COMPREHENSIVE SOLUTIONS FOR IMPROVING AIR QUALITY IN THE VALLEY OF MEXICO

Mario Molina Center
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Last February, the Mario Molina Center published a position paper entitled "Improving air quality in the Valley of Mexico is urgent and represents an enormous challenge for society", in which we reflected on the causes, consequences and possible solutions to the serious problems of air pollution and traffic congestion that Mexico City's Metropolitan Area (MCMA) suffers. This document emphasized the urgency of implementing drastic measures in order to solve both problems simultaneously. Some of these methods are unpopular, so it is necessary to communicate to society that implementing them with effectiveness and determination would be clearly beneficial, since otherwise the situation in the region will continue to worsen.

Our proposal for solving the problem

The Mario Molina Center has insisted on the need of having a comprehensive package of measures to solve the problem of air quality in MCMA, by confronting all relevant sources of pollution, and by focusing both on short as well as medium and long term actions. It is important to avoid the temptation of looking for single or magical solutions because for this issue they clearly don't exist.

The Federal Government and state authorities that make up the Environmental Commission of the Megalopolis (CAMe, acronym in Spanish), who launched a series of rapid effect measures, have stated that the current plan has an expiration date, and that it should be followed by implementing a comprehensive program with long-term actions.

From our standpoint, such a program must contain at least the following four elements i) a set of actions to reduce emissions, prioritized according to their potential, cost and time for implementation; ii) measures to strengthen the capacity to measure and predict pollutants; iii) rules and robust processes for attending contingencies, and iv) a proposal to strengthen institutional and communication capabilities.

The array of actions to reduce emissions must include the following priority strategic lines:
1) Accelerate the development of low emission, high quality public transportation systems which are integrated at metropolitan scale.

2) Promote the rational use of cars and clean transportation technologies.

3) Drastically reduce emissions in the freight sector.

4) Update regulations on vehicle inspection and ensure compliance.

5) Reduce pollutant emissions deriving from industrial activities and fuel distribution, as well as prevent and control fires.

6) Contain the spread of the urban sprawl to reduce mobility demand.

The following section provides more details on the specific actions contained in each strategic line and challenges for its implementation. Some of these proposals are still being developed and are part of the Mario Molina Center’s current research agenda.

1) **Accelerate the development of low emission, high quality public transportation systems which are integrated at metropolitan scale**

Despite investments in public transportation made in recent years by the governments of Mexico City, the State of Mexico and the Federation, the offer for users remains not only insufficient but highly deficient from a quality and safety point of view. This explains, in large part, the intensive use of cars in the Valley of Mexico.

Public transportation currently serves about 70% of commutes carried out in Mexico City’s Metropolitan Area. From a social as well as an environmental perspective, investments and strengthening public transportation management is a high priority pending matter, even under the understanding that covering the current backlog, as well as future demand, will require substantial investments.

MCMA currently has 12 subway lines (226 km), six Metrobus (confined vehicle) lines (125 km), three Mexibus lines (57 km), a suburban train (20 km) and a light rail (25 km). Moreover, it has 93 organized public transportation routes (RTP) administered by the Government of Mexico City.

Despite having this network and available public transportation infrastructure, approximately 60% of commutes made by public transportation in MCMA are served by concession transportation operated by private parties\(^1\). This includes about 35,000 microbuses, which on average have more than 20 years of age, and

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\(^1\) It refers to routes and buses, micribuses and vans' branch lines that have a public transportation concession in MCMA.
are highly polluting, besides being dangerous from a road safety point of view. It also includes vans, which have had a very rapid growth trend in the number of units; currently there are about 80 thousand in operation, which is four times more than those that existed just in 2004. These vehicles are inefficient regarding emissions, transfer capacity and operations.

Overall, the concession scheme that proliferated in the 90's created perverse incentives, privileging the model of "man-bus", which results in certain corridors simultaneously coexisting with dozens of operator associations. This creates fierce competition, resulting in an excess of underutilized units in certain corridors and schedules, as well as constant violations of road regulations. All this creates inefficiency from an environmental, economic or social perspective.

