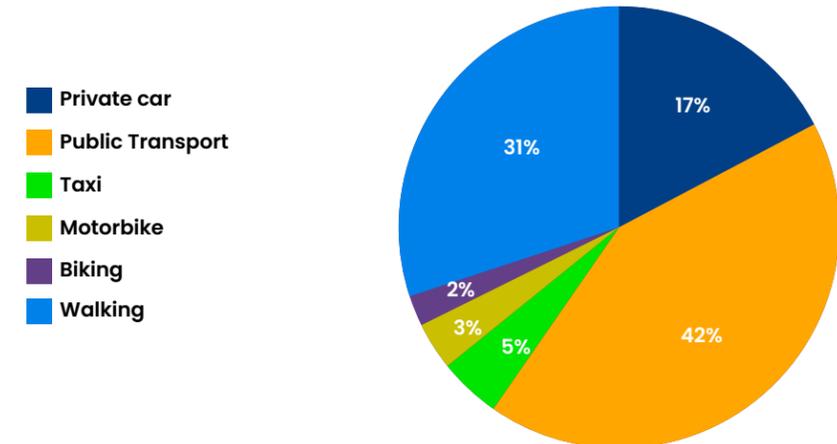
**Figure 5. Trip evolution in the two scenarios**



Note: Trips are indexed to 100 in the base year

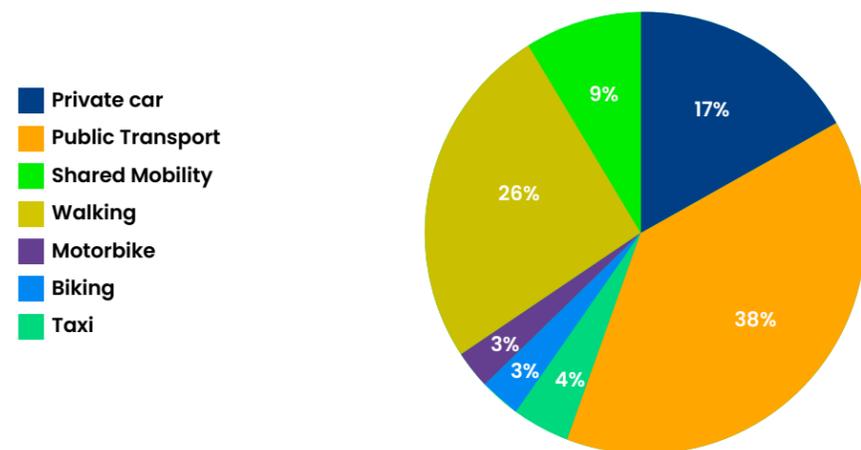
Public transport is the main mode of transport in the metropolitan area of Mexico City (Figure 6). In 2017, around two in five trips were carried out using the city's various public transport modes. Walking trips are also a substantial part, with nearly one trip in three being a walking trip. There are over 5 billion motorised trips (including car, motorcycle or taxi) a year, which corresponds to around 25% of all trips. While vehicle ownership rates in the city are not very high, the total size of the city means that the combination of cars, taxis, and buses on the streets make Mexico City one of the most congested cities in the world.

**Figure 6. Trip mode share in 2017**



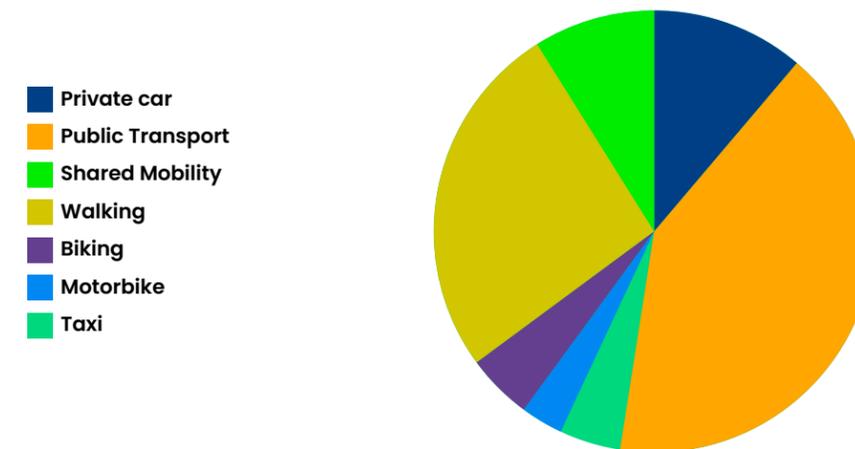
The *Baseline* scenario does not drastically change the modal balance (Figure 7). Shared on-demand vans, the new mode introduced in 2030 generates a disruption, serving 9% of all trips. Private cars and motorcycles are the modes least affected from this; their share remains the same as in the base year. The modes that are most affected from the new mode are walking, taxi, and public transport. As the new mode is a hybrid of the latter two, it draws its mode share from these latter modes. The importance of walking is reduced in this scenario, as growing GDP levels give people the opportunity to use other modes (including the new shared on-demand vans). Cycling is the only 'traditional' mode increases its share by 2050. The increased number of cycling trips reflects the multiple policies and initiatives taken by the authorities to promote this mode.

Figure 7. Trip mode share in 2050 – Baseline scenario



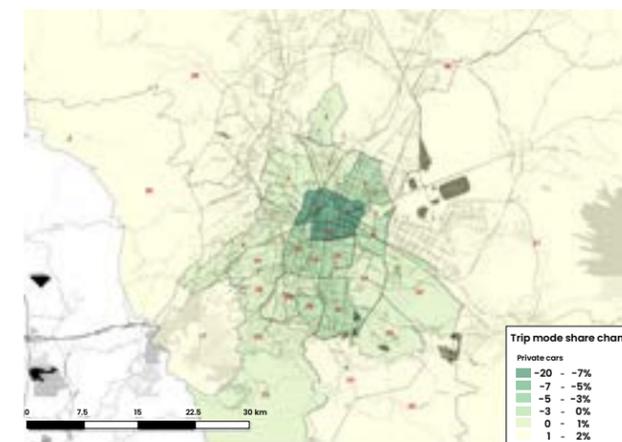
The *alternative* scenario leads to drastically reduced car use (Figure 8). Similar to the baseline, shared on-demand vans enter the market in 2030 and serve a substantial number of trips in 2050. However, the policies, infrastructure developments and measures taken in this scenario provoke a mode shift across the traditional modes. In 2050, private car trips, affected also by the expanded low-emission-zones, are fewer than the base year, even in absolute numbers. Beyond shared on-demand vans, public transport also benefits from the reduced car trips, and retains the same modal share as in the base year. Cycling also sees a significant growth, which can be primarily attributed to the expansion of the bike sharing system. Walking trips see a reduction, similar to the one in the baseline scenario. The two scenarios demonstrate how a new mode, in this case shared on-demand vans, could take trips either from more sustainable or less sustainable modes, depending on the broader policies being adopted.

Figure 8. Trip mode share in 2050 – Alternative scenario



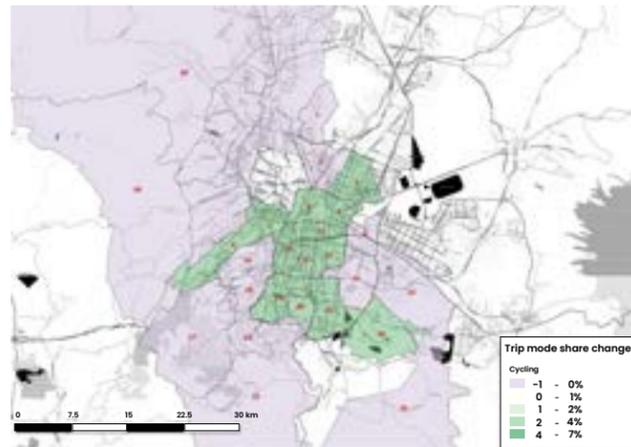
The evolution of the trip mode shares is different throughout the city. On the zone level, it can be observed that in specific parts of the city, mode shares may develop differently to the city-wide trend. This shows the local impact of the different measures in each scenario.

Figure 9. Change in car mode share by zone 2018-2050 – Baseline scenario



With the exception of the zones where the low-emission scheme is put in place, zone level results do not differ significantly from the citywide results. In the city centre of CDMX, car usage reduces a lot by 2050, as only zero emission vehicles are allowed in the low-emission zones. Overall, the share of car trips is projected to remain the same in most zones, and grow slightly in zones of the State of Mexico – echoing the overall trend (Figure 9). The new mode, shared on-demand vans take modal share from all other modes, primarily public transport and walking. The only exceptions are the zones with the LEZ measure, where public transport use remains the same and walking increases. Cycling increases in zones where measures are applied, and remain stable in others (Figure 10).

Figure 10. Change in cycling mode share by zone 2018–2050 – Baseline scenario



In the alternative scenario, this trend is partly reversed. The new mode (shared on-demand vans) does play a significant role in all zones, with more shares ranging between 7–11%. However, most of these trips are car trips. Car usage dips significantly in all zones (Figure 11). Public transport and walking still have reduced shares, but to a smaller degree than the baseline. Cycling also grows more in this scenario, especially in the state of Mexico, where the expanded bike sharing and cycling infrastructure generates more demand for cycling (Figure 12). The zones under the LEZ measure behave similar to the baseline scenario. Car use reduces substantially, which boosts public transport and walking particularly.

Figure 11. Change in car mode share by zone 2018–2050 – Alternative scenario

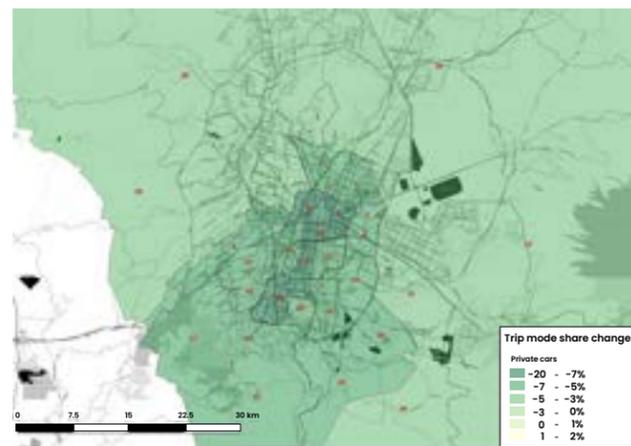
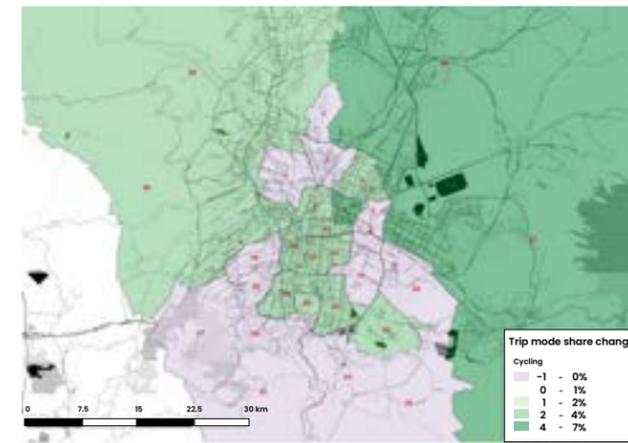


Figure 12. Change in cycling mode share by zone 2018–2050 – Alternative scenario



Public transport grows in both scenarios, but the relative share of the different public transport modes changes. In 2017, buses (standard or minibuses) provide the majority of public transport trips in the study area. Metro and BRT also play a vital role, providing high capacity trunk lines in the city itself – one in three public transport trips are done in these systems. Nonetheless, more than 60% of trips in the metropolitan area are done via buses. The relative importance of buses decreases throughout the study period. They still provide the most public transport trips in 2050 in both scenarios, but their share is lower (54% for BL and 52% for ALT). This comes as a result of the multiple infrastructure projects planned, which increase the capacity of other systems, often at the expense of buses. The importance of metro remains constant through 2050, with one fourth of trips. BRT, a cheaper alternative (compared to metro), increases its network and experiences thus an increase in both scenarios. Their combined share is around 40% in both Baseline and Alternative scenarios. Trolleybuses remain a marginal option, but rail and cable car see a significant increase in usage with the planned developments. They take a big share of public transport trips in the areas where they are built.

The dynamics of gender also have a significant impact in transport choices, and as such can also be used to better target policies and measures. Thanks to the data used for the creation of the model, different modal preferences exist for men and women. Women are more likely to take taxis or use public transport, whereas men are more likely to drive (car or motorcycles) or walk. In the city as a whole, there are slightly more women. Nonetheless, if the gender balance in the city would switch by 1% in favor of women, there would be 0.14% more public transport trips and 0.04% more taxi trips. On the other hand, car trips would reduce by 0.06% and walking trips by 0.05%. There are many underlying reasons for this, such as vehicle availability, safety concerns, trip patterns or many other factors, behavioral or not. However, it is important to acknowledge this issue and take it into consideration when designing policies and measures.

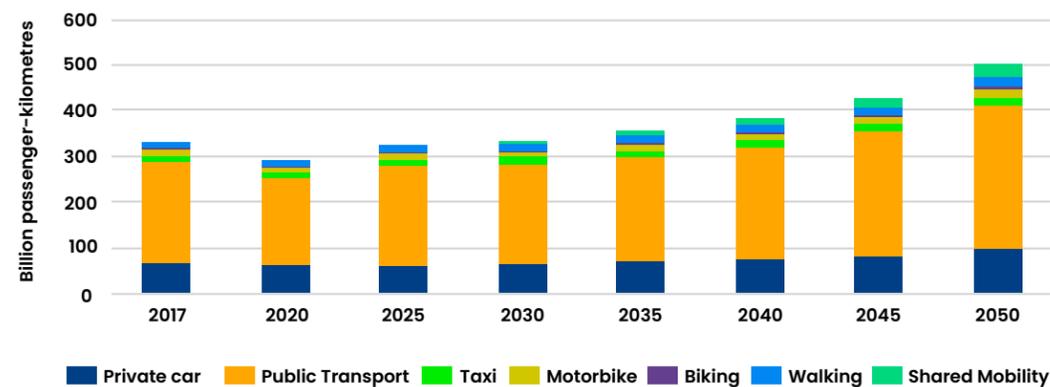
### Public transport is the backbone of Mexico City's mobility

Trip numbers, while a useful metric, is not the most accurate way to measure transport activity. A walking trip and a private car trip are both counted as one trip, even if the car trip is likely longer. Passenger-kilometres (PKM), is another metric that commonly describes transport activity. It gives a different representation of transport activity, one that focuses on the transport activity provided by each mode. The importance of motorised modes, which usually serve longer trips, is amplified.

**Measuring activity by PKM shows the importance of public transport in Mexico City.** In 2018, two thirds of the total PKM travelled in the study area are served by public transport (Figure 8). Private vehicles provide a little over one in every four PKM (21% car and 4% motorcycle) and taxis provide 4% of the total. The PKM mode share of all these motorised modes is higher than their equivalent trip mode share. This comes at the “expense” of non-motorised modes, where biking and walking provide only 1% and 4% respectively.

**In the Baseline scenario, total PKM grow by 51% by 2050** (Figure 13). Following this growth, activity for all modes in 2050 will be higher than in the base year. However, some modes grow more, following the evolution of the underlying factors that affect mode choice as well as relevant policies that are put in place. The mode that experiences the biggest growth in PKM is cycling – it more than doubles its activity totals. However, as the total activity by bike is low in 2018, its modal share in 2050 still remains low.

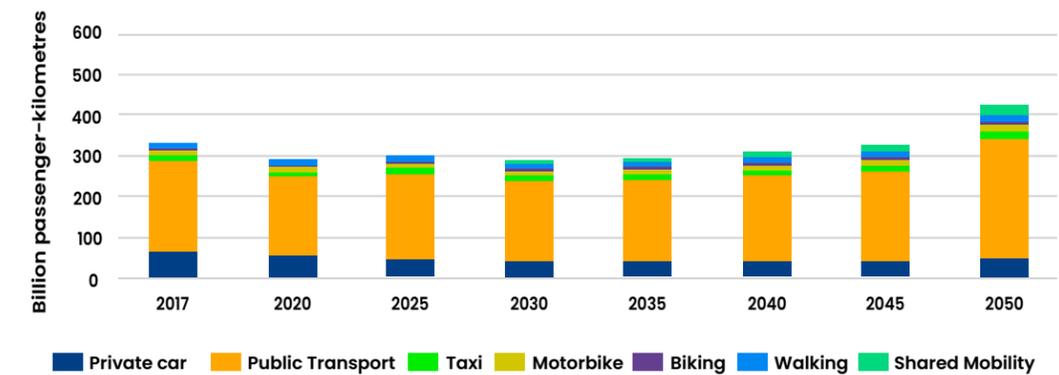
Figure 13. Annual transport activity by mode – Baseline scenario



The “order” of traditional modes in terms of their mode shares stays the same throughout the study period, with public transport and the private car providing the largest shares of passenger transport activity. However, shared on-demand vans, a new mode assumed to arrive in 2030, takes the third place in 2050, with 6% of the total projected transport activity.

**The growth of PKM is lower in the Alternative scenario** (Figure 14). By 2050, activity grows by 28% compared to 2018, 23 percentage points less than in the baseline scenario. The increased teleworking trend is the biggest factor behind this reduction in growth, as it eliminates long commuting trips. The combination of the teleworking trend and the LEZ scheme that is now expanded to five zones, leads to an overall reduction in car PKM. Compared to the base year, car activity decreases by 20%. Cycling becomes more common, boosted by the expanded bike-sharing system and the cycling infrastructure, tripling its activity share. All other modes maintain a similar share to the base year. Shared on-demand vans provide a similar share of activity to the baseline (6%). Nonetheless, as total activity is lower in the alternative scenario, the PKM provided by the new mode of shared vans are fewer. Within public transport, the expanded rail, cable-bus, trolleybus and BRT networks lead to an increased activity share, particularly in the zones directly affected by them. This comes at the expense of buses, which grow the least among public transport modes.

Figure 14. Annual transport activity by mode – Alternative scenario

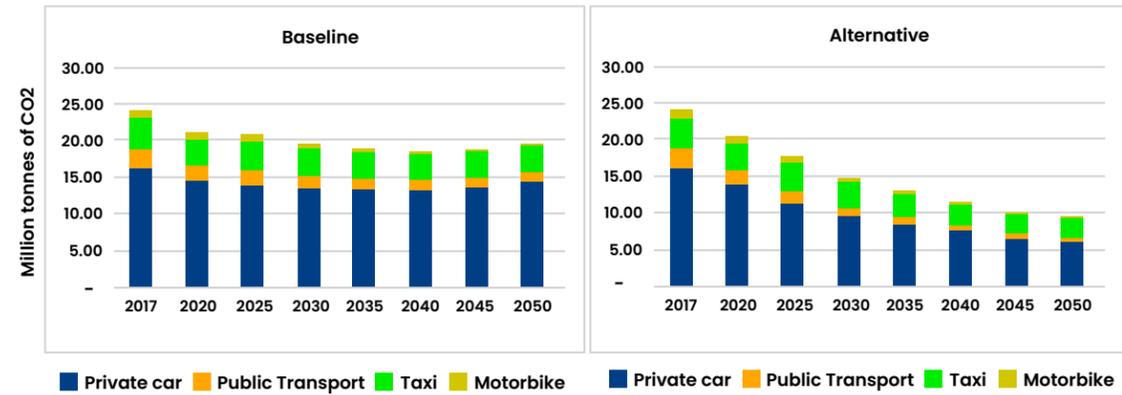


### Emission reduction possible with more ambitious targets

**CO<sub>2</sub> emissions in the metropolitan area of Mexico City will decrease in both scenarios** (Figure 15). The majority of emissions in the city comes cars and taxis. Combined, they produce almost 85% of all direct (tank-to-wheel) emissions. The remaining emissions are split between public transport (10%) and motorcycles (5%). The allocation of CO<sub>2</sub> emissions demonstrates the efficiency of public transport. It provides two thirds of all passenger movements and emits only 10% of transport CO<sub>2</sub> emissions. The high occupancy rates of buses and BRTs are a key factor to this, but also the fact that large parts of the public transport are electrified and do not cause in tailpipe emissions (i.e. metro, rail, cable-buses and trolleybuses). These electric modes provide one fourth of public transport activity (or 18% of the total PKM in the city) without any direct CO<sub>2</sub> emissions. Nonetheless, it needs to be acknowledged that the electricity required to operate them does generate upstream emissions (well-to-tank).

