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MEXICO

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Preface

One of the most compelling reasons for pursuing low-carbon development is that the potential impacts of climate change are predicted to be severe, for both industrial and developing countries, and that reducing greenhouse gas emissions can reduce the risk of the most catastrophic impacts. The challenge of reducing emissions is sobering: leading scientific models indicate that limiting the rise in global mean temperatures to less than 2°C will require that global greenhouse gas emissions peak within the next 10–15 years and then fall by 2050 to levels about 50 percent lower than in 1990. Although many countries recognize the need to curtail carbon emissions, there is considerable uncertainty about how much this will cost in individual countries, what measures can be undertaken in both the short and longer term, and how cost-effective specific interventions are in reducing emissions.

"Low carbon" is quickly entering the lexicon of development, adding an important climatic dimension to the concept of economic sustainability. *Low-Carbon Development for Mexico* provides an economywide analysis of low-carbon options for mitigating greenhouse gas emissions in Latin America's largest fossil fuel–consuming country. The study is the first of several low-carbon studies to be produced by the World Bank in key developing and middle-income countries.

Mexico was a logical choice for a low-carbon study for several reasons. At the international level, it has demonstrated strong commitment to global actions to reduce greenhouse gas emissions, as reflected in its proactive stance in global climate discussions and the aggressive emission reduction target it announced at the United Nations Climate Change Conference in Poznan in 2008. At home, Mexico recently published the *Programa Especial de Cambio Climático* (PECC), which sets out a broad program to address the impacts of climate change in Mexico and to reduce greenhouse gas emissions across all sectors.

This volume, intended to complement the PECC and other Mexican studies, presents the results of a two-year effort by a team of Mexican and international researchers to identify and evaluate high-priority measures for reducing greenhouse gas emissions. The study makes use of two important tools for undertaking low-carbon assessments. The first is an economic methodology for estimating the costs of interventions across sectors. This methodology allows, for example, the costs of reducing emissions from introducing more efficient residential refrigerators to be compared with those achieved through afforestation or reforestation programs. A second tool is an integrated economic and emissions model that keeps track of annual emissions as well as needed investment costs over the coming two decades.

The need to reduce emissions associated with energy production and consumption—including from transport and power generation—is often at the heart of discussions about low-carbon development. The fastest emissions growth in Mexico over the past three decades has occurred because of rising energy consumption in the road transportation sector, and the growth in private automobiles and light trucks is expected to continue to fuel this growth in the future. This study presents new research on low-carbon interventions in the transport sector, including measures to improve the efficiency of both new and used vehicles as well as measures to improve urban transportation. Because a large percentage of transportation energy use occurs in Mexico's cities, there is significant potential for lowering greenhouse gas emissions by modifying the spatial organization of cities and improving the availability of public transportation infrastructure. Although major changes in urban design will take time to develop, other measures—such as investing in BRT-type systems, strengthening public transportation, and reorganizing freight transport systems—can be implemented in the near term.

This study analyzes a range of energy efficiency options available in Mexico, including supply-side efficiency improvements in the electric power and oil and gas industries, and demand-side electricity efficiency measures addressing high-growth energy-consuming activities, such as air conditioning and refrigeration. It also evaluates a range of renewable energy options that make use of the country's vast wind, solar, biomass, hydro, and geothermal resources.

But low-carbon development is not only about energy production and consumption. In Mexico one of the most important sources of greenhouse gas emissions continues to be deforestation. The rate of deforestation has fallen steadily in Mexico over the past decades. Expanded programs for forest management, wildlife management, and efforts to increase the stock of forests can provide needed employment in rural areas and help make Mexican forests net absorbers of CO_2 in the coming years.

A fundamental question often asked about low-cost mitigation options is why they are not already being undertaken. As the study shows, the availability of commercial technology and even low financial costs is often not enough to overcome barriers related to institutional and knowledge gaps, regulatory and legal constraints, or societal norms. Inability to surmount these "transactions costs" is typically at the root of the problem of why supposedly low-cost actions are not undertaken. To partially overcome this dilemma, one of the explicit criteria used in this study for identifying low-carbon measures was that they had already been implemented on some scale in Mexico or in a similar economy outside of Mexico. In order to mainstream low-carbon development, a package of new stimuli will be needed, including public and consumer education and training, public demonstrations, standards and regulations, and financial incentives.

