ESMAP
Energy Sector Management Assistance Program

Briefing Note 003/10

Low-Carbon Development for Mexico

LOW CARBON GROWTH COUNTRY STUDIES PROGRAM

MITIGATING CLIMATE CHANGE THROUGH DEVELOPMENT

CARBON FINANCE ASSIST

LOW CARBON GROWTH COUNTRY STUDIES PROGRAM

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Mitigating Climate Change in Mexico

LOW-CARBON DEVELOPMENT IS POSSIBLE FOR MEXICO

Mexico has the potential to rapidly move towards a low-carbon future. Currently, there are a broad number of cost-effective measures for reducing greenhouse gas (GHG) emissions, such as energy efficiency and sustainable transport interventions, being implemented in Mexico. At the same time, barriers exist to expanding many low-carbon interventions, ranging from information gaps to regulatory and policy barriers. By undertaking selective interventions, Mexico can benefit its national economy, demonstrating to the world the importance of low-carbon development to avoid the negative impacts of climate change.

Mexico is Latin America's largest fossil fuel-consuming country. The majority of the country's GHG emissions come from energy production and consumption. ***Low-Carbon Development for Mexico*** provides an analysis of how the country could significantly reduce its GHG emissions without hindering economic growth (Box 1). Beyond Mexico, the report provides useful lessons on low-cost interventions commonly employed in a variety of developing and industrial countries. With climate change at the forefront of global policy, low-carbon development is no longer an option for developing countries and middle-income nations like Mexico.

Climate change is a central part of Mexico's national development policy as established in the National Climate Change Strategy (*Estrategia Nacional de Cambio Climático*, 2007), which outlines medium- to long-term goals for adaptation and mitigation. Mexico has taken a committed stance to reducing GHG emissions, as seen in its targets announced at the United Nations Climate Change Conference in Poznan, Poland, in 2008, and its recently published *Programa Especial de Cambio Climatico*, which sets out a broad program to address climate change.

This overview highlights the main findings of ***Low-Carbon Development for Mexico,*** specifically the logic of low-carbon growth within the country's development goals and priorities, GHG mitigation opportunities, and the additional costs and benefits of lower carbon growth.

BOX 1 | Getting Started

Low-Carbon Development for Mexico or *México: Estudio Sobre la Disminución de Emisiones de Carbono* (MEDEC)[1], was two years in the making based on a study by the World Bank for the Mexican government, with the help of the Energy Sector Management Assistance Program (ESMAP). It evaluates the potential for GHG reduction in Mexico over the coming decades. A common methodology is used to evaluate low-carbon interventions across key emission sectors that form the basis for a low-carbon scenario to the year 2030. Analysis is presented using reader-friendly charts, graphs, and annotations organized in chapters according to the key emission sectors, allowing for a quick overview of priority issues.

This volume is the work of an international team of economists and researchers. It was prepared by Todd M. Johnson, an energy specialist in the Sustainable Development Department of the Latin American and the Caribbean Region; Claudio Alatorre, a consultant with expertise in energy transition programs; Zayra Romo, a power specialist in the Africa Energy Unit; and Feng Liu, an energy specialist with the Energy Sector Management Assistance Program.

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[1] Johnson, T. M., C Alatorre, Z. Romo, and F. Liu. 2010. *México: Estudio Sobre la Disminución de Emisiones de Carbono* (MEDEC). The World Bank, Washington, DC.

MITIGATION OPTIONS FOR MEXICO

Current GHG emissions and trends in Mexico indicate future potential for reduction. Energy consumption currently dominates Mexico's GHG emissions, accounting for 61 percent of GHG emissions in 2002; followed by land-use, forestry, and agriculture (21 percent) and wastes—solid and liquid (10 percent; Figure 1).

Low-Carbon Development for Mexico evaluates low-carbon interventions in five principal sectors:

- **Electric Power**—the production and distribution of electricity
- **Oil and Gas**—the extraction, processing, and distribution of oil and gas
- **Energy End-Use**—the potential for energy efficiency in the manufacturing and construction industries, and the residential, commercial, and public sectors
- **Transport**—primarily road transportation
- **Agriculture and Forestry**—crop and timber production, forest land management, and biomass energy

It uses a cost analysis to look at interventions projected to 2030 and also considers immediate changes that can be implemented and operational within 5 to 10 years (Box 2).