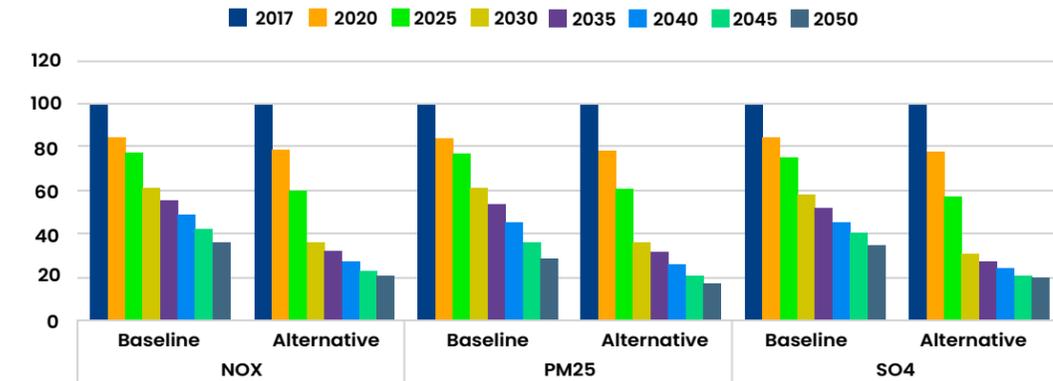
**Emissions in the baseline scenario follow trends in demand to a certain extent.** Following the teleworking trend and the planned policies for the first decade of the study period, transport emissions first decrease in the baseline scenario to 2040 before they then start increasing slightly up to 2050. Total CO<sub>2</sub> emissions in 2050 are 17% lower than 2017. The majority of emissions still comes from private cars and taxis, which represent 90% of the total in 2050.

**Emissions per travelled PKM reduce for all modes in the Baseline scenario.** The various developments and targets set for public transport in this scenario drive emissions per PKM down. In the base year, the average emission factor for buses and BRTs (the only public transport modes that cause direct emissions) was 16 grams of CO<sub>2</sub> per PKM; in the baseline scenario, by 2050, this figure drops to 6 grams. CO<sub>2</sub> per car PKM travelled also reduces throughout the study period, from 244 grams to 148 grams of CO<sub>2</sub> per PKM.

Figure 15. Annual transport CO<sub>2</sub> emissions by mode

**The alternative scenario more than halves CO<sub>2</sub> emissions in the study area.** In this scenario, emissions reduce throughout the study period. The rate of reduction slows down after 2035. In the first part of the study period, the significant reduction in passenger transport activity caused by teleworking and the other policies and measures assumed in this scenario result in a drop of emissions in the metropolitan area of 59% in 2050 compared to the base year. Car and taxis continue to be responsible for most emissions, with shares similar to the base year. Emissions per PKM drop more compared to the baseline scenario, as electrification targets and sales are more ambitious in this scenario. In 2050, an average car PKM emits 118 grams of CO<sub>2</sub>, whereas an average bus PKM emits 3 grams of CO<sub>2</sub>.

**Local pollutants reduce drastically thanks to vehicle electrification and advances in ICE technology** (Figure 16). Local pollutants such as NO<sub>x</sub>, particulate matter, and SO<sub>4</sub> are an issue of concern in Mexico City. Under the two scenarios tested, exhaust pollutants will reduce drastically. These pollutants come mainly from the burn of diesel fuel and motorcycles, so their electrification and reliance on natural gas (for buses and BRTs) reduces them significantly. The reduction is much bigger in the Alternative scenario, where, by 2050, levels of all pollutants are less than 25% of the base year levels. In the Baseline scenario, the most enduring local pollutant is NO<sub>x</sub> and SO<sub>4</sub>, whereas PM<sub>2.5</sub> volumes reduce faster. However, it is important to note that exhaust emissions are not the only source of non-CO<sub>2</sub> pollutants. A big share of non-CO<sub>2</sub> emissions come from the wear-and-tear of tires or other components of the vehicles. These pollutants are not measured in this analysis as they depend on a number of external factors that cannot be assessed by the underlying model framework.

Figure 16. Change of annual non-CO<sub>2</sub> emissions

Note: Values are indexed to the base year; NO<sub>x</sub>=Nitrogen oxides; PM<sub>2.5</sub>=Particulate matter 2.5; SO<sub>4</sub>=Sulfate ion

### Travel time savings and accessibility by public transport

The public transport infrastructure improvements and other policy measures assumed in the two scenarios generate travel time savings for the people in the metropolitan area of Mexico City. The average travel time savings for any given origin-destination pair are almost 8 minutes. However, this value does not take into account the passenger flows. When they are taken into account, average travel-time savings across all public transport trips are estimated to be around 1.5 minutes. The gain of 1.5 minutes might seem small, but with over 30 million trips a day, the total travel time saved each day is the equivalent to around 85 years.

The weighted travel time savings are lower because of the changing flows and usage of public transport, partly caused by the LEZ measures. As the LEZ is applied on some zones, travel patterns to and from these zones change. Even if the travel time by public transport is high, no other alternative exists. This forces more long-distance public transport trips, which affects the average.

Nonetheless, there are significant travel time savings for some people, especially the ones living near newly developed infrastructure. In some cases, public transport users might see savings of up to 45% of their total travel time. Travel time savings are higher for inhabitants of CDMX in average compared to inhabitants of the State of Mexico. This happens because the majority of the new public transport infrastructure happens within CDMX. As people travelling from the surrounding region typically travel longer distances, the reduced travel times affect only a smaller segment of their trip.

**The Alternative scenario reduces travel time savings from public transport trips compared to the baseline.** In this scenario, the average travel time saved for a public transport trip in 2050 is a little under a minute. Again, the LEZ and the shifted mode balance between specific zone pairs are the reasons for this outcome. Using the flows of 2017, average travel time saved in the alternative scenario would be 3.5 minutes. Similar to the baseline scenario, travel time savings are bigger for people living in CDMX compared to the State of Mexico.

**Accessibility by public transport will improve in both scenarios.** Figure 17 shows the number of zones that an average public transport user can reach within 45 minutes starting from any given zone in 2017. This is door-to-door travel time, including access and egress times, waiting time, transfer time, and

on-board time. Only zones in the city centre of CDMX can reach more than 7 zones within 45 minutes, benefiting from their central location. The number of accessible zones decrease as one moves further away from the centre. Certain zones around the city centre benefit from the high speed public transport networks of BRT and metro and have higher accessibility.

Figure 17. Accessibility by public transport in 2017

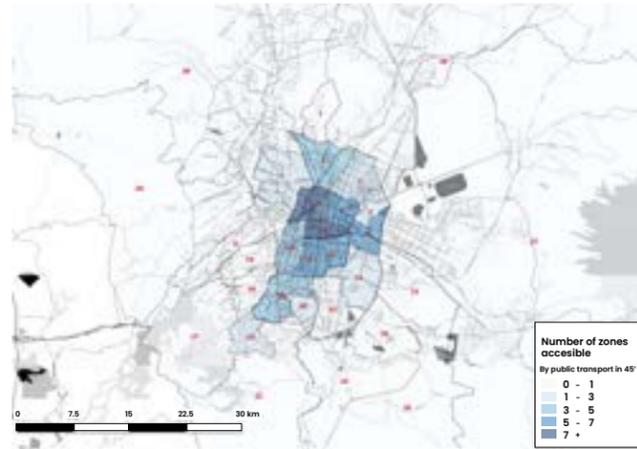
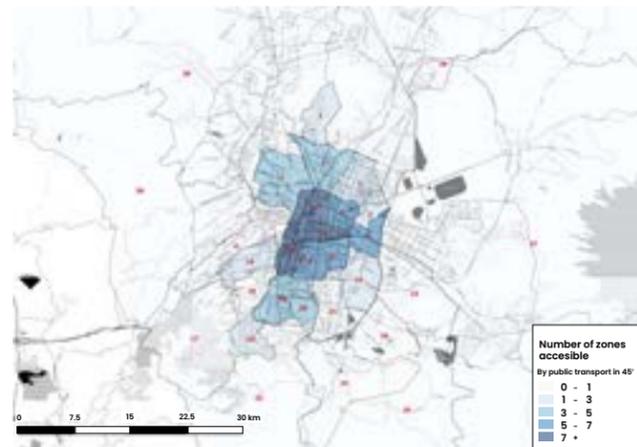


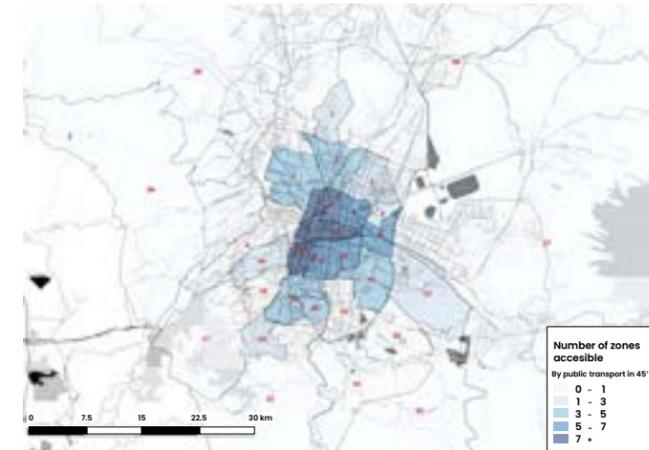
Figure 18 shows the same indicator for 2050 under the Baseline scenario assumptions. The accessibility of several zones near the city centre increases. These zones benefit from the planned public transport infrastructure, which make public transport a fast and reliable alternative in these areas. It is worth noting that these zones are quite dense and large in size. As such, having access to even a small number of them within a reasonable time provides a lot of opportunities. For the 26 zones of CDMX, the median size is 28 km<sup>2</sup> and their median population is 300 000. These numbers are bigger for the zones covering the State of Mexico.

Figure 18. Accessibility by public transport in 2050 – Baseline scenario



The Alternative scenario has few additional gains in accessibility compared to the baseline. As evident from Figure 19, the accessibility levels in most zones in CDMX remains the same. Only a few zones in the outer parts of the city see higher levels of accessibility. The surrounding zones in the state of Mexico do not see almost any improvement with this indicator for any scenario. Travel times from these zones tend to be longer and they benefit less from the new infrastructure in the city.

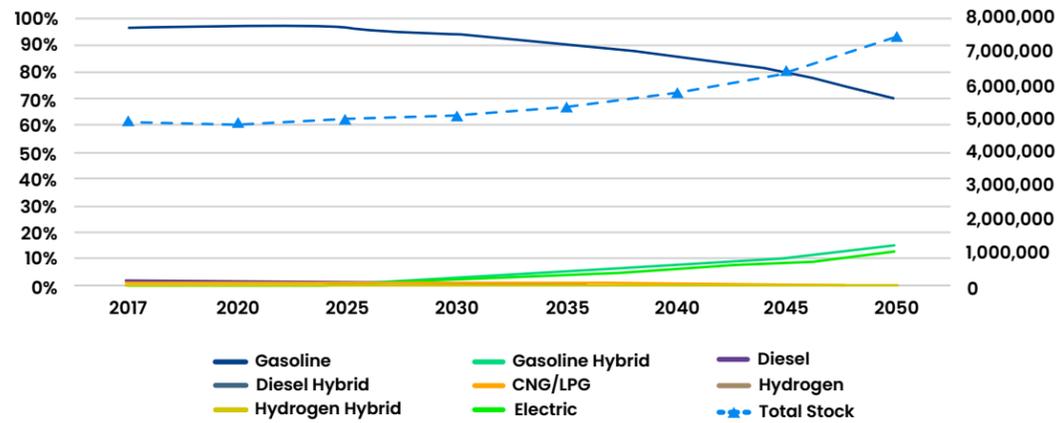
Figure 19. Accessibility by public transport in 2050 – Alternative scenario



### Vehicle fleet composition and impact on emissions

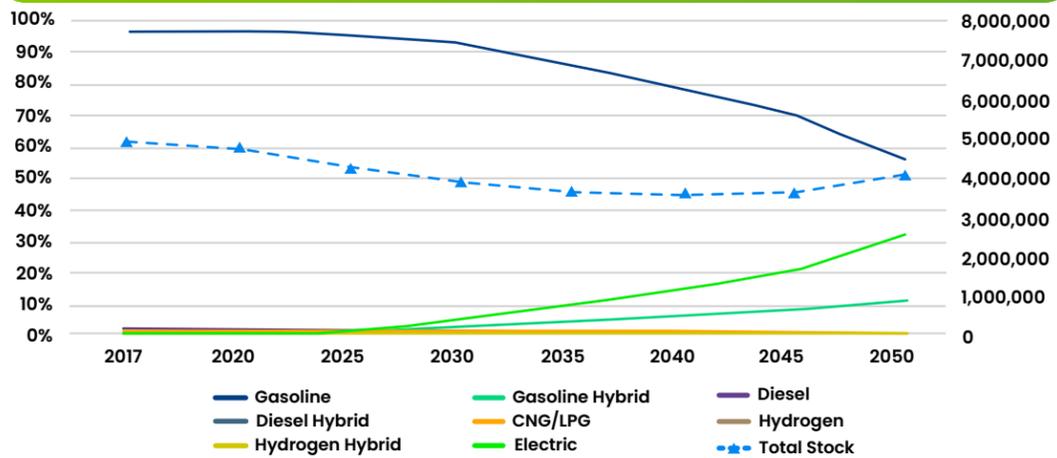
**Vehicle fleet compositions are different between the two scenarios, following the assumptions underlying the scenarios.** The Baseline scenario represents a continuation of current trends in terms of vehicle sales. The majority of the vehicles in this scenario are and will remain gasoline powered, with little increases for electric or hybrid-electric vehicles. The assumptions for the sales in 2050 are a combination of scenario inputs for electric (20%) and hydrogen (0%) vehicles and inputs from the IEA's New Policy scenario for the rest of the vehicle fleet. This translates to a fleet share of 13% for electric vehicles and 17% for hybrid electric vehicles in 2050. Figure 20 provides the fleet composition following these assumptions. Total private car stock remains flat for the first half of the study period, picking up pace and growing after. It should be pointed out that in this analysis new vehicles enter the market to cover projected demand. Therefore, as teleworking and other policies limit car activity, fewer vehicles are required to cover that demand. In reality the evolution of vehicle fleet also depends on various other factors and decisions made often on an individual level.

Figure 20. Car fleet composition by fuel type – Baseline scenario



**Electrification picks up faster in the Alternative scenario.** By 2050, around 50% of new vehicles sold are assumed to be electric, with the remaining sales split between gasoline and hybrid-electric vehicles. In terms of total stock composition at the end of the study period, almost half the fleet uses a connection to the grid (Figure 21). This naturally is the main reason behind the much lower CO<sub>2</sub> emissions achieved in this scenario. Given trends of teleworking, LEZs, and increased public transport availability, the total private vehicle stock is forecast to reduce. A big decline is observed at first, but total vehicle numbers grow a bit at later years as growing population and income levels make up for the car demand reduction caused by teleworking and other measures. This is another signal that shows that continuous effort is required to achieve decarbonisation. Stakeholders and policy makers should continue to adopt measures and policies that have CO<sub>2</sub> mitigation potential over the whole study period.

Figure 21. Car fleet composition by fuel type – Alternative scenario



Vehicle fleet composition is the main driver behind total CO<sub>2</sub> emissions estimates. Nonetheless, also other measures assumed in the scenarios have an effect on CO<sub>2</sub> emissions. Car CO<sub>2</sub> emissions in the Alternative scenario are 41% of the Baseline scenario emissions. By applying the car CO<sub>2</sub> emission factors of the Baseline scenario to the Alternative Scenario, we can assess the CO<sub>2</sub> impact of the other policies in car travel. Doing this analysis shows that the set of the additional and/or more stringent policy measures applied in the Alternative scenario are responsible for about half the CO<sub>2</sub> savings (45%) compared to the Baseline scenario. The remaining difference between the car CO<sub>2</sub> emissions in the two scenarios (55%) comes from the vehicle fleet composition.

## Chapter 3: Buenos Aires



### Summary of findings

Transport demand growth and emissions in the region Buenos Aires will depend on policies and measures taken by the authorities. With a growing population, especially in the areas surrounding city of Buenos Aires, transport activity will grow if left unchecked. Ambitious mitigation measures coupled with infrastructure developments and other policies can curtail this growth and drastically reduce climate related externalities.

Teleworking has the potential to drastically affect Buenos Aires' transport ecosystem. The city of Buenos Aires works as the economic centre for the region, attracting significant transport flows from around the region. These flows use the full capacity of the existing road and public transport infrastructure. However, if teleworking is widely adopted for jobs that can be carried out at distance, this will relieve the system immensely. Teleworking reduces commuting flows to CBD and other central locations, but increases local trips for other purposes. Supported with other policies, such as mixed land use development and increased density, these change can enable the creation of many local "centres". Trips to those "centres" will be shorter distance, and as such easier to shift to more sustainable modes such as walking and cycling. If the full teleworking potential is realised, transport activity in Buenos Aires will not change substantially until 2050.

Public transport moves the most people in the Buenos Aires region, providing two thirds of total transport activity measured in passenger-kilometres. The public transport system, with the metro and train system, the BRT corridors, but also the regular buses, covers the mobility needs of many inhabitants, especially the ones who do not own private vehicles. As the city grows and evolves, the public transport system must evolve alongside it. New developments of the trunk systems, coupled with transit oriented development policies, can bring new users to the network and increase its modal share. In the alternative scenario, its modal share will even increase to reach 71%.

Public transport usage grows at the expense of private car usage and vice versa, as they both primarily meet mobility needs that can often not be met by other modes. If left unchecked, private car usage will increase and magnify many of the existing issues like congestion. A way to restrict this growth and shift users to public transport is restriction and fiscal policies. The former limits the use of car in specific areas, based on specific attributes such as vehicle emissions (low-emission-zones) or not (car restriction policies). The latter increase the cost of using a car, with measures such as congestion charging and parking regulation and pricing. These policies are adopted in both scenarios tested but to a different extent. In the Baseline scenario, defined by, and assessed for, the city, they are more focused, less ambitious and happen later in the study period. This results in car activity maintaining its overall share, but increasing in absolute numbers. In the Alternative scenario, these policies are enacted earlier and for larger parts of the city. The result is that total car activity actually decreases. It must be pointed out that these restrictions and fiscal policies should be coupled with increased public transport supply, otherwise they may suppress vital economic activity.

The combination of restriction policies and measures supporting sustainable modes can make Buenos Aires a people centred city. These policies enable large parts of the city centre to essentially become car-free areas, leaving space for sustainable modes and people.

Beyond public transport, non-motorised modes play an essential role in reducing transport emissions. While nearly one in four trips (23%) happens with non-motorised modes in Buenos Aires, they only represent a small part of total passenger-kilometres (3%), as most of them are local and short distance trips. Cycling is the mode that has more potential, as it can be used also for medium-distance trips. Proper infrastructure must be put in place to ensure that cyclists feel safe and can move comfortably. Dedicated and separated bike lanes, improved signalling and education campaigns for drivers and cyclists can encourage cycling. Bike sharing is another measure that has a lot of potential, as it removes the burdens of owning a bike and can be a great "entry-point" for people who are unsure if they want to cycle in a city. The combination and mass adoption of these measures in the alternative scenario, may lead to a doubling of cycling activity in the study area.