The next few years will be critical for enacting a serious international climate mitigation program, beginning with major industrial countries and quickly involving large developing countries. A number of mitigation studies have looked at the longer term, many of them focusing on the promise of new technologies to achieve significant reductions in carbon emissions. Although new technologies will be critical to meeting the longer-term emissions reduction goals needed to avoid the most severe impacts of climate change, many promising low-carbon technologies will not be commercially available for more than a decade, during which time the world will lose valuable degrees of freedom in stabilizing atmospheric concentrations, if short-term options have not been simultaneously and vigorously pursued. One of the explicit objectives of this study was to identify a range of options that could contribute to meaningful emissions reductions over the next two decades and that could begin almost immediately. As new technologies are developed and the costs of current technologies fall, the range of options for low-carbon development will become even broader.

Although this study focuses on Mexico, many of the low-carbon options presented—such as specific energy-efficiency and renewable energy technologies and urban transport or forestry programs—are likely to be applicable to other countries. It is our hope that both the methodologies and the findings presented in this volume will be of use to Mexico and other countries as they seek to define and implement low-carbon development.

Laura Tuck, Director
Sustainable Development Department
Latin America and the Caribbean Region
The World Bank

CHAPTER 5

Transport

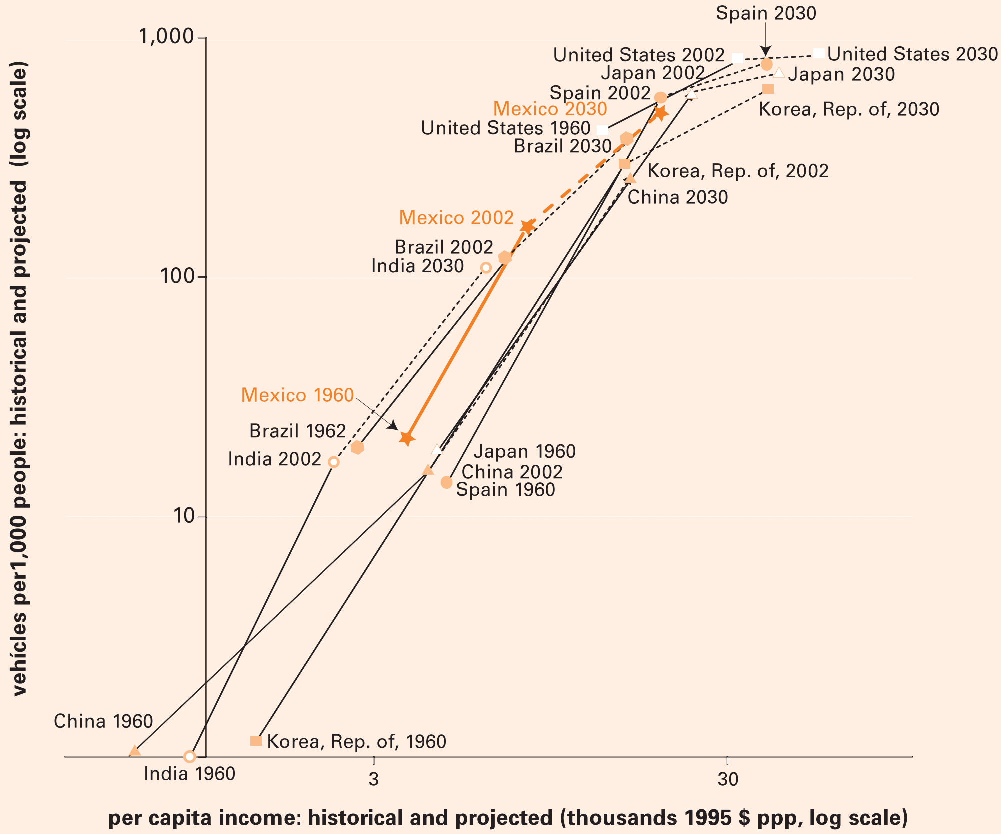
Transport is the largest and fastest-growing sector in Mexico in terms of energy consumption and greenhouse gas emissions. The sector consists of the road, air, rail, and water transport subsectors. It produces about 18 percent of total greenhouse gas emissions in Mexico, with road transport accounting for about 90 percent of energy consumption and CO_2e emissions from the transport sector (SEMARNAT 2007).