BOX 2 | Mexico's Low-Carbon Intervention Analysis: Criteria to Prioritize Options

In **Mexico,** 40 near-term priority mitigation measures have been identified using 3 principal criteria to rank options to 2030:

1. *CO_2 emission reduction potential.* An intervention must generate 5 million tons of CO_2 equivalent (CO_2e) emission reductions from 2009 to 2030.
2. *Low cost per ton of CO_2e reduced.* Only interventions with positive economic and social rates of return (at a given discount rate or cost of capital) and an abatement cost of US$25 per ton CO_2e reduced or less were considered. Interventions with positive net benefits are "no-regrets" measures since the financial and economic benefits more than cover the costs.
3. *Feasibility of implementation.* Determined by sector experts who considered technical potential, market development, and institutional needs; and by government officials who considered the political and institutional feasibility of scaling up interventions across the economy. Before adopting an intervention, public discussion with sector experts, government officials, the private sector, and civil society will take place. All selected interventions have already been implemented, at least on a pilot level, in Mexico or in other countries in similar conditions. Some interventions face barriers in the short term (next five years) but it is considered that these barriers can be removed in the medium term.

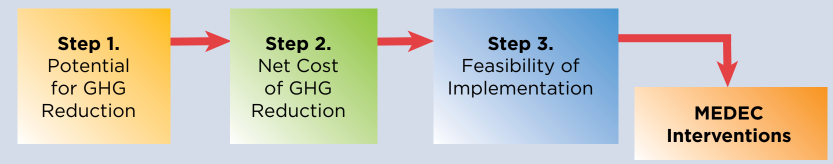
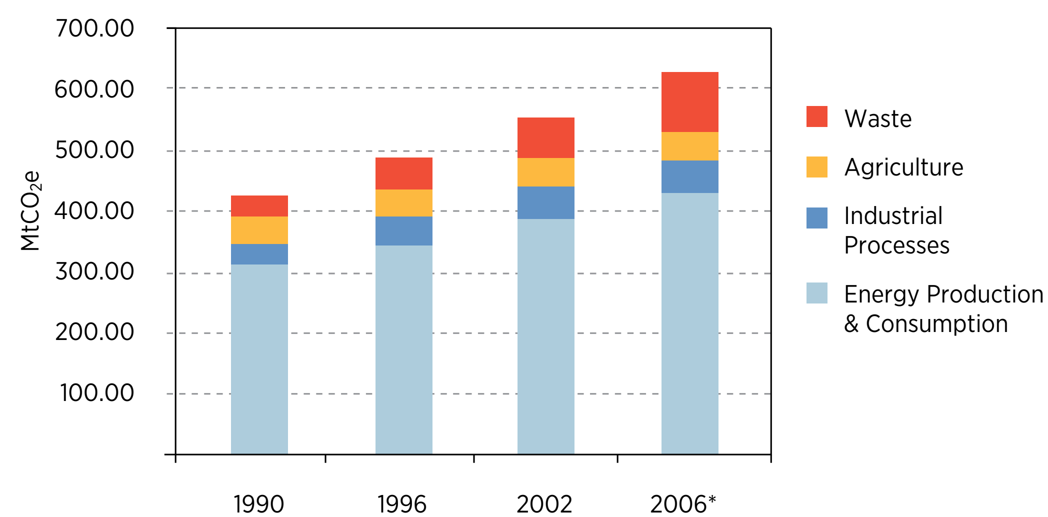


Figure 1: Mexico's GHG Emissions Inventory, 1990, 1996, 2002, and 2006* Excluding Land-Use, Land-Use Change, and Forestry (LULUCF)



Source: National Greenhouse Gas Inventory, 1990-2002
*Preliminary data from the National Ecology Institute