Emissions in Buenos Aires will decrease in both scenarios tested. The degree of reduction will, however, depend on the ambition of the adopted measures and the targets set. In the baseline scenario, total direct transport CO<sub>2</sub> emissions in 2050 will be nearly halved from 2015 levels. In the alternative scenario, they have the potential to come close to zero, at only 10% of 2015 levels. Most policies and measures outlined in the two scenarios have a direct or indirect impact on emissions, but the vehicle fleet composition is the one element that is will drastically reduce emissions.

The uptake of electric buses can drastically reduce CO<sub>2</sub> emissions and local pollutants from public transport. In 2015, public transport is responsible for a significant share of CO<sub>2</sub> emissions (30%), but is the main source of local pollutants. In the baseline scenario, the bus fleet will still relying on ICE engines to a large extent, albeit more efficient ones. Their CO<sub>2</sub> emissions will decrease, but they will still be a reason for concern. The alternative scenario envisions that all buses circulating in Buenos Aires in 2050 will be electric. Naturally, this would translate to zero CO<sub>2</sub> and pollutant emissions from fuel burn. To properly integrate electric vehicles in the existing fleets, cities need to address several regulatory, normative, financial and infrastructure barriers that may limit the deployment of e-mobility.

The alternative scenario also assumes biofuel as a transition to electric buses. Until adequate infrastructure is put in place, biofuel can readily replace diesel. It is important to point out, that while biofuel still produces emissions and local pollutants, it is considered net-zero in its entire lifecycle. The CO<sub>2</sub> emissions created when burning biofuel are negated by the carbon captured by the plants used for its

creation. Other potential (in)direct externalities of the use of biofuels and notably their production need to be assessed carefully.

The uptake of electric and other low- and zero-emission vehicles will have the biggest effect in projected CO<sub>2</sub> emissions reductions in both scenarios. In 2015, more than 60% of all CO<sub>2</sub> emissions in Buenos Aires came from private cars. In the alternative scenario, all vehicles sold in 2050 are either electric or hydrogen vehicles. This drastically reduces private vehicle emissions by 85% compared to 2015. To achieve this sales target, a comprehensive enabling framework needs to be put into place. As discussed in the other cities, while electric vehicles have a higher upfront cost than conventional ICE vehicles, governments could use financial or fiscal benefits to encourage the purchase of electric vehicles. Preferential parking policies for clean vehicles can be another policy to encourage the use of these vehicles. Provision of charging infrastructure can be another relevant factor in the enabling environment for clean mobility. The adoption of low-emission-zones can also contribute to the uptake of clean vehicles. Also, in the specific case of hydrogen vehicles, further technological breakthroughs are needed for their mass adoption, so they are likely to only appear at a later stage in the study period. Moreover, any policies supporting the uptake of clean vehicles should be duly assessed with regards to their impact on equity. They will only be justified where people without access to private vehicles are sure to benefit from enhancements of the transport system overall as well. Communicating the broad benefits of clean vehicle uptake, having an effect on the liveability of the city as a whole, will help in bringing the broad public on board for the support of clean vehicle uptake.

#### Buenos Aires' passenger transport system, related key challenges and policy plans

**For the purpose of this study, the metropolitan area examined is the Región Metropolitana de Buenos Aires (RMBA).** This covers the Autonomous City of Buenos Aires (CABA) and 42 of the partidos (municipalities) of the Province of Buenos Aires. These 42 municipalities form what is referred to as the Greater Buenos Aires. RMBA has a population of around 15 million inhabitants. This represents more than one third of the country's population. The RMBA also accounts for more than half of the country's GDP.

The study area for this model includes the entirety of the RMBA. It has been split in 32 zones, 7 of which cover the city of Buenos Aires and the remaining 25 cover the rest of the metropolitan area (Figure 22). Outside the city of Buenos Aires, the zone boundaries align with municipal boundaries. However, several zones are comprised from more than one municipalities. The zoning system was decided in coordination with the national ministry of transport and Buenos Aires mobility department.

Figure 22. Zoning system used for Buenos Aires



**Inhabitants of the Buenos Aires region make more than 28 million trips every day.** The most common mode of transport in the region public transport, providing more than four out of ten trips. The remaining modes in Buenos Aires are private car, walking, cycling, taxi, and motorbike, in descending usage order.

#### Public transport

**Public transport trips make up for around 43% of trips in the RMBA.** Buses provide the majority of those trips, making them the main passenger transport mode in the RMBA. They transport around 9.5 million passengers per day. The network of almost 8 000 km is served by national, provincial and municipal bus lines, which are under the authority of the National Government's Ministry of Transport, the Province of Buenos Aires and the different municipalities respectively (whereas in the CABA, all bus lines are under the authority of the National Government's Ministry of Transport). Metrobus, a Bus Rapid Transit (BRT) corridor system, operates on seven lines in CABA and on three lines in the Greater Buenos Aires region. There are no distinct buses operating in the BRT corridors; the buses are able to enter and exit the corridors for parts of their route. Around 6% of trips in the metropolitan region were made by rail in 2010 – a network that currently comprises eight lines. Buenos Aires' subway system provides almost 4% of the total daily trips. The system has six lines, is limited to the boundaries of CABA, and is managed by the city authorities. The network also includes one tram line. Since 2018, multi-modal trips across the bus and rail systems have been facilitated with the introduction of the SUBE smart card.

Authorities are planning expansions to the (mass) public transport systems and the uptake of cleaner vehicles in the public vehicle fleet. In particular, authorities aim to increase the metrobus network to up to 22 lines by 2030 and to add three subway lines to the current system. There are plans to create a Regional Express Network (RER) to triple urban rail capacity in the metropolitan area to complement the existing radial structure of the network with better connections between route segments outside the CABA. Regarding the uptake of cleaner vehicles, the national government aims, for example, at electrifying around 30% of the bus fleet by 2030. In CABA, city authorities have put in place pilot projects with two electric buses, two GNC and two 100% biofuel buses. Such trials have will shed light onto the operational and economic viability of cleaner technologies and inform the wider scale implementation of new vehicle technologies for public transport.

### Authorities are facing financial challenges to follow through on public transport enhancement plans.

For example, from 2002 to 2015, only around 10% of annual maintenance needs of the rail network were met (Barbero, 2015). This lack of investment has contributed to major quality issues of the system, resulting in an increased number of delays and accidents. The RER project was stalled due to financial difficulties. Public transport financing concerns are particularly high for provincial authorities, where budgets are relatively tighter. CABA and the Province of Buenos Aires are required to promote fleet upgrades for more energy efficient and cleaner vehicles and to respond to day-to-day transport needs. In particular, since 2019 it is the provinces, not the State, that need to cover the 60% subsidies for public transport fares (Perfil, 2018). Shifting such financial responsibilities from the State to the Provinces limits their capacity to fund policies that foster public transport improvement programs.

### Private cars and motorcycles

Private motorised transport plays a big role in Buenos Aires even if ownership levels are low. By 2010, only around 35% of households owned a car. Nonetheless, almost 9 million trips are done daily with private cars and motorcycles. The vast majority of those (8 million) are done via cars. CABA, with its central location and economic importance for the region, attracts the largest share of those trips daily.

### Walking and cycling

**More than one third of trips in RMBA are done by non-motorised modes. 95% of these trips are made on foot.** From 2009 to 2018, the share of walking increased from 28% to 32% of all trips in the metropolitan region. Pedestrian priority areas, so called “macromananzas” (macro blocks), are characterised by larger sidewalks, enhanced public lighting and overall better walking conditions. There are five such areas in CABA at the moment, located in the city centre. City authorities aim at expanding these areas in the future. Other measures that have promoted walking include the setting of stricter speed limits for motorised traffic to create a safer walking environment.

In **2018, 4% of trips in the metropolitan area are done by bike, mostly in the rings of RMBA.** Here, cycling is a traditional transport mode, especially as part of longer trip chains. In the frame of the Ecocycles programme, the City of Buenos Aires has been developing a network of protected cycle lanes on secondary streets that are connected with public transport nodes to promote multi-modality. In addition, the program allows for the free loan of shared, docked municipal bicycles. Today, there are 400 stations, with 1200 bicycles and a total of 238 km of bike lanes.

### Taxi services

Taxis cover around 3% of trips in the metropolitan region. Trips can be done by regular taxi, combis (charter-type services) or “remis”. Combis are a particular type of taxi services that mainly transport daily commuters from the Greater Buenos Aires to CABA. “Remis” services are on-demand para-transit services that offer private collective transport, mainly for inhabitants of the metropolitan rings. Vehicles are typically mini-vans, which offer higher comfort than regular public transport buses. In municipalities of the rings, “remis” tend to compete with existing public transport services, partly due to comfort and quality differences. They can also serve as a complement for public transport in municipalities with service gaps. Depending on the service provider, they can operate door-to-door services or follow a pre-established route. Around 50% of the “remis” fleet operates under informal conditions. New forms of unregulated app-based services bring high competition to traditional taxis. CABA authorities have launched BA Taxi, an app to help regulated taxi drivers compete in digital platforms against these new services.

### Challenges across the different modes

Growth in the peripheries has partly been driven by an increase of low-density, gated communities with a high reliance on the use of the private car, partly due to a low public transport connectivity. Authorities need to respond to such lack of (public) infrastructure in peripheries and may need to counter-balance urban sprawl tendencies. In some peripheries also further road pavement programmes will be required as a first step to help improve public transport connectivity and allow for safe walking and cycling trips.

In the Buenos Aires metropolitan region, no single authority has the capacity to plan, coordinate and put in place metropolitan-wide policies required for decarbonising transport. Public transport responsibilities in RMBA are split between three main governance levels. Environmental and road network planning are also split between different levels of authority. Metropolitan-wide action and coordination will be particularly important for aligning land-use and transport policies across the metropolitan area. It will also be necessary for budgetary planning across the metropolitan region.

### Key policy plans with regards to transport decarbonisation

**The Climate Change Action Plan Buenos Aires** for 2030, developed in 2009, defines the goal to reduce CO<sub>2</sub> emissions by 30% by 2030 compared to 2008 levels. Next to the power and waste sectors, transport was selected as one of the three priority sectors for GHG emissions reductions. Highlighted measures include the construction of car parking areas at peripheral areas (to discourage private car use in the metropolitan area), and improvements to the pedestrian, cycle and public transport networks. Vehicle efficiency improvements and clean vehicle technologies, such as hybrid and electric vehicles are also mentioned.

**Buenos Aires’ Sustainable Mobility Plan (SMP)** of 2010 was elaborated in close consultation with authorities of the Province and of the National Government. The plan puts a focus on the promotion of public transport and non-motorised modes. The SMP further emphasises investments for cycling and pedestrians infrastructure. It also highlights the importance of awareness raising among the public to encourage soft modes.

The **Clean Mobility Plan** of 2018 serves as the main planning framework for policies linked to transport decarbonisation and reduced local pollutants in CABA. The two main emission objectives set out in the plan include reducing CO<sub>2</sub> emissions by 14% in the period from 2015 to 2035; as well as reducing 50% of NO<sub>x</sub> and of PM emissions in the same period. Regarding CO<sub>2</sub> emissions reductions, the plan includes a policy mix that integrates measures for reducing motorised mobility (shared mobility); shifting towards more sustainable modes such as public transport; and improving energy technology of vehicles, such as by promoting the use of cleaner technologies for private and utility vehicles, buses and taxis.

**The Master Transport Plan (PDT)** is the only metropolitan-wide transport-related policy document set for the metropolitan area. The Plan, developed by the Metropolitan Transport Agency (ATM), serves as a 5-year guiding tool for interjurisdictional transport interventions. However, it is not legally binding in any of the three main jurisdictions in the area. The guiding document includes objectives for improving the energy efficiency of the transport system and also sets objectives for reducing GHG emissions, and air and sound pollution.

### The key challenge is going to be the economic sustainability of the plans and measures proposed.

Private sector actors will be key partners, also concerning the enhancement of public transport services.

### Assessing scenarios for Buenos Aires' passenger transport system

The transport assessment model for Buenos Aires mainly relies on data coming from a mobility survey that was carried out in the Buenos Aires region in 2015 and from Buenos Aires' transport model. Like for the other case study cities, other key sources of information were OpenStreetMaps (OpenStreetMap) for road network information, GTFS data to describe the public transport system and OECD forecasts of future GDP growth.

#### Scenario definition

The model that the ITF built for the authorities of Buenos Aires allows assessing the impact of future scenarios of transport policies and transport infrastructure developments on key passenger transport indicators for the city (such as transport activity and transport-related CO<sub>2</sub> emissions). For the purpose of this report, the ITF, together with Buenos Aires' authorities, designed two distinct scenarios, named Baseline and Alternative. The first scenario represents the currently envisaged path of future policies and measures for the region, without significant infrastructure developments beyond the short-term. The second scenario assumes increased ambition of the implemented policies for CO<sub>2</sub> reduction, further measures and a number of public transport infrastructure developments throughout the study period.

The two scenarios were defined during a series of virtual technical meetings that took place in November 2020. Participants included representatives of the mobility secretary of Buenos Aires and various other stakeholders from the city and the region. The meetings allowed the ITF to present a beta version of the model, describing its workings and functionalities. Using a predefined template, the participants then defined the two scenarios for use in this report. The meeting participants then validated the scenario outputs after the ITF had made them available.

#### Baseline (BL) scenario

The Baseline scenario includes the policy plans and ambitions of the current administration. This scenario is less ambitious, taking into consideration the impacts of the Covid-19 pandemic in future policies and infrastructure plans.

Buenos Aires has plans for various public transport infrastructure projects, but not all of them are included in this scenario. This was done in order to evaluate how transport activity and emissions could evolve if the aftereffects of the pandemic prohibited the development of these projects. The Baseline scenario includes two new BRT corridors for 2025.

There are also plans to improve infrastructure for non-motorised modes, primarily in the near-future. The developments included in the Baseline scenario target mostly zones within CABA, but also some in surrounding municipalities. There is limited walking infrastructure improvement – only within CABA zones. There is higher ambition regarding cycling as cycling is considered to a mode where significant improvements are still possible. Enhancing cycling infrastructure and expanding/reinforcing the bike-sharing program is planned for zones within and surrounding the city centre.

Buenos Aires also aims to implement Transit Oriented Development policies, increasing building density near trunk public transport stops. These policies are also phased over the study period, but apply only within CABA zones, creating higher concentration of inhabitants living close to high capacity public transport lines. Public transport pricing is assumed to grow in line with inflation throughout the study period. Speed limits of motor vehicles will be reduced by 15% starting in 2030.

Parking policies are seen as an area of focus in the Baseline scenario. In general, cost elements in the model are assumed to grow in line with inflation throughout the study period. Parking costs, however, are set to grow slightly more than within the study area. The availability of parking will also be regulated in this scenario. Through the study period, parking capacity will be slightly reduced in several zones.

The baseline scenario includes two types of restriction policies. A car restriction scheme will be applied in the city centre starting in 2025. It will steadily grow through the study period to cover the entire area of CABA. This policy will restrict usage of private vehicles based on the last digit of license plates. At the onset, each day a single digit will be restricted, but it will expand to eventually alternate odd and even numbers. Buenos Aires will also implement a low emission zone (LEZ) in the city centre in 2025. The LEZ will touch only older heavy duty vehicles at first, and will eventually become more stringent to also cover more polluting private cars. By 2050, only zero-emission vehicles will be allowed in the LEZ. The LEZ will also be coupled with a congestion charging scheme for private cars and taxis. This scheme, however, will only be enforced while LEZ restrictions apply only to heavy duty vehicles. When the LEZ is expanded to cover private vehicles in 2035, the charging scheme will be dropped.

A trend that takes hold in the Baseline scenario is teleworking. Teleworking is assumed to reduce total trips in the study region by 17.5% by 2050. Teleworking is assumed to reduce primarily trips to the city centre, where most jobs are located, while slightly increasing local short-distance trips.

Decarbonisation of vehicle fleets is an important long-term priority for Buenos Aires. This concerns both private and public transport fleets. In the Baseline scenario, the majority of buses will continue using diesel engines until 2050. At that point, 50% of the bus fleet will use diesel, with the rest split between all-electric, hybrid-electric, and CNG/LPG vehicles. CNG/LPG is both the short- and long-term option for taxis, 70% of which will be using it in 2050; with 20% of taxis being fully electric at that year. Private car sales are targeted to be split between all-electric, hydrogen, and conventional (ICE and hybrid ICE) in 2050. Motorcycle sales for the year 2050 are assumed to be 60% electric, with the remaining ones using conventional fuels.

#### Alternative scenario

The Alternative scenario builds upon the policies of Baseline scenario and assumes a higher ambition for decarbonising transport in Buenos Aires and the surrounding region. This scenario includes the adoption of broader policies, stricter measures, and significant public transport and non-motorized infrastructure developments. The Alternative scenario also has more ambitious targets with regards to the uptake of clean vehicles.

The Alternative scenario assumes multiple infrastructure developments for the public transport system of RMBA. Beyond the two BRT corridors included in the Baseline, three new metro lines/extensions are added, all of them within CABA. Three new rail lines are also planned for this scenario, linking and expanding the existing rail network. All these new developments are planned for the medium- and long-term (2030-2050).

There is increased emphasis of non-motorised infrastructure, with walking infrastructure being improved in more zones, also outside the city. Similarly, cycling infrastructure and bike-sharing are put in place in more parts of the city. Finally, TOD related measures are also applied in CABA and some of the surrounding suburbs, complementing the planned public transport developments.

Parking pricing and restriction policies in the Alternative scenario create disincentives for people to use their private cars. Prices increase with a higher rate, while parking availability is continuously reduced in

most zones of the study area. Eventually, in 2050, parking availability is decreased by as much as 50% in some zones. Public transport fares remain in line with inflation, while new speed regulations are put in place, reducing speed limits further.

Restriction policies play a significant role in this scenario as well. The LEZ scheme, following a similar structure as in Baseline regarding the vehicles affected, is applied in more zones. Furthermore, car restrictions are applied earlier and in more zones. The congestion charging scheme is also expanded, covering all of CABA by 2035 and outside municipalities in the following years. This measure is envisioned as a distance-based scheme, where drivers pay for the distance travelled within the cordon. It applies for private cars and taxis.

Teleworking becomes more common in the Alternative scenario. Teleworking is assumed to reduce total trips in the RMBA region by as much as 35% in 2050.

Decarbonisation ambitions of vehicle fleets are much stronger in the Alternative scenario. The transition to electric buses starts earlier, by 2030 half the fleet is electrified. This paves the way for an all-electric bus fleet in 2050. Until that is achieved, biodiesel is seen as a sustainable transition fuel. Taxis, continue to rely on CNG/LPG for the short-term (80% in 2030) before switching to a more electric fleet in 2050. Private vehicles sales follow the same trend. In 2050, all new vehicles sold are either electric or hydrogen-based, both of which have no tailpipe emissions. The same electric vehicle sales shares (100%) apply to motorcycles sales in 2050.

Table 3 and Table 4 have the exact specifications for each scenario.