Energy use by road transport in Mexico increased more than fourfold between 1973 and 2006, compared with the approximate doubling of energy use by industry and other sectors (IEA 2008a). The country's vehicle fleet nearly tripled in a decade, increasing from 8.3 million vehicles in 1996 to 21.5 million vehicles in 2006.

The import of used vehicles from the United States has been an important factor behind the growth of the vehicle fleet. It has also led to an increase in the average age of the fleet and related problems of low gas mileage and high emissions of criteria pollutants (CO, NO_X, SO_X, and particulates). In 2005 alone, Mexico imported 1.3 million vehicles from the United States that were more than 10 years old (CTS 2009).

Over the next 25 years, Mexico's motorization rate—defined as the number of vehicles per 1,000 people—is projected to continue to increase, following a worldwide trend (figure 5.1). Important factors explaining the increase in motorization in Mexico include the increase in per capita income, the availability of inexpensive vehicles (new and used), and the relatively low cost of transport fuels. Other factors that have contributed to increasing energy use and greenhouse gas emissions from the transport sector are the deteriorating quality of public transportation, the inadequate enforcement of vehicle emission standards, the neglect of transportation needs in urban development plans, and the lack of regulation of freight transport.

Figure 5.1 Motor Vehicle Ownership: Historical Trend and Projected Growth for Selected Countries



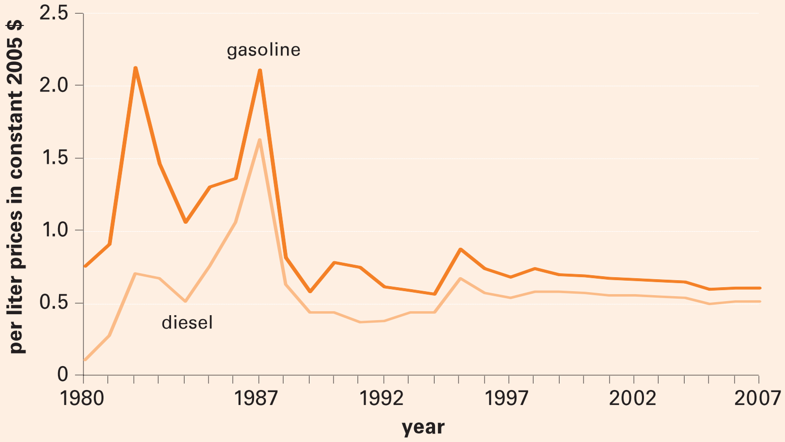
Source: Dargay, Gately, and Sommer 2007.
Note: PPP = purchasing power parity.

One additional factor that contributes to demand for transport fuel is fuel pricing. The prices of the two primary road transport fuels—gasoline and diesel—remained stable or fell over the past 15 years in Mexico (figure 5.2). Fuel prices in Mexico are lower than those of most countries in the Organisation for Economic Co-operation and Development.