In any case, the metropolitan area of the State of Mexico presents an even greater backlog: currently 80% of the structured public transportation offer in MCMA is located in Mexico City, home to 45% of the population; in contrast, in neighboring municipalities in the State of Mexico, which account for the remaining 55% of the metropolitan area’s inhabitants, there is only 20% of the total supply of this type of transportation.

It is possible to identify a correlation between the increase in car ownership rate per capita and the absence of structured public transportation for the different areas in MCMA. It is in the peripheral districts and municipalities where this case most often manifests. For example, the Cuajimalpa District in Mexico City stands out as well as the municipalities of Tlalnepantla, Naucalpan and Atizapan in the State of Mexico. On the other hand, given the socioeconomic distribution and limited purchasing power of some population groups, a very important part of the growth in motorization occurs by the purchase of used vehicles imported from other places with an average age above 15 years, which makes the problem of increased motorization even more serious from the environmental perspective.

To cover the lag in public transportation infrastructure, according to the analysis by the Mario Molina Center, sustaining during the next ten years an annual expansion of mass transportation systems of at least 40 km per year will be required, while guaranteeing the integration between Mexico City’s and the State of Mexico’s systems, which are now independent of each other, including a single mode of payment. It will also be necessary to articulate networks that integrate transfer stations, services, operation, tariff schemes and user information systems, and encourage their use among the population. Also, the areas around the new stations must be designed with an urban development perspective which is transit-oriented, thus ensuring minimum population densities and mixed land uses. In planning these improvements, priority should be given to increasing coverage to neighboring municipalities in the Valley of Mexico.

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2 By structured public transportation we understand any system with high passenger mobilization capacity, covering great distances in a short time, and that ensures its quality with attributes such as speed, safety, reliability and comfort. Examples would be the suburban train, subway, light rail, Metrobus and Mexibus.
Coupled with this, projects that have already been announced by various authorities must be immediately started, such as the Suburban Train from Cuautitlan to Huehuetoca (21 km); extending 32 km to the subway network, with extensions to the A line from La Paz to Chalco (14 km), line 4 Martin Carrera to Ecatepec de Morelos (12 km), line 9 Tacubaya to Observatorio (2 km), and line 12 Mixcoac to Observatorio (4 km); this, plus eight Metrobus lines with a total of 160 km, and five lines of Mexibus totaling 100 km.

A high impact metropolitan coordination project that could take place to better articulate Mexico City’s and the State of Mexico’s transportation systems, is integrating the new Mexibus line from Tecamac-Indios Verdes with Metrobus’ line 1 from Indios Verdes-El Caminero, which would allow buses from both systems to share the corridor’s segments and would prevent passengers from having to change trains at Indios Verdes.

As for concession transportation, it will be necessary to identify priority corridors where the individual public transportation concession scheme is eliminated giving way to business-operation corridors for the fleet, where new information technologies are taken advantage of, as well as monitoring and managing services, incorporating low-emission vehicles with professional operators.

In corridors with high volume of users, Metrobus or Mexibus lines may be convened as those already mentioned, while those with lower demand, a replacement and retirement program could be implemented for highly polluting units, alongside with a scrappage program. Some examples of concession transportation corridors worth analyzing are: Chimalhuacan to Pantitlán using Bordo de Xochiaca; Cuautitlan Izcalli to Toreo using the Mexico-Queretaro highway; Canal de Chalco to Tacubaya using Periferico, and Escuela Medico Naval to CTM El Risco using Eje 1 Oriente. The estimated cost for replacing all units circulating in the Valley of Mexico, after making the system more efficient, would be around 20 billion pesos. This cost may seem high, but only a fraction should be given to a sunk fund, or through soft loans, in exchange for the promise of a concession change and structuring profitable companies. To finance the replacement scheme, a trust could be constituted for the metropolitan area or even for the whole Megalopolis, aided by the federal government and the state governments that comprise it.