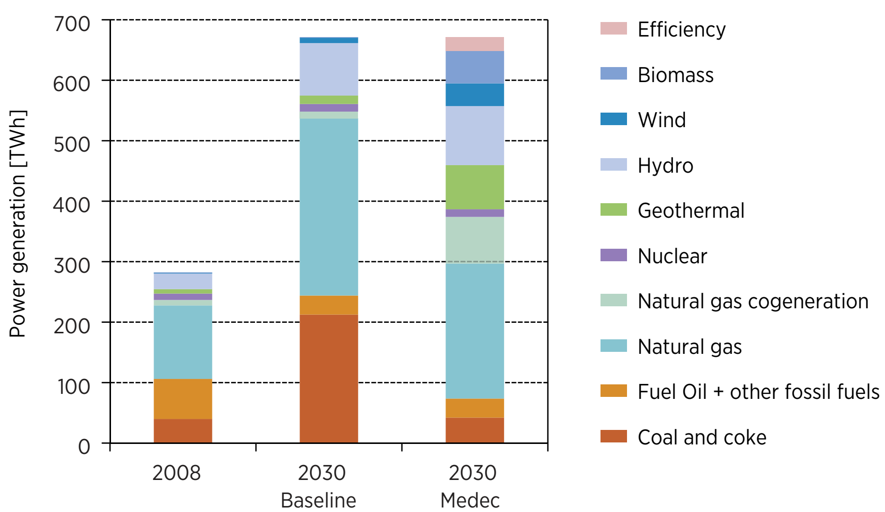
Electric Power | Supply Efficiency and Renewables

Demand for electric power has been growing faster than gross domestic product (GDP) in recent decades and is likely to continue for the foreseeable future with associated growth in electricity use across the economy. In a business-as-usual (BAU) scenario, total carbon dioxide equivalent (CO_2e) emissions from power generation would increase by 230 percent between 2008 and 2030—from 138 to 312 Mt CO_2e—to meet the increasing demand for power. In this scenario, the use of fossil fuel-fired power generation would increase—because they are least-cost without considering global environmental externalities—with coal accounting for 37 percent of new installed capacity, and natural gas 25 percent.

If the net cost of CO_2e is set at US$10/ton, additional low carbon energy technologies—small hydropower, wind, biomass, geothermal, cogeneration—could replace much of the fossil fuel generation, principally coal, but also natural gas, in the BAU scenario. Then, power generation would look very different in 2030 (Figure 2). Under the low-carbon scenario, cogeneration (i.e., the combined generation of heat and electricity in the same facility) could provide 13 percent of new power capacity at net costs[1] that are less than current marginal costs of power generation in Mexico.

Expanding renewable energy and energy efficiency in the power sector would require several policy and regulatory changes (Table 1). For example, the cost of wind power generation is among the lowest in the world due to high-quality wind resources in the Isthmus of Tehuantepec. Unfortunately, excessively low planning prices that do not account for fossil-fuel power generation, a lack of recognition of the portfolio effect in power planning, and ill-fitting procurement procedures hamper the development of wind and other renewable energy projects.

Figure 2: Power Generation in 2030: BAU vs. Low Carbon Scenario



[1] Costs were calculated by comparing the net costs (including capital, energy, operations, and maintenance) of each low-carbon technology with the costs of the displaced coal and natural gas capacity.

Table 1: Barriers to Low Carbon Development in the Mexican Power Sector

BARRIERS	CORRECTIVE ACTIONS
LARGE-SCALE PROJECTS	
Power sector planning is based on low fuel price scenarios	Use appropriate fuel price scenarios for electricity planning (not necessarily the same scenarios used for oil sector planning)
Power sector planning seeks least cost technology and does not consider portfolio approach	Modify the planning procedures to assess and consider, in addition to costs, volatility risks associated with the different technologies, and to minimize the overall risk and cost of the portfolio in the long term
Power sector planning does not consider ex-plant infrastructure costs and co-benefits	Include other benefits, such as local environmental externalities, all infrastructure costs (e.g., ports, pipelines, transmission lines), and possible carbon mitigation revenues
Only large-scale projects can participate in bidding processes	Allow small-scale renewable energy and cogeneration projects to offer partial capacity in bidding processes
Social conflicts for large hydropower projects	Put in place better negotiation mechanisms for the planning, construction, and operation of hydropower plants, such as those proposed by the World Commission on Dams[2]
SMALL-SCALE PROJECTS	
No predefined contracting procedures to allow renewable energy and cogeneration projects to sell electricity to the grid	Develop small power purchase agreements
Renewable energy generators are only paid short-term marginal costs and capacity	Develop payment systems that reward all benefits, including capacity, risk reduction, and externalities (including carbon payments)
No capacity payments for cogeneration projects	
Difficulties in obtaining local and federal licenses	Implement streamlined licensing procedures
Transmission bottlenecks	Expand transmission capacity in areas with large renewable energy potential