Table 3: Policies in the two scenarios				
Measure	Baseline		Alternative scenario	
Speed limitations	Speed change [%]		Speed change [%]	
	2030	-15%	2040	-32%
Parking regulation/ pricing	Parking cost change every 5 years [%]		Parking cost change every 5 years [%]	
	2020	3.5%	2020	7.5%
Public transport pricing	Average fare change every 5 years [%]		Average fare change every 5 years [%]	
	2020	In line with inflation	2020	In line with inflation
Transit Oriented Development	Zones affected		Zones affected	
	2025-2045	5 zones in total	2025-2045	9 zones in total
Enhanced walking infrastructure	2025-2050	7 zones in total	2025-2040	21 zones in total
Enhanced cycling infrastructure	2025-2050	11 zones in total	2025-2040	14 zones in total
Bike-sharing	2025-2050	11 zones in total	2025-2035	11 zones in total
Car restriction scheme	2020	All Buenos Aires - peak hours	2020	All Buenos Aires - all day

Table 3: Policies in the two scenarios

Measure	Baseline		Alternative scenario	
Parking Regulation	2025-2050	19 zones in total – reduction of 10%	2025-2050	25 zones in total – maximum reduction of 60%
Congestion Charging	2035-2050	2 zones in 2050 – progressive application for cars reaching ULEV in 2050	2035-2050	3 zones in 2050 – progressive application for cars reaching ULEV in 2050
Car restriction Scheme	2025-2050	4 zones in 2050 – progressive reduction of vehicles allowed to enter based on license plates	2025-2050	11 zones in 2050 – progressive reduction of vehicles allowed to enter based on license plates
Congestion Charging	2025-2050	3 zones in total – applies for private cars and taxis	2025-2050	18 zones in total – applies for private cars and taxis
New BRT corridors	2025	2 new corridors	2025	2 new corridors
New metro line			2030-2050	3 new metro lines
New train line			2030-2050	3 new train lines
Teleworking	% of the total trips reduced due to teleworking in 2050		% of the total trips reduced due to teleworking in 2050	
	17.5%		35%	

**Table 4. Vehicle stock/sales targets for the two scenarios**

	Baseline			Alternative		
Vehicle stock targets	Bus fleet composition in [%]:	2030	2050	Bus fleet composition in [%]:	2030	2050
	Electric	10%	30%	Electric	50%	100%
	Hydrogen	0%	0%	Hydrogen	0%	0%
	CNG/LPG	20%	20%	CNG/LPG	20%	0%
	Hybrid	0%	10%	Hybrid	0%	0%
	Diesel	70%	50%	Diesel	30%	0%
	Taxi fleet composition in [%]:	2030	2050	Taxi fleet composition in [%]:	2030	2050
	Electric	5%	20%	Electric	10%	40%
	Hydrogen	0%	0%	Hydrogen	0%	10%
	CNG/LPG	50%	70%	CNG/LPG	80%	40%
	Hybrid	0%	0%	Hybrid	0%	0%
	Gasoline	45%	10%	Gasoline	10%	0%
	Car fleet	2050		Car fleet	2050	
	Vehicle sales target in [%]:			Vehicle sales target in [%]:		
	Electric	30%		Electric	50%	
Hydrogen	30%		Hydrogen	50%		
Moto fleet	2050		Moto fleet	2050		
Vehicle sales target in [%]:			Vehicle sales target in [%]:			
Electric	60%		Electric	100%		

**Results**

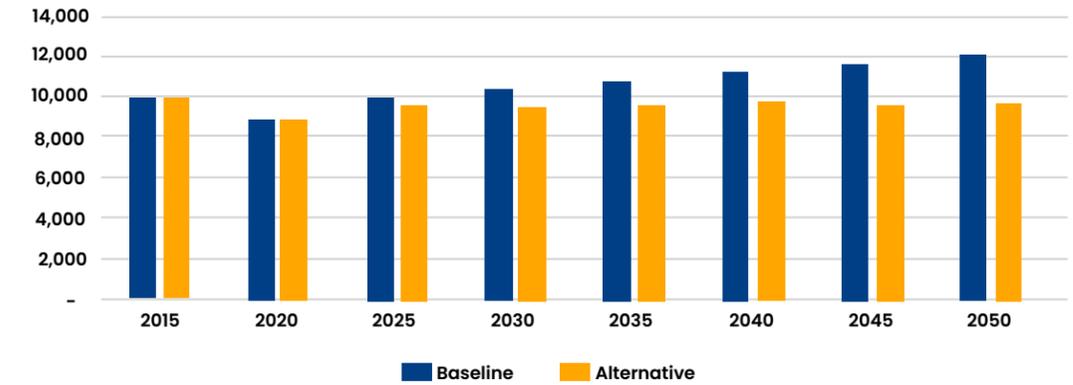
The different scenarios demonstrate two (out of many) possible futures for Buenos Aires' transport ecosystem and its impacts in terms of transport activity and emissions up to 2050.

**Trip growth contained with increased teleworking uptake**

**The degree of teleworking will determine whether total transport activity will grow during the study period.** The primary drivers of urban mobility, population and economic growth, are pushing total transport activity levels. These factors are external variables to the scenarios, and are therefore coherent across the two scenarios. Teleworking, however, might contain this growth if it becomes widespread. Figure 23 shows the growth in the total number of trips for the two scenarios, indexed to the base year (2015). By 2050, under the Baseline scenario, trips in the study area will increase by 21%. This follows an initial dip in 2020, and a steady growth afterwards. In the Alternative scenario, total trip activity will remain fairly stable through the study period, ending at 96% of the base year activity in 2050. This re-

duction is the result of the assumed increased uptake of teleworking in the Alternative scenario, a trend that may become more common after the Covid-19 pandemic.

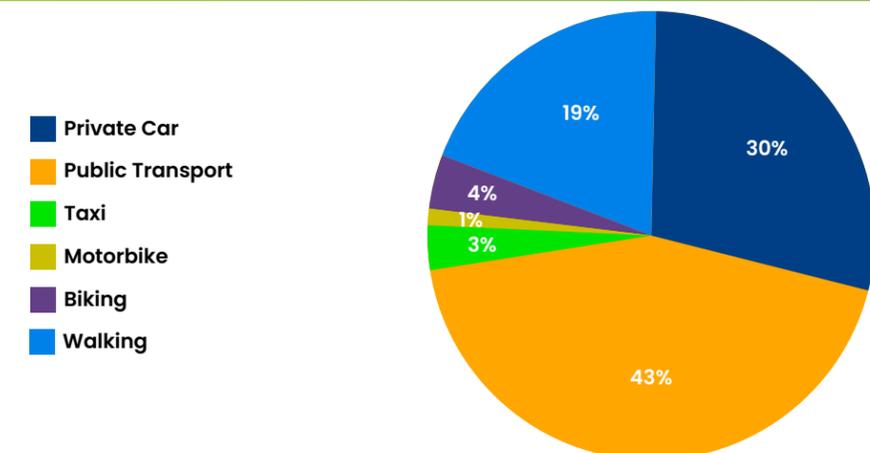
**Figure 23. Trip evolution in the two scenarios**



Note: Trips are indexed to the base year

**Public transport is and will remain the main mode of transport in the region of Buenos Aires in both scenarios.** In 2015, 43% of all trips in the study area were done via public transport (Figure 24). Trips with private vehicles corresponded to 30% (29% for car and 1% for motorcycles) of all trips. The mode share of taxis was 3%, with the remaining trips being done by non-motorised modes (19% on foot and 4% on bike). No drastic change is projected in the mode share balance in either scenario, but some different trends can be observed.

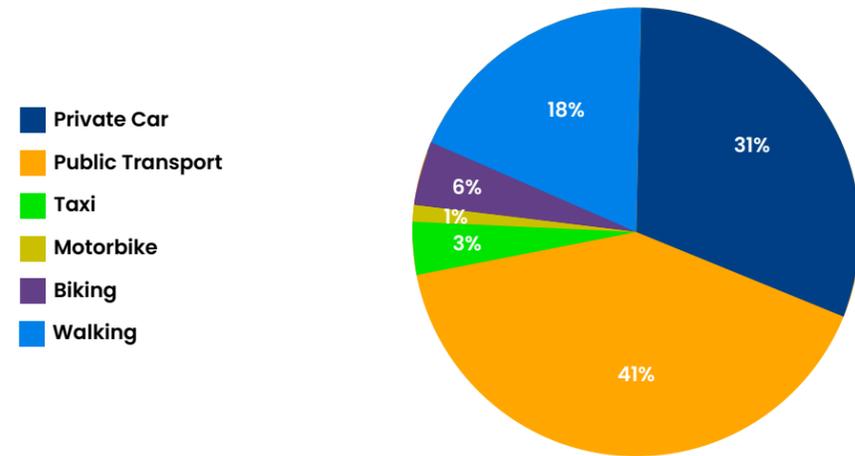
**Figure 24. Trip mode share in 2015**



**In the Baseline scenario, the share of trips done with private vehicles will grow slightly, reaching almost one trip in three** (31% of car trips and 1% of motorcycle trips – Figure 25). This growth comes at the expense of public transport trips, whose share is reduced by 2 percentage points. Cycling is the other mode that gains ground in 2050, with a trip modal share of 5%. Walking and taxi trip shares remain the

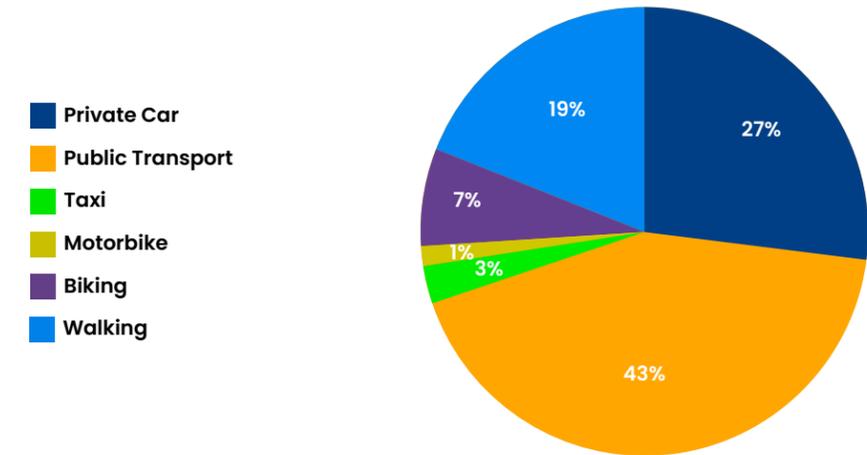
same. These changes hint on the importance of expanding public transport infrastructure and strong policies that support its usage.

Figure 25. Trip mode share in 2050 – Baseline scenario



**The Alternative scenario manages to reverse the growth of less sustainable modes** (Figure 26). In the Alternative scenario, private car usage decreases by 2 percentage points compared to the base year, a 4 points difference to the Baseline scenario. The share of motorcycle trips remain about the same (1%). This scenario instead sees a growth in cycling as a result of the cycling-related measures included in the scenario parameters. In 2050, 7% of trips in the study area are cycling trips, nearly double in absolute numbers compared to 2015. This growth comes despite the total trip numbers remaining the same over the study period. As the share of the other modes remains relatively the same with the base year, this means that there is a transition towards more sustainable modes. It is unlikely that the increased number of cycling trips comes exclusively from car trips. In all likelihood, they come mostly from walking or public transport trips. Public transport, in turn, takes many of the former car trips, as the combined infrastructure developments and policies make it a more attractive option. The continuous adoption of strong and ambitious policies and measures is key to achieve this future.

Figure 26. Trip mode share in 2050 – Alternative scenario

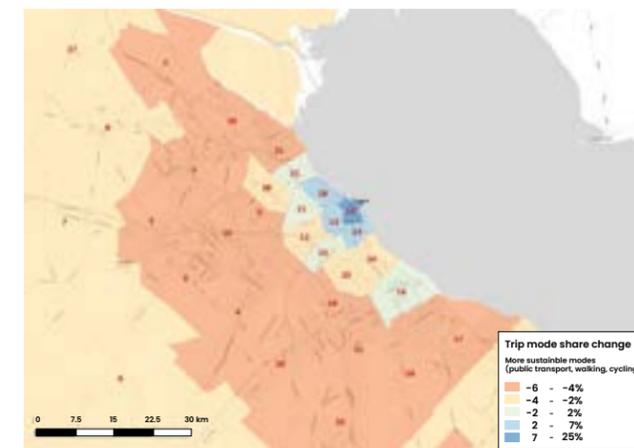


**Measures have increased impacts in some zones compared to others**

**The evolution of the trip mode shares is different throughout the city.** On the zone level, it can be observed that in specific parts of the city mode shares may develop differently to the city-wide trend. This shows the local impact of the different measures in each scenario.

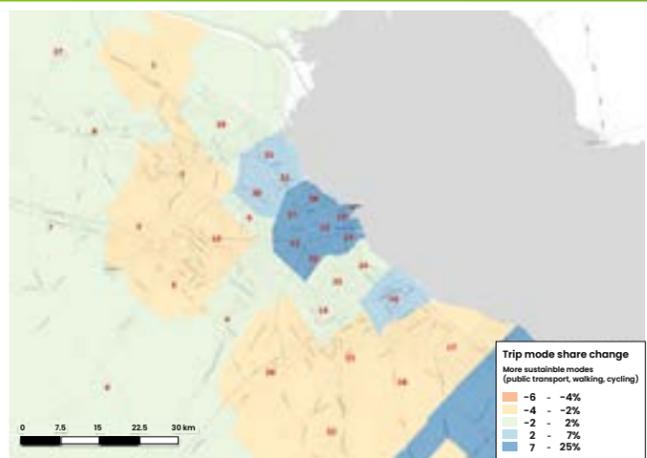
In the *Baseline* scenario, in 2050, the share of more sustainable modes (public transport, walking, cycling) grows only in zones within CABA (Figure 27). These areas are primarily the zones where the LEZ and the car restriction schemes are applied, which significantly limits the use of private vehicles. Other measures, such as parking regulation and cycling related policies, play a role in this shift, which is also evident in some of the zones nearby, in CABA or the immediately surrounding municipalities. These zones do not see significant changes in the mode balance. By contrast, all other zones in the RMBA region see an increase in the use of less sustainable modes, primarily through private cars.

Figure 27. Change in trip mode shares by zone 2015-2050 – Baseline scenario



In contrast, the *Alternative* scenario results in an increased growth of more sustainable modes (public transport, walking, cycling) in the entire CABA and many zones within RMBA (Figure 28). There are still a few zones, mostly in the 2nd ring, that see increased use of private vehicles, but to a lesser extent than in the Baseline. In 2050, the entire CABA is under car restriction and congestion pricing schemes, with half of it under the LEZ scheme as well. As a result, it has very low private vehicle activity. This translates to a significant growth in the modal share of sustainable modes, primarily public transport. Many of the municipalities of the 1st ring also see a growth in the mode share of sustainable modes, albeit smaller. In contrast, the growth here is driven by cycling, which reaches a 10-12% share. Given the importance and central location of CABA, the policies taken for these zones have an impact on all surrounding areas.

**Figure 28. Change in trip mode shares by zone 2018-2050 – Alternative scenario**



**Buses are and will remain the main public transport mode in the Buenos Aires region.** In 2015, more than three out of four public transport trips were done by bus. The BRT corridors are utilised differently in Buenos Aires compared to the other two cities. In Buenos Aires, regular buses use the dedicated BRT corridors for parts of their route. The metro system provides almost 10% of all public transport trips, but is geographically limited within CABA. The rail network connects CABA to the rest of RMBA, reaching a mode share of 14% of the total trips.

No significant changes happen in the Baseline scenario with regards to the modal shares within public transport. As no major infrastructure developments are planned in this scenario, the relative shares of buses, metro and rail remain stable up to 2050.

**The Alternative scenario assumes enhanced rail and metro networks.** The new developments increase the relevance of these systems to more zones. Their combined share within public transport grows to almost 30% (17% for rail and 11% for metro). Nonetheless, buses still provide the majority of public transport trips, both in and outside BRT corridors.

The dynamics of gender also have a significant impact on transport choices, and as such can also be used to better target policies and measures. Thanks to the data used for the creation of the model, different modal preferences for men and women can be observed. Women, on average, are more likely to take taxis, use public transport, or walk, whereas men are more likely to drive (car or motorcycles) or take the bike. If the gender balance in the city were to switch by 1% in favor of women, there would be a 0.12% increase in public transport trips and 0.05% more walking trips. On the other hand, car and cycling

trips would reduce by 0.17% and 0.02% respectively. There are many underlying reasons for this, such as vehicle availability, safety concerns, trip purposes and trip patterns. It is important to acknowledge these gender differences and take them into consideration when designing transport policies and measures.

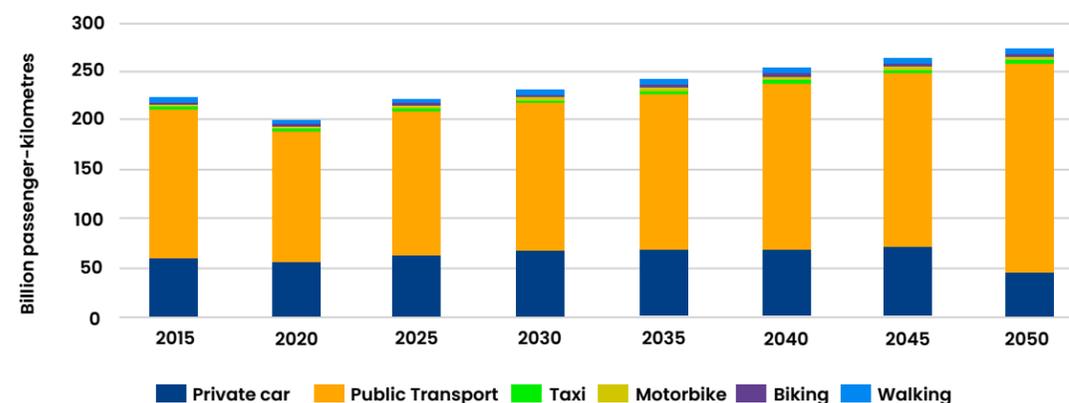
**Sustainable modes have a high potential in Buenos Aires**

Trip numbers, while a useful metric, is not the most accurate way to measure transport activity. A walking trip and a private car trip are both counted as one trip, even if the car trip is likely longer. Passenger-kilometres (PKM), is another metric that commonly describes transport activity. It gives a different representation of activity, one that focuses on the transport activity provided by each mode. The importance of motorised modes, which usually serve longer trips, is amplified.

**Measuring activity by PKM shows the importance of public transport in Buenos Aires.** In 2015, two thirds of the total PKM travelled in the study area are served by public transport (Figure 29). Light duty vehicles (private cars and taxis) and motorcycles provide 30% of the total PKM. Most of those (27%) are done by private cars. The PKM mode share of all these motorised modes is higher than their equivalent trip mode share. This comes at the “expense” of non-motorised modes, where biking and walking provide 1% and 2% respectively.

**In the Baseline Scenario, total PKM grow by 23% by 2050.** This growth is constrained by the teleworking trend that reaches its potential of 17.5% in 2050 in this scenario. Despite this, activity for all modes in 2050 will be higher than in the base year. However, some modes grow more, following the evolution of the underlying factors that affect mode choice as well as relevant policies that are put in place. Cycling is the one mode that stands out, increasing its total activity in PKM by 88%. As its starting share is small, the growth does not translate to a significantly higher modal share overall. Most of the other modes grow slightly more or less than the average. In 2050, the relative shares of all modes are almost the same as the base year.