2) Promote rational use of cars and clean transportation technologies

Mexico City’s Metropolitan Area’s dominant mobility model in recent decades has privileged and subsidized private transportation. One of its clearest manifestations is the disparity in investment between road infrastructure (roads for motor vehicles) and public transportation, as well as the imbalance between the total space allocated to cars versus the one dedicated to public transportation, pedestrian areas or lanes dedicated to bicycles. The existence of this mobility model, coupled with the absence of an urban planning policy, has triggered congestion levels that affect the city’s productivity and
competitiveness and cause a very high impact on the quality of life of its inhabitants.

Nowadays, the Valley of Mexico has a fleet exceeding 5 million vehicles, in addition to about 300,000 trucks and buses with federal plates, which largely explains the congestion suffered in the city, and has persistently worsened, increasing pollution and affecting the region’s productivity. The comparison between the origin and destination surveys for 1994 and 2007 indicate an increase of 25% in time for short commutes, and 12% for long trips between those years. Moreover, some road congestion studies worldwide indicate that MCMA is, in the world, the city with the greatest relative increase (over 50%) in the time required for an average trip when there is traffic congestion compared to when there is none.³

Private transportation is the largest contributing source to nitrogen oxides emissions, and also represents a very important fraction of total emissions for volatile organic compounds. On the other hand, motorcycles, whose use is growing at a rate up to 35% above car use, represent a very important source of these compounds within the transportation sector.

From an environmental perspective, to the motorization increase we must add the fact that the compliance of regulations is almost null with regards to vehicle inspection, and that the average age of the fleet is over 12 years. This is a determining factor for pollutant emissions, although we must recognize that even with its advanced age, the Valley of Mexico’s fleet is not the oldest in the country. This is due, at least in part to the implementation of a set of policies, among which the Hoy No Circula (day without circulation) program stands out, in the terms applied until last month, as it made a distinction in the prerogatives to circulate, depending on the type of hologram. Since the vehicle age was associated to the hologram, renewal of the vehicle fleet was encouraged.

Changing MCMA’s mobility pattern will require designing and implementing policies to restrict the use of private transportation, including eliminating the implicit subsidy with which it has been favored. For example, a fuel price that reflects the environmental and health impacts generated by its use should be established; rates that discourage car use; limits to parking spaces; congestion charges, and a tax or tenure charge associated with the value, dimensions and vehicle emissions should also be adopted.

There are countless cases in the world where models such as these have been implemented. In Tokyo and Singapore, for example, the selling price of a car reflects the actual cost it has for society, and reaches more than twice its market value; in New York, the cost of parking is so high that it discourages everyday use of the vehicle; in London or Milan successful congestion policies are applied which decrease mobility in central areas of the city; in Germany they have implemented Low Emission Zones (LEZ), which aims at reducing emissions from mobile sources in areas with high population density, high vehicular congestion

³ Data from TomTom Traffic Index, 2016.
and poor air quality; in Santiago de Chile, they implemented an environmental tax on automobiles, calculated on the basis of their emissions and their carbon footprint, and in most European countries the fuel tax is such that it discourages intensive vehicle use and favors other transportation means.

MCMA could implement one or more of these actions in parallel, knowing that the population, although very critical of some restrictive measures such as the Hoy No Circula program, haven’t been that much against the implementation of economic instruments such as charging for the use of second-level roads or vehicle inspection payment. In any case, it is important to inform the public of the benefits of such policies to reduce congestion and improve air quality. Besides this, it is highly recommended to destine resources obtained by these instruments towards investments in public transportation. Thus, a policy of this nature not only makes environmentally sense but also socially, as it has been demonstrated in various cities around the world.

In addition to these instruments, the Federal Government and the governments of Mexico City and the State of Mexico, could grant tax benefits to companies that are organized to provide shared transportation to their employees. The authorities should even set an example by doing the same. Likewise Mexico City's School Transportation Program (PROTE) should be updated, and its implementation expanded to the neighboring municipalities in the State of Mexico.