Oil and Gas | Increase Efficiency and Gas Production

GHG emissions can be reduced in the oil and gas sector (Table 2) through no-regrets and low-cost interventions, such as reducing gas distribution leakage; improving the efficiency in PEMEX oil, gas, and refining facilities; and introducing cogeneration in six PEMEX refineries and four petrochemical plants (representing more than 6 percent of Mexico's current installed power capacity). Developing this potential will require a regulatory framework that enables and encourages the sale of excess energy and capacity to the electricity grid.

From PEMEX's perspective, while having excellent rates of return, investments in cogeneration and reductions in gas leakage, for example, are less attractive than oil exploration and development. Financing of investment is also difficult due to PEMEX's high debt and oil revenues that account for over one-third of Mexico's federal budget—but the oil industry only accounts for around three percent of GDP—which constrains the Government from taking measures that reduce tax payments from PEMEX in the short term.

[2] "Dams and Development. A New Framework for Decision-Making." The Report of the World Commission on Dams. Available from www.dams.org.

Table 2: Low-Carbon Interventions in the Oil and Gas Sector

INTERVENTIONS	MAXIMUM ANNUAL EMISSION CORRECTIVE ACTIONS ($MTCO_2E$/YEAR)	NET COST OR BENEFIT OF MITIGATION (US$/$TCO_2E$)
Cogeneration in PEMEX	26.7	28.6 (benefit)
Gas leakage reduction	0.8	4.4 (benefit)
Refinery efficiency	2.5	16.6 (cost)

Allowing the private sector to tap cogeneration potential and reduce gas flaring and leakage could lower the need for "public" investment. The low-carbon scenario already envisions a major increase in the absolute amount of natural gas consumption. Successful implementation of the Government's plan to expand natural gas production is extremely important. Recent measures to expand natural gas production (29 percent between 2000 and 2007) have lagged compared to rising demand (38 percent in the same period), resulting in significant gas imports, mainly from the U.S.

Energy End-Use | Available Low-Cost Interventions

Electricity demand is rapidly growing–over 4 percent per year since 1995. Energy efficiency measures will be critical for the management of electricity and fuel demand growth, and mitigation of GHG emissions.

Over half of industrial energy use occurs in the cement; iron and steel; and chemicals and petrochemicals industries. Some of the large-scale basic materials industries in Mexico, such as iron and steel and cement, are among the most efficient internationally. At the same time, a great portion of Mexico's industrial sector is made up of small and medium enterprises that have relatively high energy intensity, often using old equipment and lacking access to technical know-how and financing for upgrades. The main sources of energy savings in the industrial sector come from energy efficiency improvements in motor and steam systems, kilns and furnaces, as well as from cogeneration. More than 80 percent of Mexico's industrial cogeneration potential has not been utilized.

Air conditioning, refrigeration, and electronics are expected to be the main growth areas of residential electricity demand and thus are prominently featured in the low-carbon interventions in the sector (Table 3). Air conditioner (AC) saturation rates are about 20 percent (2005), compared with about 95 percent in regions of the U.S. with similar cooling-degree days. The saturation rate of refrigerators is relatively high at 82 percent (2006), but is still expected to grow considerably. Notwithstanding recent efforts to promote compact fluorescent lamps (CFLs), incandescent lamps still account for about 80 percent of the in-use residential light bulbs in country, indicating large potential for scaling up. There is also a significant mitigation potential in thermal applications, by means of solar water heating in urban areas and improved fuelwood cookstoves in rural areas (Box 3). Although currently small (4 percent of total energy use and 11 percent of electricity), energy use by the commercial and public sectors is expected to grow significantly in the future.