**Figure 29. Annual transport activity by mode – Baseline scenario**

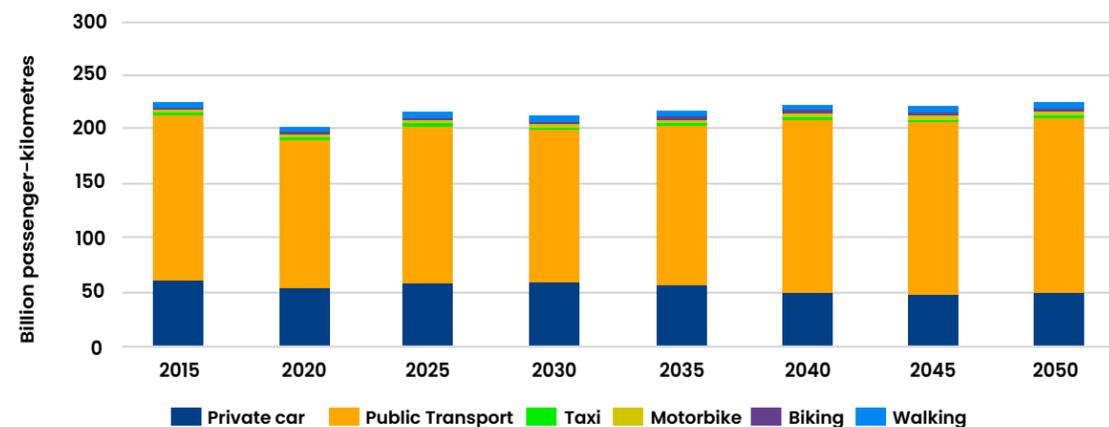


**Transport activity in the Alternative scenario is the same as the base year.** By 2050, total activity is almost the same as in 2015, 23 percentage points less than the Baseline scenario. This comes as a result of the increased uptake of teleworking, which reduces total trips by as much as 35% in 2050. It is

interesting to point out that compared to the base year, activity in PKM remains the same, while activity measured in trips reduced. The main reason for this difference is the various restrictive measures put in place in the zones of CABA. As CABA remains the centre of economic activity, people will travel there even if car use is restricted. Public transport would be the reasonable alternative for many trips, and public transport trips tend to be less direct than driving, thus resulting in higher PKM per trip.

**The mode that has the highest growth in this scenario is cycling.** Infrastructure policies, the widespread use of bike-sharing and the continuation of the cycling trend almost double the transport activity done by bikes. In 2050, under the assumptions of the Alternative scenario, cycling doubles its modal share, as total activity remains the same. Private car, motorcycle, and taxi usage decrease, influenced by the many restrictions put in place in central parts of the city. These modes will provide 25% of all PKM in 2050, a 5 percentage point reduction compared to the Baseline scenario. PKM done by public transport increase, which leads to a share increase of 4 percentage points. Public transport will provide 7 out of 10 trips in RMBA. Walking has the same modal share of PKM as in the base year and the baseline scenario (Figure 30).

Figure 30. Annual transport activity by mode – Alternative scenario



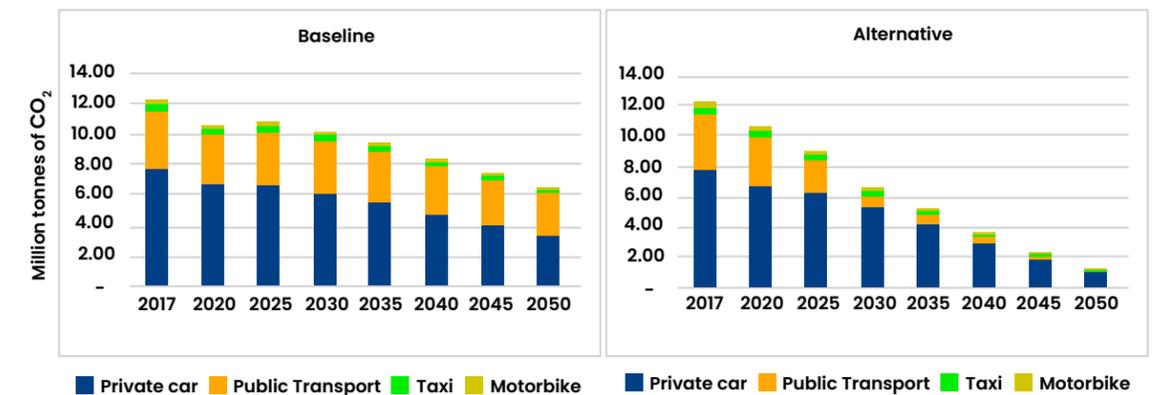
### Stronger emission reduction under the Alternative scenario

**In 2015, the majority of emissions came from private transport** (Figure 31). Private cars and motorcycles contributed to 65% of all direct (tank-to-wheel or tailpipe) emissions in the Buenos Aires region (63% for cars and 2% for motorcycles respectively). Public transport, despite providing 67% of the total activity was responsible for 30% of emissions. Grouped together, the less sustainable modes (car, motorcycle and taxi) emitted 70% of transport related CO<sub>2</sub> emissions, while only providing 30% of the total PKM.

**By 2050, the Baseline scenario reduces emissions by about 50%, in spite of the increase in total activity.** Private cars are still projected to be responsible for the largest share of emissions, but their share is declining – now half of the total in 2050. Public transport emissions reduce slower than emissions from the other modes. This is because a significant part of the public transport fleet still relies on diesel engines, even in 2050, in the baseline scenario. In 2050, public transport emissions are only 25% lower than in the base year, and 45% of the total. Private cars, on the other hand, decarbonise faster, and on a per vehicle-kilometre basis, their emissions in 2050 will be one third of the 2018 value. Increased fuel

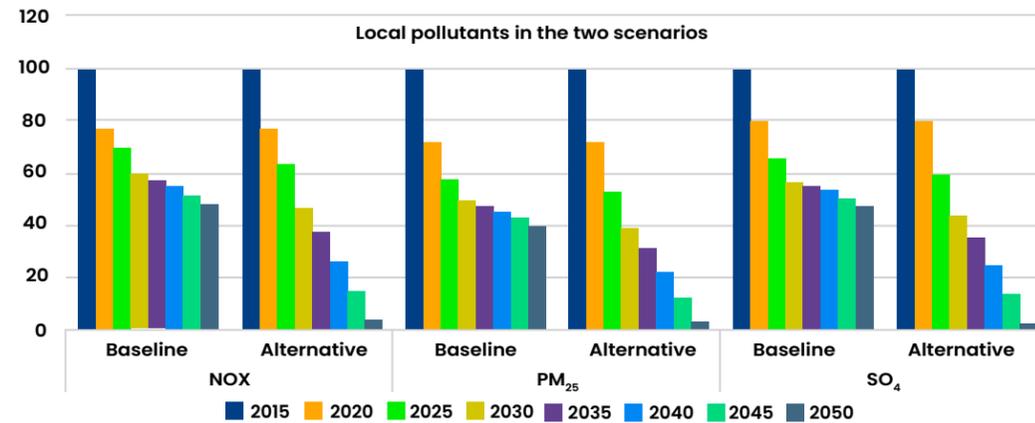
efficiency of ICE vehicles, conventional or hybrid, and the penetration of electric and hydrogen vehicles are the two main factors that lead to this result.

Figure 31. Annual transport CO<sub>2</sub> emissions by mode



**The Alternative scenario projects a much bigger reduction in CO<sub>2</sub> emissions.** In 2050, direct transport CO<sub>2</sub> emissions will be only one tenth of the base year. As the public transport fleet is assumed to entirely rely on electric vehicles, private cars, taxis and motorcycles are the only modes that produce tailpipe CO<sub>2</sub> emissions. Nonetheless, almost three quarters of cars and motorcycles are using electricity or hydrogen, which leads to the big reductions by 2050. Public transport emissions also drop much faster, even earlier in the study period, because the remaining diesel powered buses increasingly use biodiesel. The estimated emissions for the two scenarios can be seen in Figure 28. In terms of cumulative CO<sub>2</sub> emissions, the Alternative scenario also yields better results. Throughout the entire study period, total CO<sub>2</sub> emissions are here 33% less than in the Baseline scenario.

**Local pollutants reduce drastically thanks to vehicle electrification** (Figure 32). Local pollutants such as NO<sub>x</sub>, particular matter, and SO<sub>4</sub> are an issue of concern in Buenos Aires. Under the two scenarios tested, exhaust pollutants will reduce drastically. These pollutants come mainly from the burn of diesel fuel and motorcycles, so their electrification and reliance on natural gas (for buses and taxis) reduces them significantly. The reduction is much bigger in the Alternative scenario, where levels of all pollutants are less than 5% of the base year levels. In the Baseline scenario, the most enduring local pollutant is NO<sub>x</sub>, with increased reliance of diesel powered buses being the main cause. However, it is important to note that exhaust emissions are not the only source of non-CO<sub>2</sub> pollutants. A big share of non-CO<sub>2</sub> emissions come from the wear-and-tear of tires or other components of the vehicles. These pollutants are not measured in this analysis as they depend on a number of external factors that cannot be assessed by the underlying model framework.

Figure 32. Change of annual non-CO<sub>2</sub> emissions

Note: Values are indexed to the base year; NOx=Nitrogen oxides; PM25=Particulate matter 2.5; SO4=Sulfate ion

### Travel time savings and accessibility by public transport

In the Baseline scenario, as there are almost no new infrastructure developments for public transport there are no travel time savings for public transport trips in 2050. There is actually an average loss of 8 seconds per trip. This happens as other measures that increase the generalised cost of other modes – private car in particular – shift trips to public transport. Most of these trips are inter-zonal, which increases the average distance travelled per public transport trips. Public transport trips in general tend to be less direct than private vehicle trips.

The public transport infrastructure improvements and other policy measures assumed in the Alternative scenarios generate travel time savings for the people in the Buenos Aires region. In this scenario, the average travel time saved for a public transport trip in 2050 is about half a minute. This reduction might seem small, but with the total number of public trips done every day, it adds up to almost 9 years. The travel time savings actually come from the greater RMBA region; for CABA, travel time increases can be observed. The reason is, again, that CABA is almost a car-free zone in the alternative scenario. This forces many people to take public transport, which, in turn, increases average public transport travel times. For a zone in RMBA, average travel time savings can be as high as 3 minutes. For individual trips, savings could be up to 30%.

**Accessibility by public transport will improve only in the Alternative scenario.** Figure 33 shows the number of zones that an average public transport user can reach in 45 minutes starting from any given zone in 2015. This is door-to-door travel time, including access and egress times, waiting time, transfer time, and on-board time. Only zones in the city of Buenos Aires and one directly adjacent to it can reach more than 10 zones within 45 minutes, benefiting from their central location. The number of accessible zones decrease as one moves further away from the centre. The accessibility by public transport does not change in 2050 for the Baseline scenario, as the few public transport infrastructure developments do not decrease travel times enough.

Figure 33. Accessibility by public transport in 2018

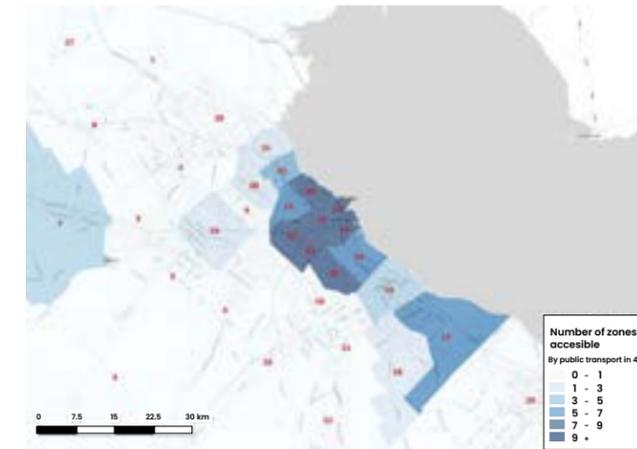
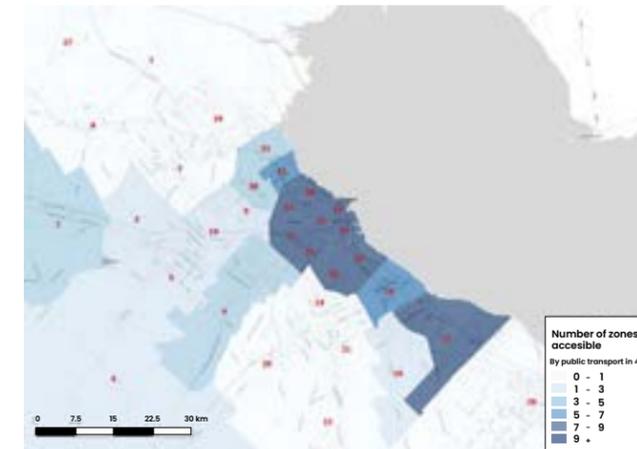


Figure 34 shows the same indicator for 2050 under the Alternative scenario assumptions. The accessibility clearly increases for most zones in the entire region. The zones in CABA, which have higher levels of accessibility, do not see big changes in accessibility by public transport. Zones immediately next to CABA are the ones who experience most benefits thanks to new developments. Notably, in 2050, 10 zones in total are able to reach 10 zones or more by public transport within 45 minutes.

Figure 34. Accessibility by public transport in 2050 – Alternative scenario

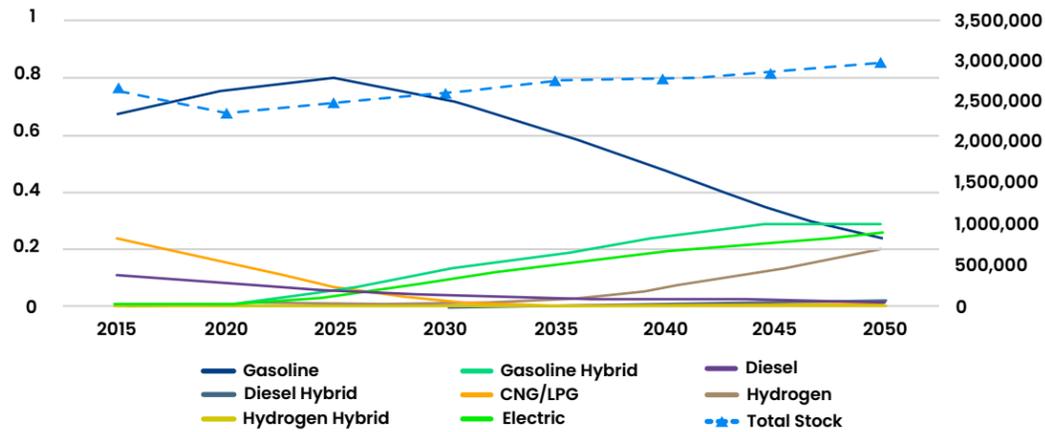


### Vehicle fleet composition and impact on emissions

**Vehicle fleet compositions are quite different between the two scenarios.** The Baseline scenario assumes less ambitious targets for private vehicle sales in 2050 (Figure 35). By 2050, 30% of new vehicles sold will be electric and 30% more will be hydrogen-powered. Figure 15 shows the fleet composition following these assumptions. By 2050, the majority of vehicles circulating on the streets of Buenos Aires are low- or zero-emission vehicles. Gasoline-hybrids represent the biggest share of those, having surpassed conventional gasoline ICE vehicles only a few years before. Total private car stock continues to

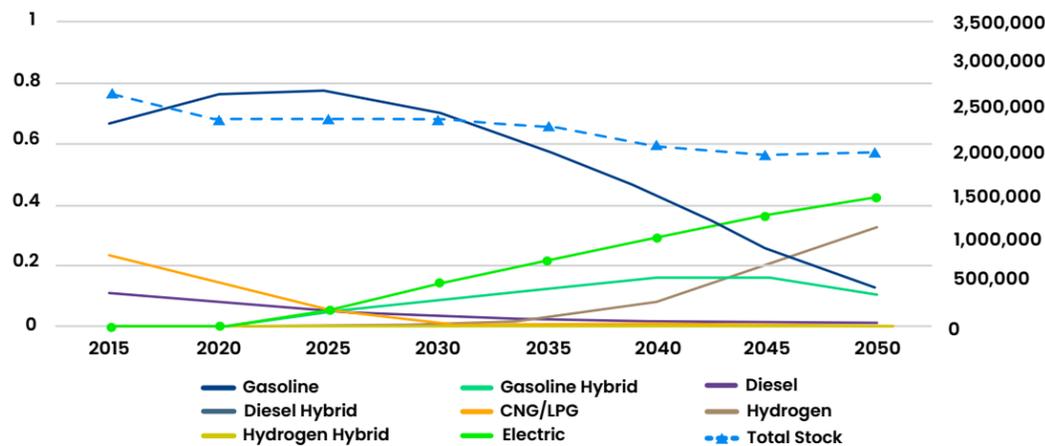
grow throughout the study period, reaching 3 million vehicles by 2050. It should be pointed out that in this analysis new vehicles enter the market to cover projected demand. Therefore, as teleworking and other policies limit car activity, fewer vehicles are required to cover that demand. In reality the evolution of vehicle fleet also depends on various other factors and decisions made often on an individual level.

**Figure 35. Car fleet composition by fuel type – Baseline scenario**



**Zero-emission vehicle sales increase in the Alternative Scenario** (Figure 36). By 2050, all new vehicles sold are electric or hydrogen-powered. In that timeframe, hydrogen and electric vehicles take a share of three quarters of the total fleet (42% electric and 32% hydrogen). This vehicle technology uptake is the main reason behind the much lower CO<sub>2</sub> emissions achieved in this scenario. Given trends of teleworking, restriction policies in CABA, and increased public transport availability, the total private vehicle stock is assumed to actually decrease in the Alternative scenario. By 2050, 2 million vehicles circulate the streets of RMBA, a reduction of 25% compared to the base year.

**Figure 36. Car fleet composition by fuel type – Alternative scenario**



Vehicle fleet composition is the main driver behind total CO<sub>2</sub> emissions estimates. Nonetheless, also other measures assumed in the scenarios have an effect on CO<sub>2</sub> emissions. Car CO<sub>2</sub> emissions in the *Alternative* scenario are one third of the *Baseline* scenario. By applying the car CO<sub>2</sub> emission factors of the *Baseline* scenario to the *Alternative* scenario, we can assess the CO<sub>2</sub> impact of the other policies in car travel. Doing this analysis shows that the set of the additional and/or more stringent policy measures applied in the *Alternative* scenario are responsible for one third of the CO<sub>2</sub> savings between the two scenarios scenario. The remaining difference between the car CO<sub>2</sub> emissions in the two scenarios (67%) comes from the vehicle fleet.

## Chapter 4: Bogota



### Summary of findings

Transport activity in Bogotá will increase significantly in the coming decades, following population and economic growth. The increased activity – by as much as 45% – has the potential to create significant burdens for the transport ecosystem of Bogotá. Increased public transport supply, and ambitious policy measures can manage this growth by shifting part of it to sustainable modes, hereby contributing to emissions reductions.

Public transport is the backbone of the Bogotá region, providing more than 50% of all transport demand. It will continue having this role throughout the next decades. To maintain this share amidst growing transport activity, infrastructure provision will be important. The new developments, particularly the metro system and the BRT corridors will ensure that there is adequate public transport supply for the increased demand. Another measure that could bring significant benefits and increase in public transport usage is transit oriented development. This measure increases building density around public transport developments, and will be particularly useful near the new metro system and BRT corridors.

The Bogotá region can also expect a growth in private vehicle travel<sup>2</sup>. This comes on top of the already existing private vehicle traffic, which has made Bogotá one of the most congested cities in the world. The economic growth of Bogotá brings opportunities to many people to acquire private cars or motorcycles. In the “Current Policies” scenario, defined by the city, the combined mode share of cars and motorcycles in passenger-kilometres will increase substantially (31% in 2050 from 26% in 2018). If policies that penalise private vehicle use, such as restriction or pricing measures, are taken, their growth can be controlled. Under the assumptions of the “Positive” scenario, the share of private vehicles in transport activity will actually decrease a bit – a direct result of these policies. The surrounding region of Cundinamarca is also a big concern regarding private vehicle usage. Its population is forecasted to grow faster than Bogotá D.C.’s, and there is a lack of alternatives. The development of the Regiotram lines will enable the inhabitants of these regions to travel to the city fast without the need of a car.