The Baseline Scenario

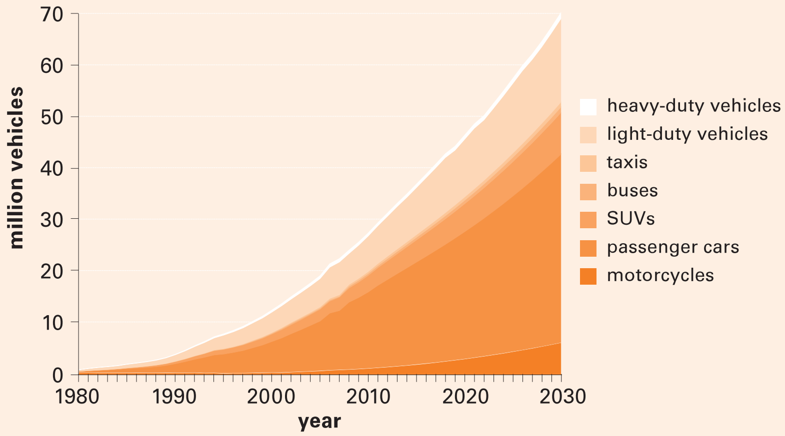
The baseline scenario follows historical trends in Mexico and is consistent with the pattern of motorization growth worldwide. Under this scenario, the national fleet increases from 24 million vehicles in 2008 to a little more than 70 million vehicles in 2030 (figure 5.3). The majority of the increase is for passenger cars, but there is also a large increase in light-duty trucks, buses, and sport utility vehicles (SUVs). Greenhouse gas emissions from the

Figure 5.2 Gasoline and Diesel Fuel Prices in Mexico, 1980–2007



Source: CTS 2009.

Figure 5.3 Transportation Fleet: Historical Trend and Projected Growth under the Baseline Scenario, 1980–2030



Source: Authors.

transport sector increase from 167 Mt CO_2e in 2008 to more than 347 Mt CO_2e in 2030, with 72 percent of the emissions (and energy consumption) generated by private vehicles (passenger cars, SUVs, and light- and heavy-duty vehicles) (figure 5.4). Total emissions rise from 659 Mt CO_2e in 2008 to 1,137 Mt CO_2e in 2030, with transport's share rising from 25 percent to 31 percent (figure 7.1).

Figure 5.4 Baseline CO_2e Emissions by Transport Mode

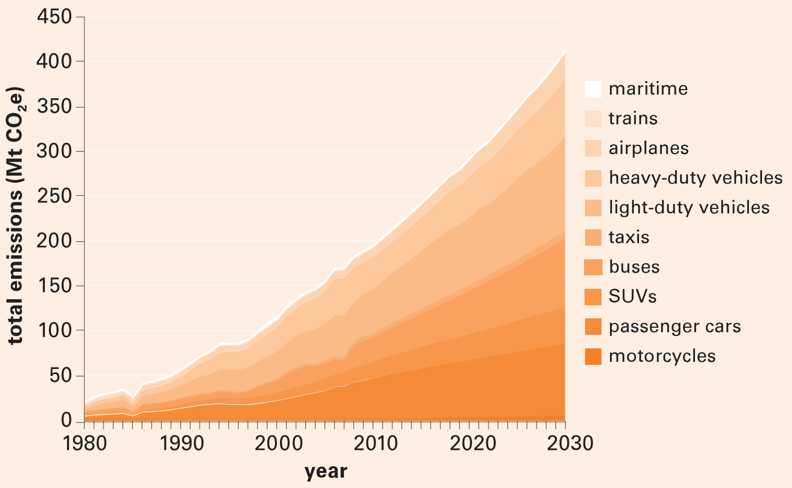


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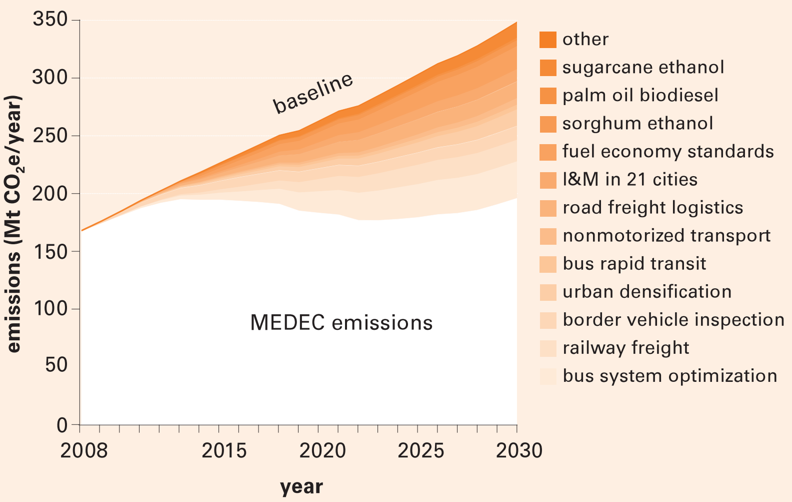
Figure 5.5 MEDEC Emissions Scenario for Transport