Policies to improve efficiency in the residential, commercial, and public sectors—including tightening and enforcing efficiency standards for lighting, air conditioning, refrigeration, and buildings—will be critical to limit future GHG emissions. The investment required in all electricity efficiency interventions is significantly less than the investment in power plants that would otherwise be needed. In other words, "negawatts" from energy efficiency are almost always cheaper than megawatts.

Transport | Enhance Public Transport and Vehicle Fleet Efficiency

Transport is the largest and fastest growth area for both energy consumption and GHG emissions in Mexico; around 90 percent of these emissions result from road transport. In the past 10 years, the country's vehicle fleet has nearly tripled (from 8 to 21 million vehicles in 1996-2006), while energy use by road transport has increased over four fold since 1973. The import of used American vehicles is an important factor behind the surge, increasing the average age of the vehicle fleet and raising concerns about low gas mileage and increased GHG emissions.

Table 3. Low Carbon Interventions in the Energy End-Use Sector

INTERVENTIONS		MAXIMUM ANNUAL EMISSION REDUCTION ($MTCO_2E$/YEAR)	NET COST OR BENEFIT OF MITIGATION (US$/$TCO_2E$)
Electricity end-use efficiency	Residential air conditioning	2.6	3.7 (benefit)
	Residential lighting	5.7	22.6 (benefit)
	Residential refrigeration	3.3	6.7 (benefit)
	Non-residential lighting	4.7	19.8 (benefit)
	Non-residential air conditioning	1.7	9.6 (benefit)
	Street lighting	0.9	24.2 (benefit)
	Industrial motors	6.0	19.5 (benefit)
Cogeneration	Cogeneration in industry	6.5	15.0 (benefit)
	Bagasse cogeneration	6.0	4.9 (cost)
Renewable heat supply	Solar water heating	18.9	13.8 (benefit)
	Improved cookstoves	19.4	2.3 (benefit)

BOX 3 | Improved Cookstoves—Time Savings and Health Benefits

Improved cookstoves provide major benefits to households and society. Not only are they a cost effective tool for reducing GHG emissions, improved cookstoves are of major benefit to households and society: saving time—family members do not have to collect as much fuelwood; and improving health—reduces exposure to fine particulate matter ($PM_{2.5}$) and carbon monoxide (CO). The net benefit of the intervention is increased from essentially 0 to US$2.34 when time savings are included and to US$18.90 when both time and health benefits are included. With approximately 80 percent of the rural population in Mexico dependent on wood for cooking and heating (reported in Armendáriz et al., 2008), the GHG mitigation potential of widespread introduction of improved cookstoves is substantial.

Per Ton Mitigation Costs of Improved Cookstoves (US$/ton)