Non-motorised modes play a very important role in Bogotá. In 2018, almost 18% of all transport activity was non-motorised (13% walking and 5% cycling). These numbers are remarkably high, but are a direct result of the high density of Bogotá D.C. Despite the challenges that density creates, it allows people to do many trips on foot or by bike. The importance of walking will remain relatively similar in the study period, although improving sidewalks and prioritising pedestrians in central areas will be instrumental to that end. Cycling on the other hand has been having a growing trajectory in the past decade. With the implementation of adequate policies to support this growth – dedicated bike lanes with physical separation, proper signalling and driver education – bike use will further increase. In the positive scenario, these policies combined with a growing cycling trend, could lead to almost one in four trips in the Bogotá region being a walking and cycling trip.

CO<sub>2</sub> emissions in Bogotá will reduce, driven primarily from the evolution of the vehicle stock, but also from other policies that shift users to more sustainable modes. Focusing in the composition of the vehicle fleet solves only a part of the problem, as it will not reduce congestion. Bogotá may decrease its annual transport CO<sub>2</sub> emissions by as much as 90% if the ambitious targets of the Positive scenario are realised. CO<sub>2</sub> emissions will decrease even under the more conservative assumptions of the Current policies scenario (36% lower in 2050 compared to 2018).

Public transport electrification is a priority for Bogotá. In Current Policies, CNG/LPG is seen as a transition fuel, powering buses and BRTs in the short-medium term until electrification picks up. The Positive scenario assumes a much earlier fleet electrification, which leads to all-electric public transport by 2050. Public transport electrification also reduces local pollutant emissions, as diesel buses are a significant source of them. It must be pointed out, that to properly integrate electric vehicles in the existing fleets, cities need to address several regulatory, normative, financial and infrastructure barriers that may limit the deployment of e-mobility.

The uptake of electric and other low- and zero-emission vehicles will have the biggest effect in CO<sub>2</sub> emissions. In 2018, 70% of all CO<sub>2</sub> emissions in Bogotá region came from private cars. In the Positive scenario, where all new private vehicles sold in 2050 will be electric or hydrogen (95% and 5% respectively), emissions from private cars reduce by 85%. To achieve this sales target a holistic enabling framework that supports the uptake of electric vehicles in the private fleet. These will need to range from fiscal and financial measures, to infrastructure and regulatory measures. As long as electric vehicles have a higher upfront costs than conventional ICE vehicles, governments could use financial or fiscal benefits to encourage the purchase of electric vehicles. Preferential parking policies for clean vehicles can be another policy to encourage the use of these vehicles. Provision of charging infrastructure can be another relevant factor in the enabling environment for clean mobility. The adoption of low-emis-

<sup>2</sup> To learn more about the attitudinal and personal factors that explain the use of private vehicles in Bogotá (Colombia) please see the forthcoming IDB publication: Understanding Automobile Modal Choice in LAC Cities.

sion-zones can also contribute to the uptake of clean vehicles. Any policies supporting the uptake of clean vehicles should be duly assessed with regards to their impact on equity. They will only be justified where people without access to private vehicles are sure to benefit from enhancements of the transport system overall as well. Communicating the broad benefits of clean vehicle uptake, having an effect on the liveability of the city as a whole, will help in bringing the broad public on board for the support of clean vehicle uptake.

### Bogotá's passenger transport system, related key challenges and policy plans

The Bogota region (as defined in the 2019 Mobility Survey of Bogotá<sup>3</sup>) – encompasses the 20 boroughs inside of the Bogota Capital District (Bogota D.C.), as well as the surrounding department of Cundinamarca. Around 10.5 million people live in the Bogota region, representing around one fifth of Colombia's total population. More than 80% of inhabitants of the Bogota region live in the densely populated Bogota D.C.

For the purposes of this study, Bogotá region is split in 32 zones (Figure 37). Out of the 32 zones, 25 cover the area of Bogotá D.C., while the remaining seven cover the department of Cundinamarca. The 25 zones covering Bogotá D.C. are smaller compared to the seven zones covering the remaining study area. This zoning system was agreed with Bogota D.C.'s mobility department.

Figure 37. Zoning system used for Bogotá region



**Inhabitants of the Bogota region make around 16 million trips every day**, excluding walking trips of less than 15 minutes. Walking is the most common mode of transport in the Bogota region, followed by urban bus, BRT, private car, bicycle, motorbike and taxi, in descending order. However, the share of sustainable modes (including walking, cycling and public transport) has declined from around 72% to 67% from 2011 to 2019 (Secretaría Distrital de Movilidad de Bogotá D.C., 2019a).

<sup>3</sup> The use of the term 'Bogota region' in this work does not make reference to any form of existing legal, administrative or planning area bearing this name.

### Public transport

#### Public transport trips make up for around 35% of trips in the Bogota region (compared to 40% in 2015)

<sup>4</sup> Within the capital district, Bogota D.C., **public transport supply is mainly provided by an integrated bus public transport system (SITP)**. It extends throughout the whole city and includes almost 140 BRT stations and more than 7 000 bus stops, served by almost 8 000 buses (Araujo, 2019). The trunk network, Transmilenio, consists of 12 high-capacity BRT lines, created in 2000. Zonal bus services include various types of intra-urban services and feeder services to Transmilenio stations. The "TuLlave" smart card provides an integrated ticketing service for most of SITP. TransMiCable, a cable car, was put in service in 2018. The 3.6km line connects one of the lowest income neighbourhoods in Bogota, Ciudad Bolívar, directly to the BRT system.

#### The mass public transport infrastructure of Bogota D.C. is expected to almost double between 2018 and 2030.

Major projects include the expansion of the Transmilenio BRT infrastructure, a new cable car line (increasing especially the access of lower income areas of the city), a metro line (currently scheduled to be built between 2020 and 2025), and a regional tram connecting Bogota D.C. with its surrounding area. Proposed infrastructure improvements have also included the transformation of 'carrera séptima', one of the main avenues in the city, into a green corridor that prioritises public transport and active modes (Concejo de Bogotá D.C., 2020).

Currently, **public transport services do not adequately meet existing transport demand in the outskirts** of Bogota D.C. In some locations of the highly dense periphery, public transport only gives access to around 6% of the total job opportunities in the city within 30 minutes. This is 10 times less than the average values for Bogota (International Transport Forum. and Inter-American Development Bank, 2022).

**Maintaining operation of the SITP is a major financial challenge** for authorities. Profits from trunk lines that run large buses on dedicated lanes are more than offset by losses from feeder routes and the zonal system of traditional buses. Many of these routes suffer from low-demand since they were designed to provide coverage rather than needed capacity, and because traffic congestion hinders their service quality. Furthermore, fare evasion throughout the system undercuts revenue (Alcaldía Mayor de Bogotá, 2017).

### Private cars and motorcycles

**Around 14% of all journeys in the Bogota region are taken by private car.** More than 1.8 million private vehicles (cars and trucks) were registered in Bogota in 2019 (Secretaría Distrital de Movilidad de Bogotá D.C., 2019b). **Ownership levels in the city increased** by 81% between 2008 and 2016. Nonetheless, annual growth rates for vehicle ownerships are decreasing. Between 2013 and 2017 the average annual car ownership growth rate was 5.9%. This is less than half of the annual growth rate of 12.9% between 2007 and 2012. In 2017, the average vehicle age for private cars in the city was of 12.9 years (Observatorio de Movilidad de Bogotá D.C., 2017).

**Almost 6% of trips in the Bogota region are made by motorcycle. The motorcycle motorisation rate multiplied by 8 within a decade**, increasing from only 5 motorcycles per 1 000 inhabitants in 2005 to 40 in 2015. (Secretaría Distrital de Movilidad de Bogotá D.C., 2019a). High adoption of motorcycles in lower-income groups has been linked to the relative affordability of motorcycles as compared to other modes.

<sup>4</sup> This number takes into account trips done by BRT and by urban bus services inside of Bogota D.C., as well as inter-municipal buses serving the rest of the Bogota region.

### Walking and cycling

In the Bogota region, the **mode share of walking has been stable at around 25%** since at least 2015 (Secretaría Distrital de Movilidad de Bogotá D.C., 2019a; Secretaría Distrital de Movilidad de Bogotá D.C., 2015). Many walking trips are carried out to access (or egress) other modes of transport. On the other hand, **the share of cycling has reached 7%** by 2019 – which is almost double the share of 2015 levels. The Bogota region has thus the highest cycling mode share among Latin American capital cities. Major infrastructure investments have been essential for the increase in the mode share of cycling. Between 1998 and 2019, the length of cycling lanes increased from 10km to 500 km. The Bicycle Public Policy, which is expected to be adopted by the end of 2020 and expire in 2038, aims at making Bogota “The World’s Capital for Cycling” (Alcaldía Mayor de Bogotá, 2019).

### Taxi services

In 2019, taxis accounted for around 4.3% of daily trips in the Bogota region. The arrival of ride-hailing apps has likely increased the number of for-hire vehicle trips taken in the city. Since 2013, various ride-hailing enterprises, such as Uber, Cabify and DiDi, have begun operations in the city without authorisation from taxi authorities. In 2017, 57 000 Uber X vehicles in circulation had already outnumbered the 50 000 official taxis (Panampost, 2017).

### Informal transport and micromobility

In 2019, **3.4% of trips in the Bogota region involved some sort of informal transport mode.** One of the main forms of informal transport is the bicycle rickshaw. Beyond informal transport activities, authorities have also aimed at regulating emerging micro-mobility services. Electric scooter leasing companies, such as Lime, Muvo and Green, had started operations in Bogota by 2019.

### Challenges across the different modes

**Air quality is one of the main policy priorities in Bogota.** Private motor vehicles are responsible for more than 40% of all transport-related PM<sub>10</sub> emissions in the city (Secretaría Distrital de Ambiente de Bogotá D.C., 2020). In 2017, almost half of Bogota’s citizens considered air pollution to be the most important environmental issue in the country (DNP, 2018). Authorities have put forward policies such as transit oriented development (TOD) around TransMilenio stations as a way to contribute to sustainable mobility and mitigate CO<sub>2</sub> emissions. However, recent data points towards a potential link between TOD projects and increased exposure to exhaust emissions around public transport stops. This increase stems from the high traffic of diesel buses around stations where TOD measures incite higher population densities (Espinosa Valderrama, 2019). The uptake of cleaner vehicles in both the private and public vehicle fleets will be essential to reduce air quality concerns overall.

Today, **there is no effective governance framework for the Bogota region.** Three main authorities co-exist in the same area: the National State, the Bogota Capital District and the Cundinamarca Department. Additionally, each municipality within Cundinamarca has its own governing body. The municipal governments and capital district typically plan and implement their own transport policies. As such, there are no defined cooperation frameworks for regional-wide services. Because of this, planning and implementation processes for regional transport projects are defined on a case-by-case basis and do not always include all relevant stakeholders. For instance, mobility surveys in the region are carried out exclusively at the request of the Bogota Capital District’s Mobility Secretariat (Secretaría Distrital de Movilidad de Bogotá D.C., 2015). A lack of a regional body responsible for transport policy and planning limits capacity to implement environmental protection measures.

### Key policy plans regarding transport decarbonisation

The **District Disaster Risk and Climate Change Management Plan** for Bogota 2018–2030 [*Plan Distrital de Gestión del Riesgo de Desastres y del Cambio Climático para Bogotá 2018–2030*] serves as the basis for future development plans and is an instrument for prioritizing future investments. The plan provides a comprehensive CO<sub>2</sub> reduction strategy across the whole economy of the city. CO<sub>2</sub> reduction goals have been identified for 2030; intermediate goals for 2020 can be assessed in the near future.

**Bogota’s zero emission policy** sets targets for the uptake of zero emission vehicles in the public and the private service fleets. Notably, by 2040, all vehicles of the public and private service fleet are to be zero emission vehicles. The city’s electric vehicle policy follows best practices around the world. It provides a balanced portfolio of both regulatory and financial measures to incite the uptake of electric vehicles. It also provides measures that target the build of recharge infrastructure and shows that the topic of battery recycling has been considered.

**Bogota’s mobility master plan** [*Plan Maestro de Movilidad*], dedicates one section specifically to sustainable development and defines objectives ranging from accessibility to finance-related challenges. Since 2017, Bogota has been in the process of updating its Mobility Master Plan. It will be most relevant for defining the future of the city’s transport system and respective CO<sub>2</sub> emissions.

Ideally, the master plan should address challenges regarding the institutional integration that have been a barrier to CO<sub>2</sub> mitigation efforts in the past. It would also be desirable if the plan provided a specific transport CO<sub>2</sub> reduction objective for 2030 and beyond.

### Assessing scenarios for Bogota’s passenger transport system

The transport assessment model for Bogota mainly relies on data coming from two mobility surveys that were carried out in Bogota in 2015 and 2019 (de Bogotá, Alcaldía Mayor, 2015; de Bogotá, Alcaldía Mayor, 2019) and from Bogotá’s transport model. Like for the other case study cities, other key sources of information were OpenStreetMaps (OpenStreetMap) for road network information, GTFS data<sup>5</sup> to describe the public transport system and OECD forecasts of future GDP growth.

### Scenario definition

The model that the ITF built for the authorities of Bogota allows assessing the impact of future scenarios of transport policies and transport infrastructure developments on key passenger transport indicators for the city (such as transport activity and transport-related CO<sub>2</sub> emissions). For the purpose of this report, the ITF, together with Bogotá D.C. authorities, designed two distinct scenarios, named *Current Policies* and *Positive Scenario*. The first scenario represents the currently envisaged path of future policies and infrastructure developments focusing on the short-term. The second scenario assumes increased ambition of the implemented policies for CO<sub>2</sub> reduction and further measures on the long-term (beyond 2030).

The two scenarios were defined during a series of virtual technical meetings that took place in August 2020. Participants included representatives of the mobility and environment secretaries of Bogotá D.C. the meetings allowed the ITF to present a beta version of the model, describing its workings and functionalities. Using a predefined template, the participants then defined the two scenarios for use in

<sup>5</sup> GTFS data for the study area come from open source data and are complemented by a data collection exercise done by a team of researchers of MIT, NYU and Universidad del Rosario. This happened in the framework of another ITF/IDB project in Bogotá region and created GTFS data for many informal routes that did not exist before.

this report. The meeting participants then validated the scenario outputs after the ITF had made them available.

### Current Policies (CP) scenario

The *Current Policies* scenario includes the policy plans and ambitions of the current administration. As the administration has direct control of short-term targets, measures are clearly defined. Longer-term policy goals are less explicit.

Bogotá D.C. has concrete plans for multiple public transport infrastructure projects, and has partly already begun their construction. These projects are all included in the current policies scenario. They cover the creation of a new metro line (to be completed by 2028), a new tramline (Regiotram – to be completed by 2025) and multiple new BRT corridors (to be completed until 2025). All of these will enhance and supplement the city's already robust public transport network of BRT corridors.

There are also plans to improve infrastructure for non-motorised modes in the near-future. The developments included in the *Current Policies* scenario target many zones in Bogotá D.C., mostly in parts around the city centre. In the city, centre walking and cycling infrastructure has been recently revamped. A bike-sharing system is also envisioned for the central areas of the city.

Bogotá D.C. also aims to implement Transit Oriented Development policies, increasing building density near trunk public transport stops. These policies are also planned for the next decade, with the majority of them happening in the southern and south-western parts of the city, alongside the many new public transport developments located in these areas.

In terms of fiscal policies, the *Current Policies* scenario does not assume any substantial changes in parking or public transport pricing. Such charges are assumed to grow in line with inflation throughout the study period. No new regulations are assumed with regards to speed limits of motor vehicles. Bogotá D.C. already has integrated ticketing for its many public transport modes that it will expand to the entire Bogotá region by 2030, without changes in the pricing schemes.

The scenario also includes a car restriction scheme for peak hour travel throughout the entire city. This policy will restrict usage of private vehicles based on the last digit of license plates. The goal is to alternate odd and even numbers for all weekdays.

The *Current Policies* scenario includes also a continuation of current trends of bicycle usage, and an increased trend of motorcycle usage. Bogotá D.C. has witnessed a growth in usage for both these modes during the last decade. Thanks to this growth, Bogotá is often referred to as both the capital of cycling and motorcycles in Latin America.

Decarbonisation of vehicle fleets is an important long-term priority for Bogotá D.C. This concerns both private and public transport fleets. In the *Current Policies* scenario, CNG/LPG is the short-term solution for public transport and taxi fleets, with a majority of buses, taxis, and half of BRT using it in 2030. In the long-term, electric vehicles will become predominant, especially for buses and BRT, of which 90% will be electric in 2050. Private cars follow the sales assumption of the International Energy Agency's New Policy Scenario (IEA, 2020), which projects 20% of private car sales in 2050 being electric, and 52% being hybrid. Motorcycle sales for the year 2050 assumed to be 50% electric, with the remaining using conventional fuels.

### Positive scenario (PS)

The *Positive* scenario builds upon the policies of *Current Policies* scenario and assumes a higher ambition for decarbonising transport in Bogotá D.C. and the surrounding area. In the short-term, both scenarios are similar, focusing on public transport and non-motorized infrastructure developments. The *Positive Scenario* includes stronger policy levers, expanding car restriction to the entire weekday, and implements a distance-based congestion-charging scheme. It also includes policies and developments envisioned later in the study period, and very ambitious targets with regard to the uptake of clean vehicles.

The *Positive scenario* goes beyond the short-term planned infrastructure developments. It complements the developments included in *Current Policies* with new trunk public transport lines. A new metro line is assumed to run northwest from the city centre; more BRT corridors are created; and two more Regiotram lines connect Bogotá D.C. to Cundinamarca. All these new developments are planned for the next decade (2030-2040).

There is increased emphasis of non-motorised infrastructure, with walking infrastructure being improved in the entire city. Similarly, cycling infrastructure and bike-sharing are put in place in more parts of the city. Finally, TOD related measures are also applied in the outer parts of the city and the surrounding suburbs, complementing planned public transport developments.

Pricing policies in the *Positive* scenario favour public transport and penalise car usage. Public transport fares decrease relative to inflation, while parking prices increase throughout the study period. New speed regulations are put in place, reducing speed limits. The expanded integrated ticketing, which already happens in *Current Policies*, is assumed to lead to a fare reduction for the users of these newly integrated services.

In addition to the expanded car restriction scheme (it lasts for the entire day in this scenario), a congestion charging measure is also applied. It is envisioned as a distance-based scheme, where drivers pay for the distance travelled within the cordon. The cordon starts from the central areas of the city, eventually covering most of Bogotá D.C. by 2050. It applies for private cars, motorcycles and taxis.

The trends of two-wheelers reverse in the *Positive* scenario. Motorcycle usage continues with the current trend, reaching about 5% of all trips in 2050. On the other hand, bicycle usage is assumed to increase by 50% compared to 2018 base year values. These trends represent the ambition of the city authorities to establish policies and implement measures that promote bicycle usage while limiting motorcycles.

Another trend that takes hold in the *Positive* scenario is teleworking. Teleworking reduces total trips in the Bogotá region by 5%. Teleworking is assumed to reduce primarily trips to the city centre, where most jobs are located, while slightly increasing local short-distance trips.

Decarbonisation ambitions of vehicle fleets are much stronger in the *Positive* scenario. The transition to electric buses and BRT systems starts already by 2030, when about half the fleet for both is electrified. This paves the way for an all-electric bus and BRT fleet in 2050. Taxis, being smaller vehicles and easier electrified, are able to switch faster. Already 70% of the fleet in 2030 is electric, with the remaining split between CNG/LPG and gasoline. By 2050, the taxi fleet is also all-electric. Private vehicles sales follow the same trend. In 2050, electric vehicles constitute 95% of total sales. Finally, all motorcycles sales in 2050 are assumed to be electric vehicles.

Table 5 and Table 6 have the exact specifications for each scenario.