Source: Authors.
Note: I&M = inspection and maintenance. Figure includes all interventions that lead to a reduction in transport sector emissions; this includes those addressed in this chapter as well as the biofuel interventions outlined in chapter 6.

The MEDEC Low-Carbon Scenario

The transport analysis used a programmatic approach to evaluate an integrated set of nine low-carbon interventions.[1] The objective was to identify an aggressive scenario that could dramatically reduce Mexico's transport-related greenhouse gas emissions. The priority areas evaluated in the study include urban land-use, fuels and technology, public transit, nonmotorized transport, travel demand management, and freight transport.

Modal Shift and Urban Development

Urban densification. This intervention seeks to promote a policy for the development and preservation of urban centers, using sustainability criteria that offer conditions of livability (access to work, schools, shops). Urban planning that incorporates increased density makes it possible to reduce the demand for motorized transportation while revitalizing urban centers with mixed land use; recovering the urban landscape; and rebuilding communities by providing equal access to goods and services, education, and maintenance of environmental and urban quality. High-density urban planning imposes growth limits on urban zones, directly affecting the use of vehicles (private and public) and fuel consumption. The cost-benefit analysis considers the changes in infrastructure investment and operation costs (lower in the high-density scenario) and in distances traveled (shorter in high-density areas).

Bus rapid transit. BRT refers to the substitution of minibuses in the main axis routes by rapid mass transit systems of the type introduced in several cities in Mexico (León, Mexico City, and Guadalajara). Systems would be introduced in Mexican cities that currently have more than 750,000 inhabitants. The target of the program is to have 1.5 kilometers per 100,000 inhabitants of BRT lanes by 2030, equivalent to 122 lines of BRT systems, with a total of 1,830 kilometers nationwide. The analysis assesses the mitigation resulting from a fraction of passengers switching from other more polluting means of transport (minibuses as well as passenger cars and taxis) to BRT.

Bus system optimization. This intervention involves the restructuring of the mass transit system's feeder routes by removing redundant vehicles. If complemented by improvements in urban infrastructure (roads, bus stops, traffic signs); public information; traffic monitoring; control; and vehicle improvements, this measure represents an important option for mitigating greenhouse gas emissions in urban public transportation, because the growth of the private vehicle fleet (and related issues of urban sprawl and congestion) has been at least in part the result of inefficient transportation systems.

Nonmotorized transport. Nonmotorized transport is a mobility alternative that gives priority to pedestrians and bicyclists, mostly for short trips. It is an efficient, accessible, nonpolluting means of transportation that is beneficial to health and has recreational value. Formal nonmotorized transport systems are typically used as feeder systems to mass transit systems for longer-distance trips; they should be interconnected with the most important trip destinations (schools, work, shopping centers, tourist sites). Under this scenario, the study quantified a 5 percent national modal share for bicycle trips by 2030. The cost and benefit data are based on studies undertaken in cities that have undertaken effective nonmotorized transport infrastructure programs.

Technologies and Demand Management

Border vehicle inspection. Border vehicle inspection would indirectly regulate the efficiency of used imported vehicles by requiring such vehicles to meet minimum environmental standards. Vehicles that exceed the 2 percent CO (volume) threshold—20 percent of imports in 2006—would be restricted from being licensed in Mexico.