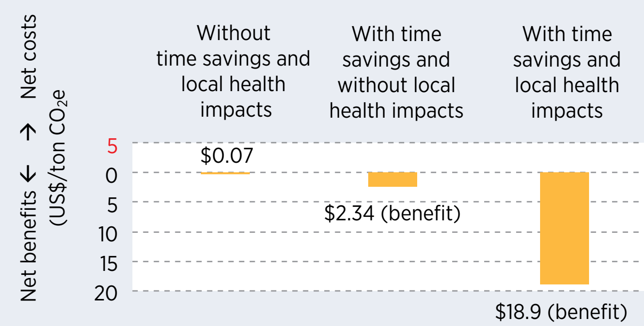
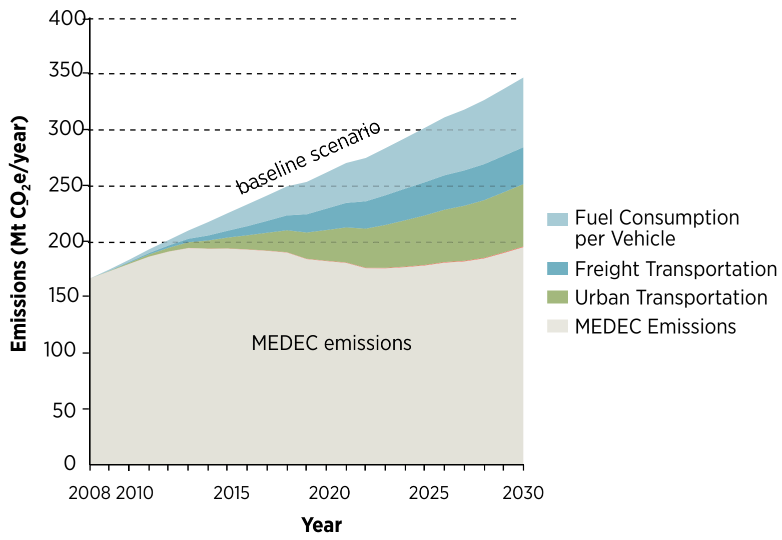
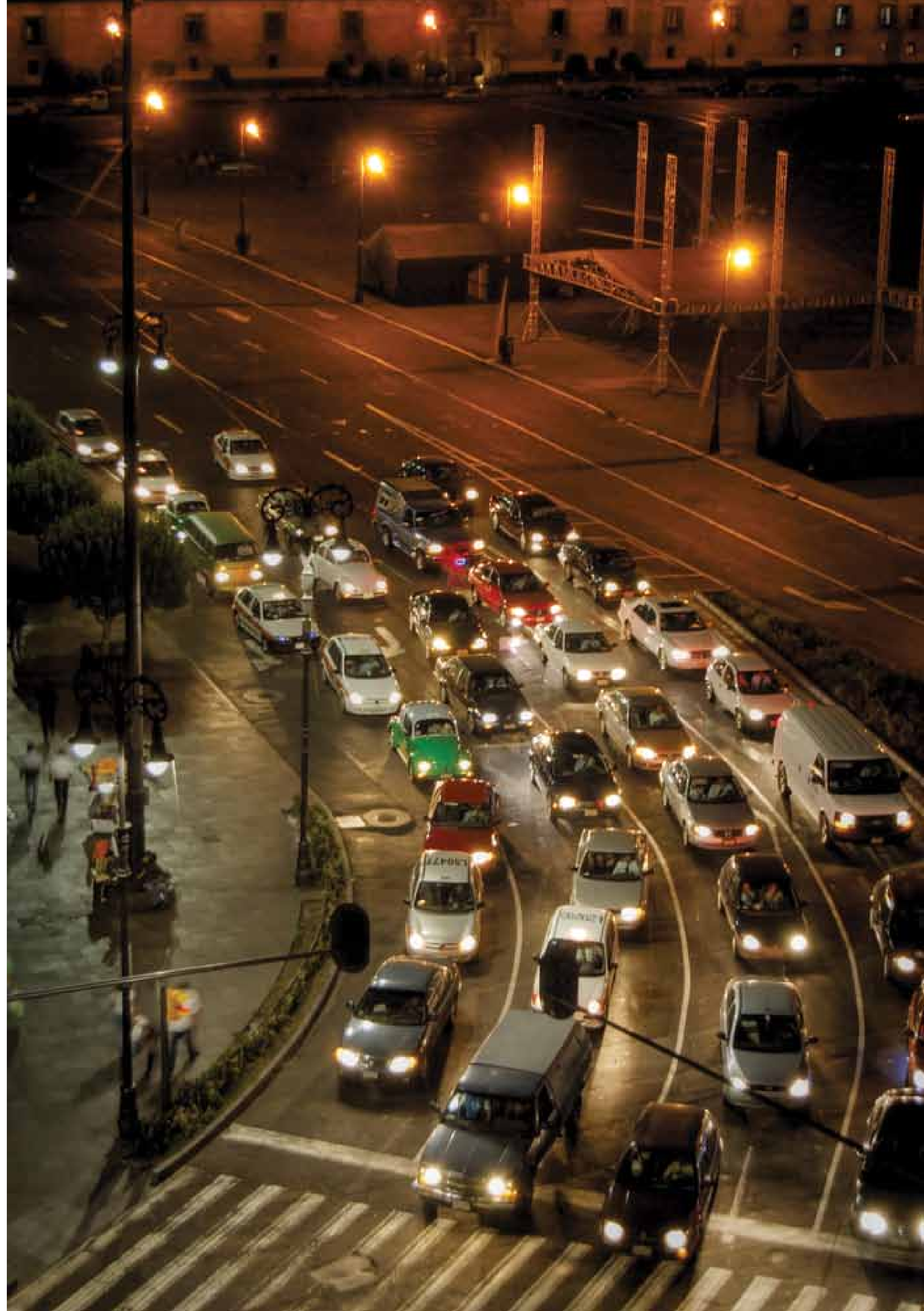