Table 5. Policies in the two scenarios

Measure	Current Policies		Positive scenario	
	Year	Average fare change [%]	Year	Average fare change [%]
Integrated ticketing (regional)	2030	0	2030	-15%
	Speed change [%]		Speed change [%]	
Speed limitations	2030	0	2030	-10%
	Parking cost change every 5 years [%]		Parking cost change every 5 years [%]	
Parking regulation/pricing	2025	20%	2025	30%
	Average fare change every 5 years [%]		Average fare change every 5 years [%]	
Public transport pricing	2025	0	2025	-10%
	Zones affected		Zones affected	
Transit Oriented Development	2025-2030	12 zones in total	2025-2030	15 zones in total
	2025	3 zones affected	2025-2050	all 25 zones of Bogotá D.C.
Enhanced walking infrastructure	2025	12 zones affected	2025	12 zones affected
Enhanced cycling infrastructure	2025	4 zones affected	2025	12 zones affected
Bike-sharing	2020	All Bogotá D.C. - peak hours	2020	All Bogotá D.C. - all day
Car restriction scheme			2025-2040	20 zones in total
Congestion Charging	2020-2025	Planned corridors and extensions	2020-2035	Planned + 5 new corridors between 2025-2035
New BRT corridors	2025-2030	Planned metro line	2025-2035	Planned + 2nd metro line
New metro line	2025	Planned Regiotram line	2020-2035	Planned + 3 new lines
New Regiotram line	% of the total trips reduced due to teleworking in 2050		% of the total trips reduced due to teleworking in 2050	
	0%		5%	
Teleworking	More trips done by motorcycle		More trips done by motorcycle	
	10%		trending growth	
Increased motorcycle usage	More trips done by bicycle		More trips done by bicycle	
	trending growth		+50% of trending growth	

Table 6. Vehicle stock/sales targets for the two scenarios

	Baseline			Positive scenario		
		2030	2050		2030	2050
Vehicle stock targets	Bus fleet composition in [%]:			Bus fleet composition in [%]:		
	Electric	20%	90%	Electric	50%	100%
	Hydrogen	0%	0%	Hydrogen	0%	0%
	CNG/LPG	60%	10%	CNG/LPG	30%	0%
	Hybrid	10%	0%	Hybrid	0%	0%
	Diesel	10%	0%	Diesel	20%	0%
	BRT fleet composition in [%]:			BRT fleet composition in [%]:		
	Electric	10%	90%	Electric	50%	100%
	Hydrogen	0%	0%	Hydrogen	0%	0%
	CNG/LPG	50%	10%	CNG/LPG	40%	0%
	Hybrid	0%	0%	Hybrid	0%	0%
	Diesel	40%	0%	Diesel	10%	0%
	Taxi fleet composition in [%]:			Taxi fleet composition in [%]:		
	Electric	5%	50%	Electric	70%	100%
	Hydrogen	0%	0%	Hydrogen	0%	0%
CNG/LPG	70%	20%	CNG/LPG	15%	0%	
Hybrid	5%	30%	Hybrid	0%	0%	
Gasoline	20%	0%	Gasoline	15%	0%	
Car fleet	2050		Car fleet	2050		
Vehicle sales target in [%]:			Vehicle sales target in [%]:			
Electric	20.40%		Electric	95%		
Hybrid	52.10%		Hybrid	0%		
Hydrogen	2.40%		Hydrogen	5%		
Moto fleet	2050		Moto fleet	2050		
Vehicle sales target in [%]:			Vehicle sales target in [%]:			
Electric	50%		Electric	100%		
Hydrogen	0%		Hydrogen	0%		

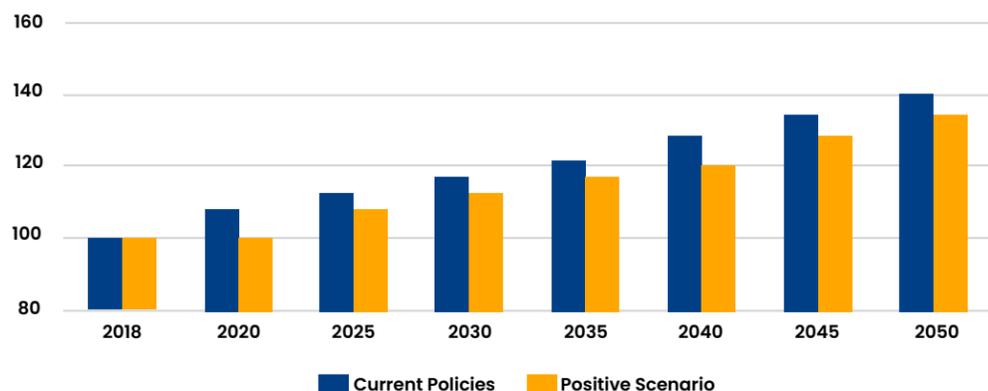
### Results

The different scenarios demonstrate two (out of many) possible futures for Bogotá's transport ecosystem and their impacts in terms of transport activity and emissions up to 2050.

**Total transport activity grows but mode shares depend on the path taken**

**Total transport activity in the study area will grow more than 30% in the next decades.** This will happen regardless of the specific transport policy scenario and is driven by population and economic growth – the primary drivers of urban mobility. Population and GDP growth are external variables to the scenarios, and are therefore coherent across the two scenarios. Figure 38 shows the growth in the total number of trips for the two scenarios, indexed to the base year (2018). There is a drop in 2020, associated with the reduction caused by the Covid-19 pandemic, but transport demand recovers fast. By 2050, under the Current Policies scenario, trips in the study area will increase by 38%. Trips will grow by 6 percentage points less in the Positive Scenario. This reduction is the result of the assumed increased uptake of teleworking in the Positive scenario, a trend that may become more common after the Covid-19 pandemic.

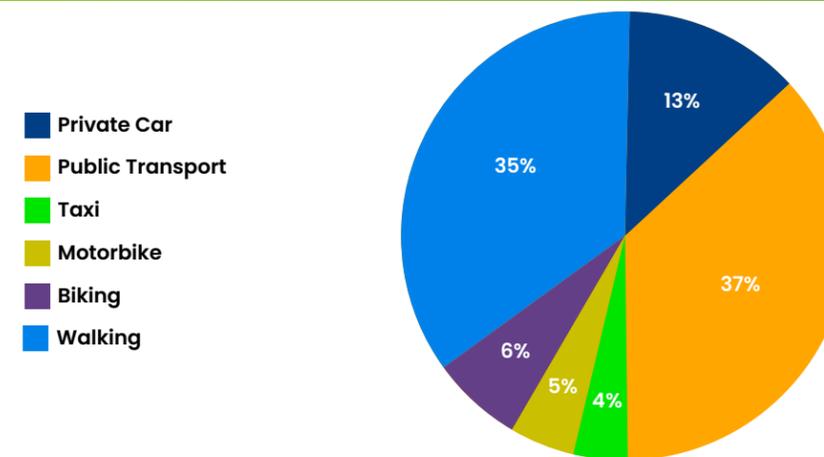
Figure 38. Trip evolution in the two scenarios



Note: Trips are indexed to 100 in the base year

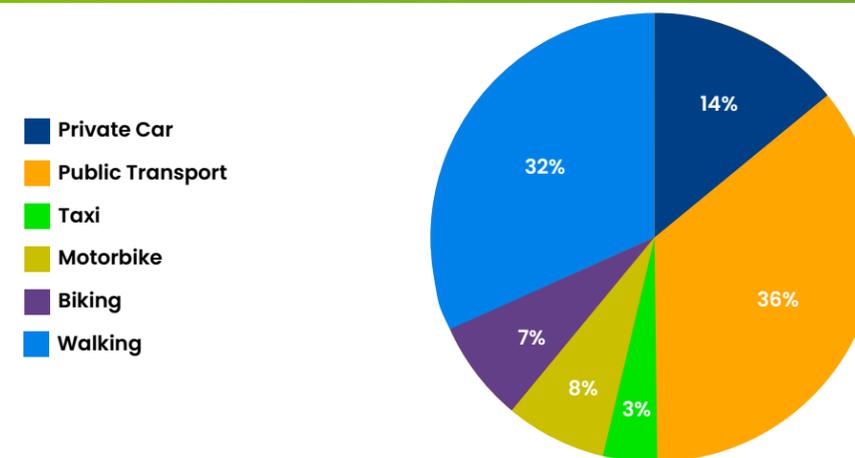
**Public transport is and will remain the main mode of transport in Bogotá region in both scenarios.** In 2018, a little over one third of all trips (37%) in the study area were done via public transport (Figure 39). Trips with private vehicles corresponded to 18% (13% for car and 5% for motorcycles) of all trips. The mode share of taxis was 4%, with the remaining trips being done by non-motorised modes (35% on foot and 6% on bike). As total trip numbers will grow in the next decades, the number of trips done with the different modes will also grow in absolute numbers. Their relative shares will vary depending on the scenario, but no drastic changes are observed.

Figure 39. Trip mode share in 2018



**In the Current Policies scenario, the share of trips done with private vehicles will grow** following the trend observed in the past decade (Figure 40). By 2050, more than one of five trips is a private vehicle trip (14% of car trips and 8% of motorcycle trips). Compared to the base year, their share grows by 4 percentage points. This reduces the share of all other modes except cycling, whose share grows by a percentage point. Walking is the mode that experiences the biggest loss, with a mode share reduction of 3.5 percentage points, whereas public transport and taxi lose half a percentage point each. These changes demonstrate that without long-term vision and policy change, past trends are hard to change.

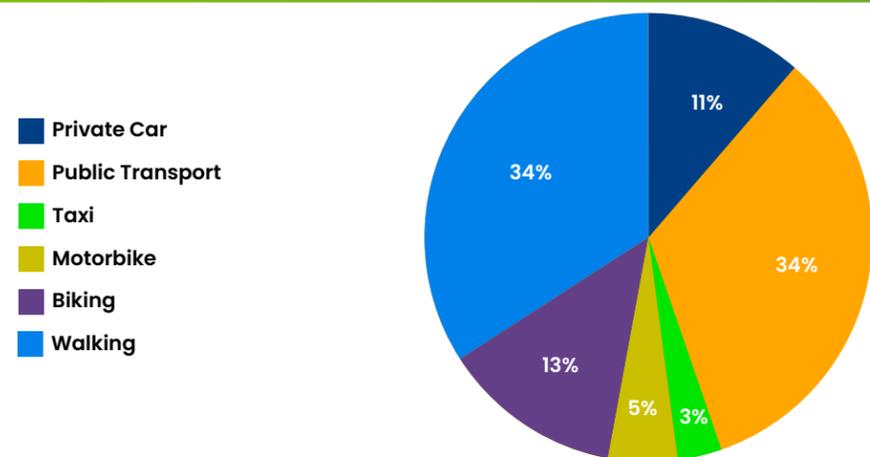
Figure 40. Trip mode share in 2050 – Current Policies scenario



**The Positive scenario manages to reverse the growth of less sustainable modes** (Figure 41). In the Positive scenario, private car usage decreases by 2 percentage points compared to the base year, whereas the share of motorcycle trips remains about the same (5%). This scenario instead sees a growth in cycling as a result of the cycling-related measures included in the scenario parameters. In 2050, 13% of trips in the study area are cycling trips. While some of the new cycling trips replace potential car and motorcycle trips, many of them replace public transport trips. As such, the share of public transport in

2050 is 34%, lower than both the base year value and the 2050 value for the Current Policies scenario. The reduction of walking trips is contained on the other hand, as a result of the policies encouraging walking. Their share in 2050 is 34%, one percentage point lower than the base year. The continuous adoption of strong and ambitious policies and measures is key to achieve this future.

Figure 41. Trip mode share in 2050 – Positive scenario

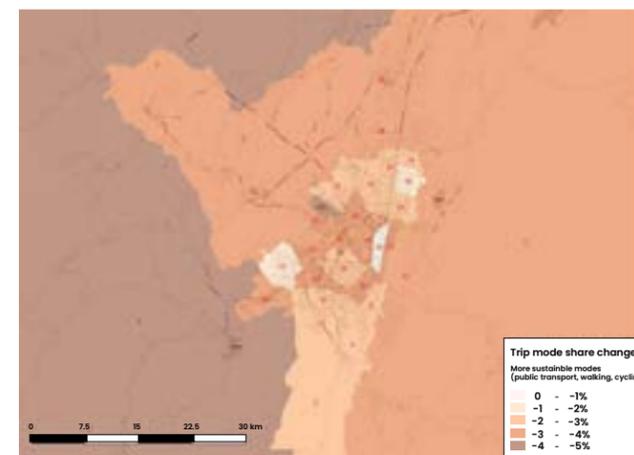


**Measures have increased impacts in some zones compared to others**

**The evolution of the trip mode shares is different throughout the city.** On the zone level, it can be observed that in specific parts of the city mode shares may develop differently to the city-wide trend. This shows the local impact of the different measures in each scenario.

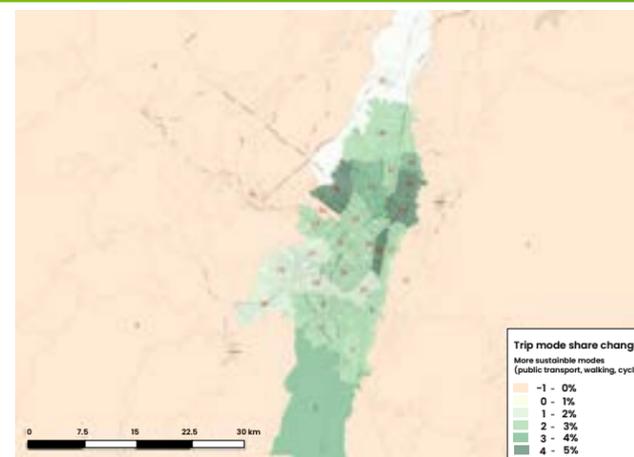
In the Current Policies scenario, the growth of less sustainable modes (private car, motorcycle, and taxi) happens in all zones of the study area (Figure 42). It is more noticeable for trips starting in Cundinamarca, where car ownership rates grow following the increased GDP. Residents of Cundinamarca also have fewer transport alternatives available. The areas where the growth in less sustainable modes is the lowest (and therefore the share of sustainable modes remains high) are in the city centre, the northern and the southern parts of the city. Infrastructure plans, both for public transport and non-motorised modes, play an important role in these zones.

Figure 42. Change in trip mode shares by zone 2018–2050 – Current Policies scenario



In contrast, the Positive scenario results in an increased growth of more sustainable modes (public transport, walking, cycling) in almost all zones (Figure 43). The exception to this are the Cundinamarca zones, which still see a growth in private motorised modes, albeit lower than in the Current Policies scenario. In general, the city centre and the zones in the north of Bogotá D.C. are the places where sustainable modes see the highest growth. A big part of this increase comes from cycling, which increases its share through the assumed continuous positive trend for biking and the enhanced respective infrastructure. The southern part of the city does not see a similar increase, despite the fact that it is the other area with lower growth of less sustainable modes in the Current Policies scenario. This, perhaps, can be highlighted as a missed potential towards enhanced sustainable mobility.

Figure 43. Change in trip mode shares by zone 2018–2050 – Positive scenario



**Buses are and will remain the main public transport mode in the Bogotá region.** In 2018, more than three out of five public transport trips were done by bus, while the rest used BRT. While the BRT network is the backbone of the transport system, regular buses are important feeder services and cover many inter-urban trips. As the metro line and new BRT corridors are created in the coming decade in both

scenarios, the share of buses steadily decreases. In the Positive scenario, which includes more developments for BRT and metro in the coming decades, the share of buses drops even further. Still, in both scenarios, buses still serve the majority of public transport trips by 2050 (58% for CP and 56% for PS).

**The metro system will provide a useful alternative, providing a quick and reliable alternative to its users.** However, a single line (or two in the Positive scenario) will have a small impact relative to the whole transport system. Within public transport trips, the share of metro trips will remain in the single digits (3% for CP and 5% for PS). However, it is important to clarify that the model might underrepresent the impact of the metro system. To understand the behaviour towards the new mode and the users' choices, stated preference survey information would be required – information that was not available for this study. Additionally, as the transport system will adapt to be well-aligned with the new metro, and land use changes around the stations can be expected, many transport users may even change their travel destinations and choices overall.

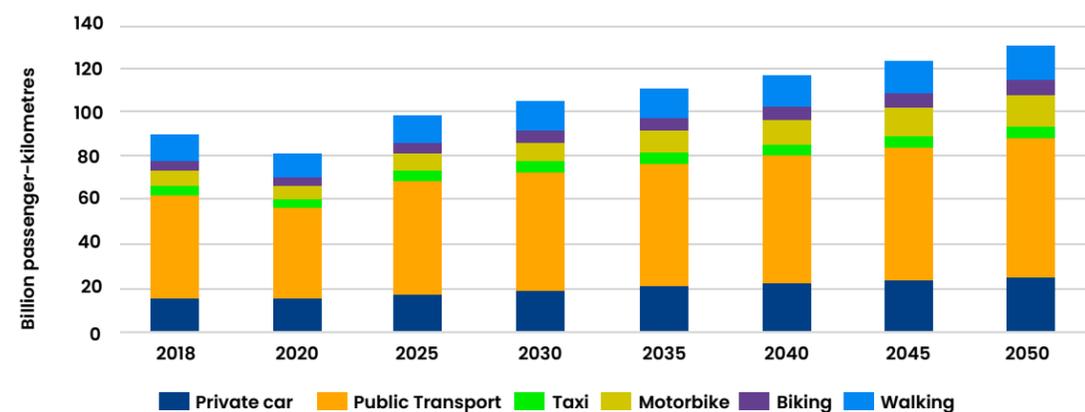
#### Sustainable modes have high potential in Bogotá

Trip numbers, while a useful metric, is not the most accurate way to measure transport activity. A walking trip and a private car trip are both counted as one trip, even if the car trip is likely longer. Passenger-kilometres (PKM), is another metric that commonly describes transport activity. It gives a different representation of activity, one that focuses on the transport activity provided by each mode. The importance of motorised modes, which usually serve longer trips, is amplified.

**Measuring activity by PKM shows the importance of public transport in Bogotá.** In 2018, half of the total PKM travelled in the study area are served by public transport (Figure 44). Private vehicles provide a little over one in every four PKM (19% car and 7% motorcycle) and taxis provide 5% of the total. The PKM mode share of all these motorised modes is higher than their equivalent trip mode share. This comes at the “expense” of non-motorised modes, where biking and walking provide 5% and 13% respectively.

**In the Current Policies scenario, total PKM grow by 46% by 2050.** Following this growth, activity for all modes in 2050 will be higher than in the base year. However, some modes grow more, following the evolution of the underlying factors that affect mode choice as well as relevant policies that are put in place.

Figure 44. Annual transport activity by mode – Current Policies scenario

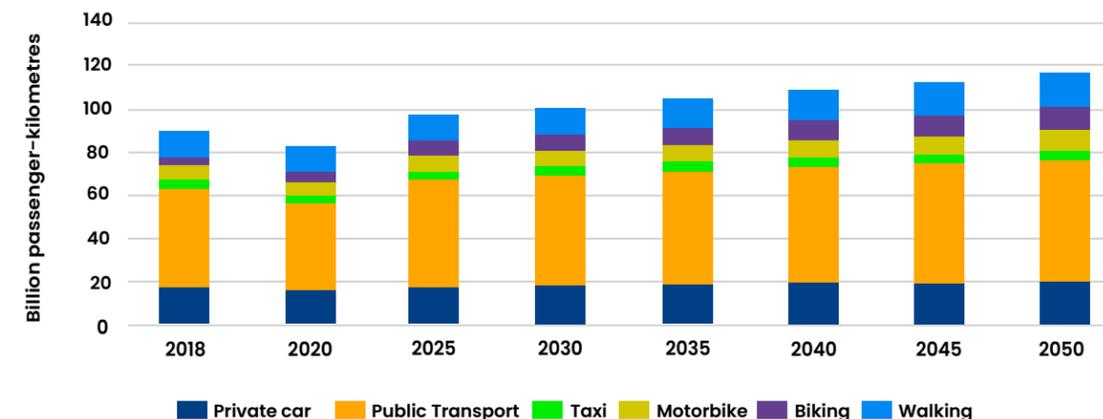


There are no differences in the order of modes by mode share between 2018 and 2050, except between cycling and taxi. Cycling PKM in 2050 are estimated to be more than the ones done by taxi. Public transport and private car remain the two most used modes. The biggest relative growth in PKM, however, comes for motorcycle, which now corresponds to 11% of the total PKM. A bigger than average growth is also projected for cycling and private car. On the other hand, public transport and walking PKM grow the least, with the PKM share for these modes being 49% and 12% respectively.