Along with discouraging the use of cars and promoting replacing public transportation, it is also important to promote a shift towards more efficient low emission transportation technologies. In this regard, several specific measures are identified below to encourage the penetration of low-emission and more efficient vehicle technologies in MCMA:

a) Increase incentives for the purchase of electric and hybrid vehicles.

b) Implement a program for changing catalytic converters, first of all in automobiles destined to public passenger service, but also potentially private cars.

c) Implement a program to install particulate traps on buses that do not have emission control systems, which makes a lot of sense given the limited availability of ultra-low sulfur diesel (ULSD).

The expected impact of these measures is a significant reduction in emissions of nitrogen oxides, sulfur oxides, volatile organic compounds, PM2.5 particulate matter and carbon monoxide.

3) Drastically reduce emissions in the freight sector

In Mexico, the freight sector is a cornerstone of economic and social development, as it helps connect the national territory and link us abroad. Its
proper functioning allows opening new markets, integrating regions and promoting international trade. However, it is also one of the main sources of emissions of ozone precursors and the most important source of PM$_{2.5}$ particulate emissions.

Currently, the average age of the freight fleet is about 17 years. This implies that the vast majority of vehicles in circulation have obsolete technologies, or lack technologies to control emissions. Furthermore, trucks, cargo trucks and buses with diesel engines, being utility vehicles of intensive use, are almost always operated on a commercial basis to full capacity, and are often overloaded intentionally in order to increase their profitability. There is also a widespread practice of retrofitting these units to prolong their lifespan.

Unfortunately, the regulatory framework on emissions and safety applicable to new and circulating freight vehicles is lagging compared to technological advances. While we understand that establishing an advanced regulation in this regard is not trivial, given the sector's structural lag in technology, fuel and emissions control, we are convinced that it is possible and it would offer significant advantages both to improve air quality and congestion.

On the other hand, for many years PEMEX failed to comply with the production schedule and supply of ULSD established by NOM-086 standard, from 2005, which in turn led to the downgrading of NOM-044, which sets limits on pollutants for new freight vehicles. This has served as an argument for the industry to delay the penetration of technological packages EPA07-EuroV and EPA10-EuroVI, since new pollution and emissions of greenhouse gases control technologies require ULSD, and this was only available from 2008, and only in the northern border and in major metropolitan areas of the country (Mexico City, Guadalajara, Monterrey).

Regarding ULSD supply, in 2015 the regulation on the quality of oil NOM-EM-CRE-2015 was published, in which the creation of corridors with availability of this fuel was set in the main cargo and passenger routes in the national territory. This measure will help the early introduction of vehicles with new technologies including particulate and urea filters; once this is widespread, it will be possible to reduce up to 99% the emissions of particulates and nitrogen oxides from freight trucks.

Coupled with the delay in updating emission standards, currently Mexico doesn't have a reliable inspection and maintenance program that identifies highly polluting units, nor a rigorous program of physical mechanical inspection, to establish and ensure minimum safety criteria which circulating cargo units must have.

All of the above has prevented designing and applying incentives for renewing Mexico's freight vehicle fleet, and has led to the import of used trucks and spare parts, mainly from the United States. This has caused an oversupply of units, lower tax revenues, black market for spare parts, more accidents, and especially a further deterioration of the environment.
In 2004, in an attempt to encourage the replacement of old units, the Ministry of Communications and Transportation initiated a scrappage program for freight vehicles; however, so far, the program has not significantly promoted their renewal.

We must add to the freight vehicle fleet obsolescence the fact that in the Valley of Mexico, up to the implementation of the response program derived from the environmental contingency, there were no time restrictions for circulating or to load and unload goods. In addition, although certain corridors that freight vehicles have no access to were defined according to their characteristics, dimensions and weights, the applicable guidelines have not been respected, which has significantly aggravated congestion in the Valley of Mexico.