Figure 5: Low Carbon Emissions Scenario for Transport



Given historical and future urbanization patterns in Mexico, integrated urban transport and land-use planning will be critical factors in overall energy use and emissions (Figure 5). The most cost-effective ways to reduce emissions are through increased use of public transport and improvements in vehicle efficiency. Increasing the use of public transportation—including through private concessions—will require the development of mechanisms that integrate public transport and urban development efforts by both federal and municipal governments. The co-benefits would be less traffic congestion, time-savings, and public health improvements due to lower air pollution.



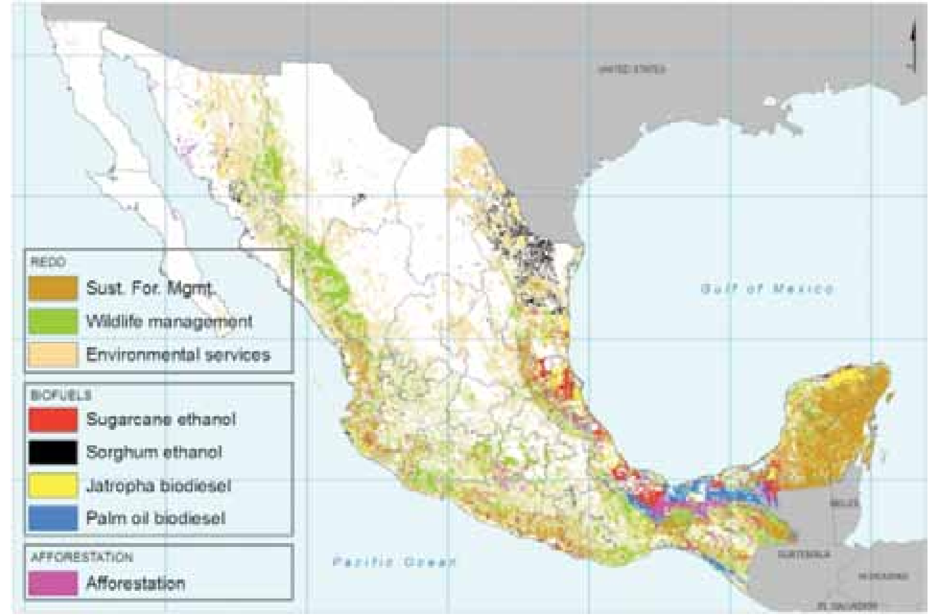
Agriculture and Forestry | Significant Potential with Large Co-Benefits

Measures to reduce emissions from agriculture and forestry are among the largest GHG mitigation options in Mexico. Eighty-five percent of this potential resides in forestry—reforestation, commercial plantations, and measures to reduce emissions from deforestation and forest degradation (REDD). The most beneficial interventions are those that achieve both (i) the substitution of fossil fuel use via the sustainable production of biomass energy and (ii) reduce deforestation and forest degradation. Many of these measures bring environmental co-benefits, such as soil conservation, water quality, and ecosystem preservation, as well as income generation and employment for rural communities. To successfully harness this potential, there must be institutional changes in forest management, improved public financing mechanisms, and the development of a market for sustainable forest products.

Opportunities for cost-effective mitigation in agriculture are more limited, partly due to a lack of research and development of low-carbon measures. Minimum tillage for maize production appears to aid soil carbon sequestration and could be a promising technology for Mexico due to lower energy requirements.

The production of liquid biofuels is another possibility. Sugarcane ethanol has significant GHG reduction potential, although the productivity of sugarcane production in Mexico is currently low and production costs are significantly above world market prices for sugar. Other liquid biofuels interventions—ethanol from sorghum, and biodiesel from palm and jatropha—have limited GHG emission reduction potential without impinging on land-use for food crops, forests, or conservation lands. All liquid biofuel options have positive net economic costs when compared with the opportunity cost of selling the feedstocks for food or other non-fuel uses.