Inspection and maintenance in 21 cities. A program of vehicular use restrictions would be implemented through inspection and maintenance in 21 cities. The objective of the program would be to deter the use of private vehicles and allow the promotion of sustainable mass transit. Within Mexico's current legal framework, the implementation of such a program would lie with state or municipal level authorities; it would be politically difficult to enact it at the federal level. This intervention therefore assumes the adoption of a vehicular inspection and maintenance program similar to the program in place in Mexico City as well as vehicle use restrictions for older vehicles in 21 other metropolitan areas, which would cover about 60 percent of Mexico's total vehicle fleet (without including Mexico City).

Fuel economy standards. This intervention would provide a regulatory incentive to promote more efficient technologies for new vehicles. An energy-efficiency standard based on the weighted average of sales, fuel consumption, and the total number of vehicles manufactured for sale in the country was evaluated for its impact on energy consumption and greenhouse gas emissions. Assuming an increase in vehicle prices as a result of the CAFE–style standard,[2] this measure runs the risk of encouraging sales of used cars, which could reduce fuel economy if implemented in isolation. Therefore, standards for new vehicles should be accompanied by mechanisms that discourage the purchase and ownership of inefficient used vehicles, such as the inspection and maintenance and border inspection interventions outlined above.

Freight

Road freight logistics. This intervention aims to optimize freight transportation by coordinating the operation of heavy-duty vehicles. It includes the creation of freight enterprises or cooperatives, specialized terminals, freight transportation corridors, and information systems. Despite higher fixed costs arising from the companies' infrastructure and management, net costs (and emissions) would be lower, because of the reduction in empty trips.

Railway freight. This intervention would expand the use of the railroad sector from 7.6 percent of all national transported freight in 2007 to 37 percent by 2030. The increase in rail transport would come at the expense of truck freight, although road freight transport would continue to grow in absolute terms, driven by economic growth.

Summary

The analysis of urban transport interventions considered the time savings associated with the reduction in congestion as well as the positive health impacts caused by the reduction in local pollutant emissions (box 5.1). Even without considering these co-benefits, all transport interventions show positive overall cost savings (net benefits) for mitigating emissions (table 5.1).

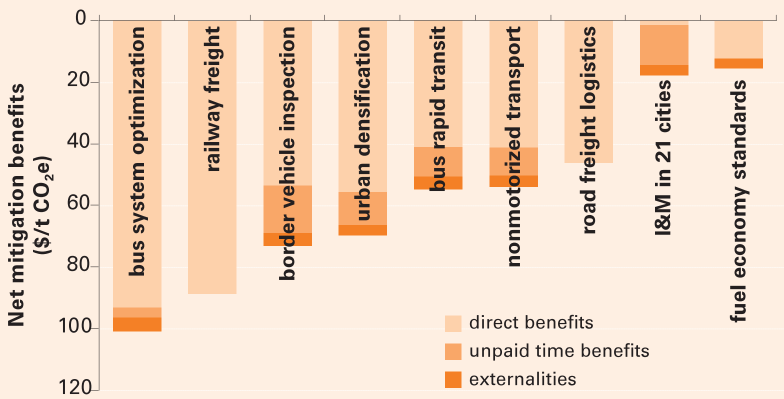
Other interventions in the transport sector were considered and assessed but ultimately not included in the MEDEC scenario, because they did not

Box 5.1 More Time and Better Health: Co-Benefits of Reducing Emissions in the Transport Sector

In addition to reducing emissions, all of the urban transport interventions examined had significant co-benefits. By reducing the distance traveled by the vehicle fleet, the reduction in congestion leads to time savings. The reduction in local pollutant emissions leads to lower health costs by decreasing the rate of respiratory illness.

These time and health impacts were assessed for all seven of the non-freight MEDEC transportation interventions (figure). The analysis estimates the average time savings likely to result from the interventions, conservatively valuing time at the minimum wage. The health analysis used externality cost factors per liter of fuel burned in urban areas, which were derived from a model that considered estimates of the exposure to local pollutants (PM2.5, NO_X, SO_2, and SO_4) by the affected population. The methodology was adapted from a study by the Instituto Nacional de Ecología (INE 2006), which used exposure response relationships between pollution exposure and health impacts, including cardiovascular mortality, pulmonary mortality, infant respiratory mortality, chronic bronchitis, lost work days, and restricted activity days. Together these co-benefits can be significant for some transportation interventions, providing a major rationale for implementation.