Because of the importance of the sector, it is essential to approach it with a comprehensive outlook that promotes reducing its environmental and energy impacts, and include the following:

a) Update regulations, programs and measures to support freight systems integration and develop standards for monitoring and verifying emissions of particulates and nitrogen oxides from vehicles with diesel engine, particularly NOM-044, and expand the parameters and procedures specified in NOM-045.

b) Ensure the strategic supply of ULSD in priority corridors. The proposed corridors are Mexico - Guadalajara - Tijuana; Mexico - Monterrey - Laredo; Mexico - Chihuahua and Mexico - Villahermosa - Merida - Cancun.

c) Establish inspection and maintenance processes and efficient physical-mechanical inspection. In particular, we recommend starting research and development mechanisms to implement the dynamic test, a measurement for particulate and nitrogen oxides, in addition to the testing procedure based on the on-board system diagnostic (OBD-II type), which is a technology that must be established in NOM-044, to avoid regulatory lag in our country with regards to Europe and the United States.

d) Conduct inspection and maintenance processes for circulating vehicle emissions by installing remote sensors in streets, particularly in loading and unloading areas of goods such as the Central de Abastos (Central Supply Market) as well as weights and dimensions stations from the Ministry of Communications and Transportation, among others.

e) Establish schedules and routes for entry and circulation of freight transportation in MCMA.

f) Implement an incentive scheme to strengthen the scrappage program for obsolete freight vehicles, and prevent the importation of used vehicles and parts that do not have technology to reduce emissions.
\textbf{g)} Limit entrance into the city of freight vehicles that are passing by.

\textbf{4) Update regulations on vehicle inspection and ensure compliance}

The vehicle inspection in MCMA is not working, because the system is overrun by unacceptable corruption practices. This explains, to a large extent, why we see a substantial increase in the number of vehicles circulating on a daily basis, which in many cases also generate high levels of emissions, since they gained access to a number 0 hologram (which allows cars to circulate daily) taking advantage of corrupt practices and obvious inspection and maintenance system failures. According to analysis by the Mario Molina Center, about 15\% of vehicles with hologram 00, 45\% of those with 0 hologram and 80\% with hologram 2 exceed the limits allowed by current regulations and, even more worrying, more than 10\% of vehicles with 0 hologram exceed the allowable limits by more than 20 times. This, which in itself is serious, is even more so if we consider that those limits are lax and must be updated.

The Federal Government announced that it is close to publishing an emerging regulation to address this problem. This regulation, although will help alleviate the situation, certainly will not completely solve the problem. The mandatory introduction of the OBD-II system, which can diagnose the operation of several central equipment for a car’s proper performance, and used in California, is desirable because it complements emission data thrown by the dynamometer used in the inspection and maintenance centers known as "verificentros". The OBD-II, used in conjunction with the dynamometer will reveal simultaneously the operation of the equipment and its emission level, and may even serve to generate information to adjust and continuously improve the systems for measuring emissions.

However, there are some elements of caution that the government should take into consideration, among them the following:

a) Only a small fraction of total cars on the road, models 2006 and older, have OBD-II readers.

b) The OBD-II system, like any other computer on board, can be manipulated. To demonstrate this we refer to the widely known case of diesel vehicles in the United States.

c) A significant fraction of vehicles from models 2006 and newer, which according to the regulations should have OBD-II connectors, do not have them factory-installed, in a clear case of failure of the auto industry.

d) The emergency standard should be enforced only for vehicles with OBD-II and EOBD on-board diagnostic, without accepting any "similar" technology, as this can lead to exceptions to vehicles that although new, have obsolete technologies and poor environmental performance.
e) In addition to regulations for including OBD-II as part of the inspection and maintenance process, tightening emission limits for various criteria pollutants used for the allocation of holograms will be needed, bringing incentives to innovation and the introduction of low-emission technologies.

Currently, the Mario Molina Center carries out a study to identify and propose improvements for inspection and maintenance systems, and to identify strategies to combat corruption. The truth is that, beyond the specific recommendations we make, we need to evaluate the desirability of maintaining the vehicle inspection in the terms in which it currently applies. It is necessary to even ask ourselves if we should gradually migrate to a model in which the citizens are responsible for ensuring the level of emission of their vehicle, through ongoing maintenance, and in which, through the use of remote sensing systems in streets, the authority can identify vehicles that are not complying with regulations, and punish or remove from circulation those who are visibly polluting.