**The growth of PKM is lower in the Positive scenario.** By 2050, activity grows by 30% compared to 2018, 16 percentage points less than the Current Policies scenario. This comes as a result of policies such as transit oriented development, or other policies that encourage land use diversification and shorter distance trips. Teleworking is another factor, eliminating long commuting trips but increasing shorter shopping or leisure trips.

**The mode that has the highest growth in this scenario is cycling.** Infrastructure policies, the widespread use of bike-sharing and the continuation of the cycling trend almost double the transport activity done by bikes. In 2050, under the assumptions of the Positive scenario, there are more PKM done with bike than by motorcycles or taxis. Motorcycle usage also continues to grow, given that it is a cheap and fast transport alternative. Nonetheless, the growth is much smaller than the Current Policies scenario; with total motorcycle PKM representing 8% of the total. The remaining motorised modes all have declining shares, especially private cars and taxis, which are now affected by the congestion charging scheme. Walking has the same modal share of PKM as in the base year, around 13% (Figure 45).

Figure 45. Annual transport activity by mode – Positive scenario



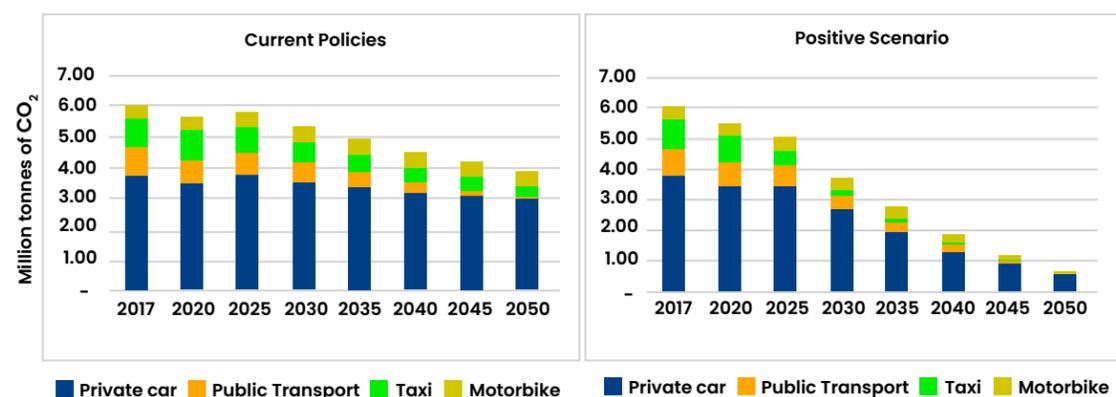
#### Stronger emission reduction under the Positive scenario

**In 2018, the majority of emissions came from private transport** (Figure 46). Private cars and motorcycles contributed to 70% of all direct (tank-to-wheel or tailpipe) emissions in the Bogotá region (60% for cars and 10% for motorcycles respectively). Public transport, despite providing 50% of the total activity was responsible for 15% of emissions. Grouped together, the less sustainable modes (car, motorcycle and taxi) emitted 85% of transport related CO<sub>2</sub> emissions, while only providing 30% of the total PKM.

**By 2050, the Current Policies scenario reduces emissions by 35%, in spite of the increase in total activity.** Private cars are still projected to be responsible for the largest share of emissions, 77% of the total

in 2050. That comes despite the fact that at a per-vehicle-kilometre basis, private car emissions in 2050 will be half of the 2018 value. Increased fuel efficiency of ICE vehicles, conventional or hybrid, and the penetration of electric vehicles are the two main factors that lead to this result. The only mode that sees an increase in the absolute figures of CO<sub>2</sub> emissions is the motorcycle. Total motorcycle activity (in PKM) more than doubles by 2050, a fact that undermines any vehicle efficiency gains. Average CO<sub>2</sub> emissions per km travelled in 2050 are estimated to be 52% lower than the base year. The high electrification rates of public transport fleets in 2050 are the key element that reduces public transport's share of CO<sub>2</sub> emissions down to 2% of the total.

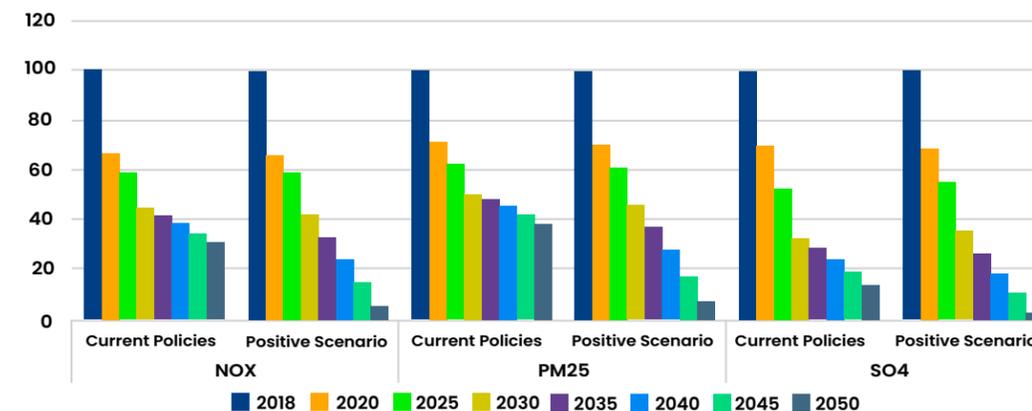
Figure 46. Annual transport CO<sub>2</sub> emissions by mode



**The Positive scenario projects a much bigger reduction in CO<sub>2</sub> emissions.** In 2050, direct transport CO<sub>2</sub> emissions will be only one tenth of the base year. As the public transport and taxi fleets are assumed to entirely rely on electric vehicles, private cars and motorcycles are the only modes that produce tailpipe CO<sub>2</sub> emissions. Nonetheless, almost 80% of cars and motorcycles are electric, which leads to the big reductions by 2050. The estimated emissions for the two scenarios can be seen in Figure 10. In terms of cumulative CO<sub>2</sub> emissions, the Positive scenario also yields better results. Throughout the entire study period, total CO<sub>2</sub> emissions are here 35% less than in the Current Policies scenario.

**Local pollutants reduce drastically thanks to vehicle electrification** (Figure 47). Local pollutants such as NOx, particulate matter, and SO<sub>4</sub> are an issue of concern in Bogota. Under the two scenarios tested, exhaust pollutants will reduce drastically. These pollutants come mainly from the burn of diesel fuel and motorcycles, so their electrification and reliance on natural gas (for buses) reduces them significantly. The reduction is much bigger in the Positive scenario, where levels of all pollutants are less than 10% of the base year levels. In the Current Policies scenario, the most enduring local pollutant is PM<sub>2.5</sub>, with increased motorcycle usage being the main cause. However, it is important to note that exhaust emissions are not the only source of non-CO<sub>2</sub> pollutants. A big share of non-CO<sub>2</sub> emissions come from the wear-and-tear of tires or other components of the vehicles. These pollutants are not measured in this analysis as they depend on a number of external factors that cannot be assessed by the underlying model framework.

Figure 47. Change of annual non-CO<sub>2</sub> emissions



Note: Values are indexed to 100 in the base year; NOx=Nitrogen oxides; PM2.5=Particulate matter 2.5; SO4=Sulfate ion

### Decomposing the impact of different measures

The policy measures and infrastructure developments included in the model affect resulting transport activity and CO<sub>2</sub> emissions in multiple ways. A measure that reduces travel time or costs for a specific mode alters the mode shares for that origin-destination pair. It can also alter the distribution (i.e. destination) of trips, as some trips may be redirected to destinations that become easier (i.e. cheaper and/or quicker) to reach. An increasing number of measures that are applied at the same time makes it more difficult to disintegrate the impact of each measure, especially as the impacts of individual measures are not necessarily additive when they are combined with other measures<sup>6</sup>. Nevertheless, comparing the two scenarios agreed by the city authorities allows for some interesting insights.

Full day vs. peak hour car restrictions result in an additional 7 percentage points reduction of car trips in 2025, the first year this measure is applied. This measure affects the entire city in both scenarios, but differs in its duration during the day. In the Current Policies scenario, it lasts only during peak hours, while in the Positive scenario it lasts throughout the day. By comparing car trip volumes that year, the difference can be estimated. The actual reduction is likely to be lower, as more measures that indirectly affect car travel are also applied in this year.

**Congestion charging reduces private car activity to/from the area where congestion charging is applied by 4% in 2025.** Congestion charging is applied only in the Positive scenario, and for a certain part of the city. The percentage difference is obtained by measuring the reduction in car trips that pass through the cordon vs. the ones that do not pass through it.

The metro line extension, planned for 2035 will increase metro activity in passenger-kilometres by 60%, increasing its mode share by 2 percentage points.

Similar observations can be made at a zone level. In zone 24 for example, walking infrastructure is improved by 2030 in the Positive scenario, whereas it does not happen under the Current Policies scenario. This results in a walking trip mode share increase by 8 percentage points compared to the Current Policies scenario.

<sup>6</sup> An assessment of the impact of single measures compared to a “do-nothing” scenario was provided to city authorities in a separate project deliverable

### Travel time savings and accessibility by public transport

The public transport infrastructure improvements and other policy measures assumed in the two scenarios generate travel time savings for the people in the Bogotá region. In the Current Policies scenario, the average travel time savings across all public transport trips is 3.5 minutes. The gain of 3.5 minutes might seem small, but with over 9 million trips a day, the total travel time saved each day is the equivalent to around 60 years. As this is the average travel time saved, there are people who will have far greater travel time savings, especially the ones living near new infrastructure. In some cases, public transport users might see savings of up to 44% of their total travel time.

**The Positive scenario nearly doubles travel time savings for public transport trips.** In this scenario, the average travel time saved for a public transport trip in 2050 is a little over 6 minutes. The savings are greater for zones in the Cundinamarca department, where the average time saved is 7 minutes. The new Regiotram lines certainly increase accessibility for people in the region. Total daily travel time savings under the Positive scenario correspond to almost 95 years.

**Accessibility by public transport will improve in both scenarios, but much more in the Positive scenario.** Figure 48 shows the number of zones that an average public transport user can reach in 45 minutes starting from any given zone in 2018. This is door-to-door travel time, including access and egress times, waiting time, transfer time, and on-board time. Only zones in the city centre of Bogotá D.C. can reach more than 10 zones within 45 minutes, benefiting from their central location. The number of accessible zones decrease as you move further away from the centre.

Figure 48. Accessibility by public transport in 2018

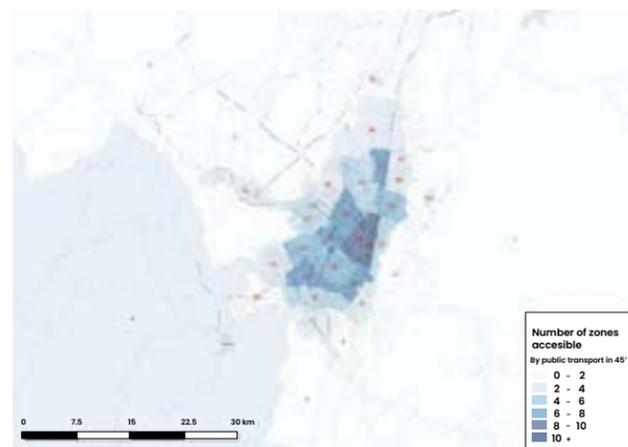
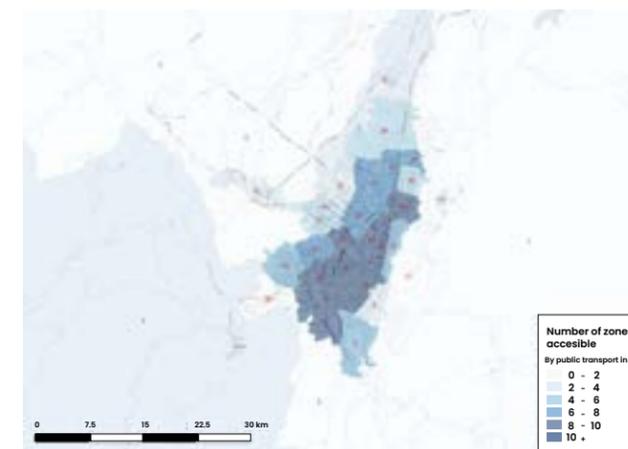


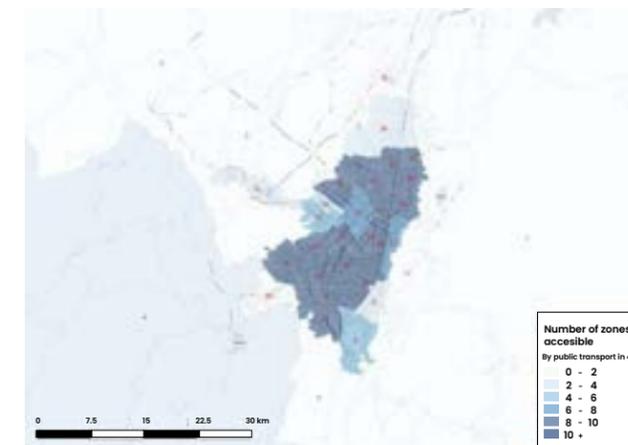
Figure 49 shows the same indicator for 2050 under the Current Policy scenario assumptions. The accessibility clearly increases, especially for zones in the southern part of the city which benefit from the new metro line. Eleven zones in total can reach ten or more zones in 45 minutes, with the maximum number being 17 zones.

Figure 49. Accessibility by public transport in 2050 – Current Policies scenario



In the Positive scenario, accessibility increases even further. As evident from Figure 50, almost the entire Bogotá D.C. can reach more than ten zones in 45 minutes by public transport (17 out of 25 zones). The surrounding zones covering the Cundinamarca department do not see almost any improvement under this indicator, as travel times from these zones tend to be longer and benefit less from the new infrastructure in the city.

Figure 50. Accessibility by public transport in 2050 – Positive scenario

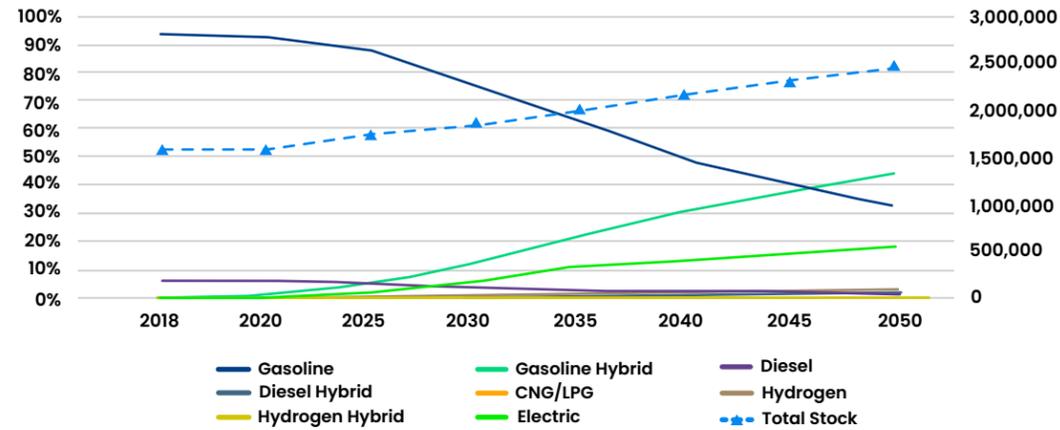


### Vehicle fleet composition and impact on emissions

**Vehicle fleet compositions are vastly different between the two scenarios.** The Current Policies scenario follows private car sales of the IEA's New Policy Scenario, which projects that about 20% of new vehicles sold in Colombia in 2050 will be electric. Figure 51 has the fleet composition following these assumptions. By 2050, the majority of vehicles circulating on the streets of Bogotá are low- or zero-emission vehicles. Gasoline-hybrids represent the biggest share of those, having surpassed conventional gasoline ICE vehicles only a few years before. Total private car stock continues to grow throughout the

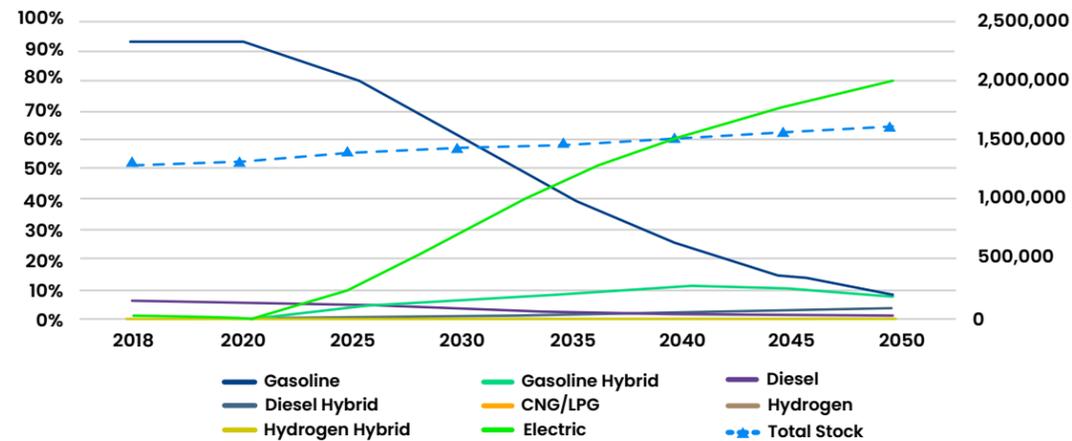
study period, reaching 2.5 million vehicles by 2050. It should be pointed out that in this analysis new vehicles enter the market to cover projected demand. Therefore, as teleworking and other policies limit car activity, fewer vehicles are required to cover that demand. In reality the evolution of vehicle fleet also depends on various other factors and decisions made often on an individual level.

**Figure 51. Car fleet composition by fuel type - Current Policies scenario**



**Electrification picks up much faster in the Positive scenario** (Figure 52). By 2050, almost all new vehicles sold are electric, and gasoline ICE vehicles are becoming outdated. In that timeframe, almost 80% of the fleet is electric, which is the main reason behind the much lower CO<sub>2</sub> emissions achieved in this scenario. Given trends of teleworking, shorter trips, and increased public transport availability, the total private vehicle stock is not assumed to grow significantly. It increases only slightly throughout the study period.

**Figure 52. Car fleet composition by fuel type - Positive scenario**



Vehicle fleet composition is the main driver behind total CO<sub>2</sub> emissions estimates. Nonetheless, also other measures assumed in the scenarios have an effect on CO<sub>2</sub> emissions. Car CO<sub>2</sub> emissions in the Positive scenario are 18% of the Current Policies scenario. By applying the car CO<sub>2</sub> emission factors of the Current Policies scenario to the Positive scenario, we can assess the CO<sub>2</sub> impact of the other policies in car travel. Doing this analysis shows that the set of the additional and/or more stringent policy measures applied in the Positive scenario result in CO<sub>2</sub> savings of 25% compared to the Current Policies scenario. The remaining difference between the car CO<sub>2</sub> emissions in the two scenarios comes from the vehicle fleet.

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