Externality and Time Costs for MEDEC Transport Interventions



Source: Authors.
Note: I&M = inspection and maintenance.

Table 5.1 Summary of MEDEC Interventions in the Transport Sector

Intervention	Maximum annual emissions reduction (Mt CO_2e/year)	Net cost or benefit of mitigation (\$/t CO_2e)
Modal shift and urban development		
Bus system optimization	31.5	96.6 (benefit)
Urban densification	14.3	66.4 (benefit)
Bus rapid transit	4.2	50.5 (benefit)
Nonmotorized transport	5.8	50.2 (benefit)
Technologies and demand management		
Border vehicle inspection	11.2	69.0 (benefit)
I&M in 21 cities	10.6	14.5 (benefit)
Fuel economy standards	20.1	12.3 (benefit)
Freight		
Road freight logistics	13.8	46.3 (benefit)
Railway freight	19.2	88.7 (benefit)

Source: Authors.
Note: I&M = inspection and maintenance.

meet the MEDEC criteria, because data were not available, or for other reasons. These included the introduction of hybrid vehicles, which have mitigation costs well above the $25/t CO_2e threshold; the introduction of diesel vehicles (passenger cars and SUVs), whose mitigation costs were also high; and other travel demand management interventions, such as parking restrictions or congestion charges, on which insufficient information was available. Besides railway freight transport, which was assessed as one of the MEDEC interventions, the redevelopment of railway passenger transport in Mexico is also a promising, although smaller, mitigation option.

Barriers to Mitigating Greenhouse Gas Emissions

Implementation of the aforementioned interventions faces political, financial, and social barriers. An important barrier for the optimization of urban transportation systems is the lack of coordination between agencies working on environment, urban planning, and transport issues, as well as across different levels of governments. The typical result has been an oversupply of low-quality public transport and a lack of overall metropolitan development and mobility planning.

Mass transit interventions also face the challenge of changing the institutional framework and the stakeholders who work in this subsector. In particular, the large number of buses and small concessions for different routes has made it difficult to implement BRT systems or mass transit optimization programs in Mexico. Successful implementation of BRT requires negotiations with route concessionaires who operate along prospective BRT corridors. Demand studies that identify the optimal location for the corridors and technical advice for system planning and operation are also needed.

The most important barrier to vehicular restriction through inspection and maintenance is the lack of enforcement of federal environmental regulations for vehicle emissions, which must be implemented at the state level. As the primary benefit of vehicle inspection programs is on the reduction of local pollutants, the best way to enforce compliance is through public education about health impacts. Vehicle inspection programs can also have an important impact on reducing CO_2e emissions by restricting the use of old vehicles that are both highly polluting and energy inefficient.

Conclusions

Reliance on private vehicles is not a sustainable transport option for Mexico. Although the increase in vehicle ownership in Mexico is probably inevitable, it is possible to substantially reduce vehicle emissions through policies that improve vehicle efficiency, expand and improve public transportation, and optimize the movement of freight. The analysis concludes that all nine transport measures evaluated produce financial and economic savings, as well as yield other benefits, including reduced congestion, pollution, and greenhouse gas emissions.

Because many transport options are interdependent and complementary, it is important that transport issues be addressed in a holistic and programmatic approach rather than as a set of individual measures. Given the historical and future urbanization pattern in Mexico, urban transport and related issues of land-use planning will be a critical determinant of the country's transport energy use and associated emissions. Improving urban transportation will require developing mechanisms that integrate public transportation with urban planning and development efforts by the federal, state, and municipal governments. Although low-carbon development can be an additional consideration, the underlying drivers of sustainable transport policies will be efficient, safe, and clean access to school, work, shopping, and neighborhoods.

Notes

1. The analysis of all transport sector interventions was carried out by the transport team.
2. The standard evaluated for Mexico is similar to the vehicle efficiency standard for new vehicles in the United States known as the corporate average fuel economy (CAFE) standard.