5) Reduce pollutant emissions deriving from industrial activities and fuel distribution, as well as prevent and control fires

According to the Mexico City Metropolitan Area Emissions Inventory, in 2012 industrial sources, primarily the chemical industry, contributed to a third of volatile organic compounds, and more than three quarters of sulfur oxides emitted into the atmosphere.

While it is true that in recent decades the change of land use in some parts of MCMA, and particularly in Mexico City, has resulted in the relocation of various industries, we also observed that there are still districts and municipalities in which industrial emissions are one of the most important sources of pollutants.

Furthermore, in Mexico, there is a legal and regulatory backlog of more than 20 years in regards to the limits of permissible emissions for various pollutants related to industrial sources, both at federal and local jurisdiction, including volatile organic compounds, nitrogen oxides and PM$_{2.5}$.

In this context, we propose reviewing sanctions and means of inspection and maintenance of emission limits, and updating the criteria for closure or relocation of emission sources. Furthermore, implementing a program to update the maximum permissible limits for stationary sources, using a multi-pollutant approach is also proposed.

In particular, the revised NOM-043-2003 update must be published immediately, so that it not only includes limits for total suspended particles, but also for emissions of fine particles. In addition, regarding volatile organic compounds, a rule that limits emissions must be established. It’s important to mention that the proposal of these two regulations has been considered by the
Ministry of Environment and Natural Resources (SEMARNAT) since 2008, and there are already some technical proposals, so its publication in the short term would be very feasible.

It will also be necessary to review both environmental and land management legal frameworks, and analyze, based on the impact on health of people and ecosystems, whether to close or relocate some industrial sources affecting areas of high population density, such as those located in the districts of Azcapotzalco and Gustavo A. Madero and in the municipalities of Tultitlan, Tlalnepantla de Baz, Ecatepec, Cuautitlan, Naucalpan and Tula, Hidalgo.

We know that currently the Federal Attorney for Environmental Protection (PROFEPA) along with Mexico City and the State of Mexico’s environmental general attorneys lack sufficient instruments to verify and enforce air quality standards. Similarly, sanctions, means of inspection and maintenance and specifications of various standards are inadequate in many cases. In view of this, we propose the implementation of emerging programs for environmental audits, focused on reducing emissions of volatile organic compounds, nitrogen oxides and suspended fine particles. Because of its importance and emissions level, the following industrial sources of federal jurisdiction should be prioritized: petroleum and petrochemical, chemical, cement, and automotive. Regarding the sources of local jurisdiction, industries that highlight include food, paint application for cars and furniture, and small print shops.

Another major source of emissions of volatile organic compounds is the one linked to leakage of liquefied petroleum gas (LP gas) in homes and businesses, as well as distribution systems; in addition there are no existing programs that ensure their control. The Security on Energy and Environment Agency (ASEA) is responsible for regulating emissions along the entire fuel chain, including distribution. It is important that a program in coordination with local authorities is implemented shortly to control emissions of LP gas and natural gas, which has been gradually reaching greater household penetration in MCMA.

Evaporative emissions from diesel and gasoline service stations also have an enormous relevance. Currently, there is a loophole with regards to regulations governing such emissions in MCMA. Gas volatile compounds significantly contribute as ozone precursors, due to their high reactivity, and are also toxic just as themselves. This makes publishing the ASEA-01 and ASEA-04 regulations essential. Once published, establishing coordination agreements between ASEA and local authorities will be necessary, so that compliance with these standards is met.

An important finding derived from scientific studies in MCMA in recent years is that the contribution of emissions from forest fires, burning agricultural waste and municipal waste in dumpsites and landfills is significant. It is therefore necessary to strengthen the implementation of programs for preventing and controlling fires, particularly in open dumpsites as well as preventing forest fires. A clear example of the contribution of such sources was observed during
the months of February, March and April, when the number of fires increased significantly in and around MCMA.

6) Containing the spread of the urban sprawl to reduce mobility demand

In Mexico, the pattern of urban growth in recent decades is characterized by the proliferation of dispersed, distant and disconnected cities. This pattern has been influenced by the lack of adequate planning tools that integrate land use, transportation and housing policies, which in turn allow transitioning towards a model of compact, connected and continuous cities.

In MCMA, nowadays three quarters of houses are more than five kilometers from main economic activity centers. An unbalanced city, in terms of employment and housing, as it increases commuting time to working areas -as well as costs associated with transportation, thereby deteriorating the quality of life of its population.

Another key to reducing demand for mobility is the proximity of housing to public transportation areas. On average, about 30% of homes in MCMA is close to structured public transportation; this percentage increases to over 40% if considering only Mexico City (formerly the Federal District) and decreases to less than 15% if the State of Mexico’s metropolitan area.

Along with the proximity to employment, access to structured transportation can reduce car use. Some analyses from the Mario Molina Center suggest that people living near structured transportation tends to make more trips using such means, and are willing to stop using their car. This has a direct impact on the mileage, travel time, fuel consumption and thus pollutant emissions.

Good urban settings can influence not only the way in which land is used, but the quality of the spaces generated. The criteria commonly used to describe the degree of sustainability of urban architecture are housing density, block size, the mixture of land uses, the proportion of public spaces and green areas per inhabitant, and urban design, among others.

MCMA continues to expand at higher rates than the population growth, mainly in the neighboring municipalities. The density determines how the land required for housing is used. It can also help promote the quality of urban environment, for example by increasing the intensity of life on the streets, and increases the profitability of structured public transport systems. As cities continue to attract residents, the increase in density will be one of the best options to control urban sprawl. However, to achieve the composition of a good urban design, a balance between the mixtures of land uses, access to public spaces and green areas is required.

Currently, a major fraction of homes in MCMA are in areas with large blocks or neighborhoods, which do not encourage walking because they limit the number
of intersections. An adequate scale can help foster the use of different transportation means other than cars, replacing them, for example, with walking or bicycles.

Some recommendations in the field of urban planning include the development of a Land Management Program at a megalopolitan scale, and updating Mexico City’s General Urban Development Program, integrating urban and environmental planning in one instrument. These programs must take an approach that encourages a compact city, the mix of land uses, and the consolidation of multi-centers, which thus help with decentralizing activities and trips.

There are some land management instruments which contribute to achieving the above objectives, such as property taxes based on land and a progressive tax rate that discourages underutilization of land and stops speculation; land banks to exchange suburban for urban land; the definition of minimum density neighborhoods, and reducing parking space in new buildings, among others. In addition, the criteria for targeted subsidies for social housing provided by federal institutions should also be revised, like the Green Mortgage from INFONAVIT, or the perimeters of urban containment posed by CONAVI to provide affordable housing within the city.

Currently the Mario Molina Center analyzes land management instruments, and the use of new information technologies and open data to enhance the effectiveness of the solutions to environmental and mobility problems, as conceptually should occur in a smart city.4

Conclusion

This document is the result of various analyses conducted over several years within the Mario Molina Center, for which we have had the support of experts and stakeholders from numerous fields. All our proposals are based on our experience in the field and on existing scientific and technical knowledge, which although abundant and often blunt, is still perfectible, so it will be essential to keep developing it.

We insist that, given its complexity, there are no single solutions to the problem of air quality in MCMA, so it is essential to jointly implement all relevant measures and take advantage of synergies between them. The problem is not getting solved, and could even worsen, if all causes are not tackled in parallel, but we also understand that the levels of complexity vary among the measures to be applied, and therefore they require varying times to mature. In any case, it is urgent to start working on all fronts, and even on long term actions.

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4 A smart city, takes full advantage of information generation for efficient decision making, both in the economic, operational, social and environmental sphere.
A key ingredient to the successful implementation of these measures is the participation of different sectors and government levels, coordinated through effective mechanisms with a regional perspective.

We believe that the implementation of the measures proposed here makes sense not only from an environmental and public health perspective, but also because it would help MCMA become more competitive and equitable. The actions addressed here may produce multiple benefits, and even contribute to reducing emissions of greenhouse gases, and thus combat global climate change.

We hope that our ideas and proposals contribute to the debate and to the integration of an action program led by the relevant authorities, including the private sector, academia, the media, non-governmental organizations, and society as a whole.