Figure 4: Territorial Distribution of Agriculture and Forestry Intervention*



*Sustainable forest management includes all interventions that involve a productive use of biomass (biomass electricity, fuelwood co-firing, charcoal production, and forest management). The areas suitable for reforestation and restoration or for zero tillage maize are not included in this map. The area depicted here for afforestation assumes eucalyptus plantations. Jatropha biodiesel, an intervention not included in the MEDEC scenario due to its high net cost of mitigation, is included here. Authors: Ghilardi, A. & Guerrero G. (Red Mexicana de Bioenergía and Centro de Investigaciones en Ecosistemas; National University of Mexico). Based on: REMBIO 2008; INEGI 1995, 2000, 2002. Created in ArcGIS 9.2 using ArcMap.

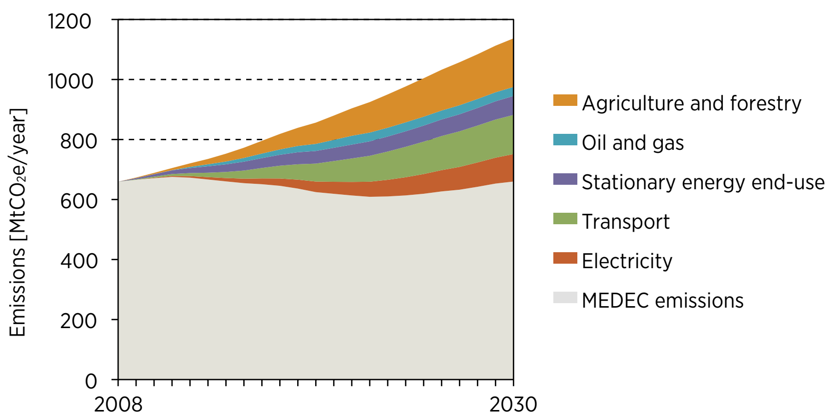
A LOW-CARBON SCENARIO FOR MEXICO

A key objective of ***Low-Carbon Development for Mexico*** is to build a low-carbon scenario for Mexico to the year 2030. The above low-carbon interventions outline options to reduce GHG emissions. The BAU scenario was generated with the Long-range Energy Alternatives Planning (LEAP) model using macroeconomic assumptions for GDP, population growth, and fuel prices in line with Mexican government estimates. In the BAU scenario, overall CO_2e emissions are estimated to grow from 660 Mt in 2008 to 1,137 Mt in 2030.

Implementing 40 cross-sectoral interventions that meet the criteria explained in Box 2 would reduce emissions by around 477 million tons of CO_2e in year 2030 (Figure 7). Mexico's GHG emissions would be virtually the same in 2030 as they are today but with significant GDP and per capita income growth. Emission reductions (Mt CO_2e) in 2030 would come from agriculture and forestry (150 Mt), transport (131 Mt), power generation (129 Mt), energy end-use (38 Mt), and oil and gas (30 Mt).

This low-carbon scenario is conservative in that only 40 interventions were considered and the analysis did not assume any major changes in technology.

Figure 5. Low-Carbon Scenario



How Much Would Low Carbon Development Cost? How Do Costs Compare Across Sectors?

The combined net marginal abatement cost curve (Figure 8) shows that nearly half of the total potential for emissions reduction—26 interventions—have positive net benefits (or "negative costs," meaning that their overall cost is less than their respective high-carbon alternative). Those with both high potential and low cost are public transport and vehicle efficiency, the majority of energy efficiency measures (including electricity supply improvements, lighting, refrigeration, air conditioning, and improved cookstoves), and a number of low-cost electricity supply options (including industrial and PEMEX cogeneration, and solar water heating).

If the value of one ton of carbon avoided is set at US$10/t CO_2e, then more interventions yield positive benefits, including reforestation and restoration, and afforestation. Fully 80 percent of the GHG reduction potential in this low-carbon scenario lies below the US$10/t CO_2e threshold. Raising the cost threshold to US$25/t CO_2e allows over 5 billion tons of CO_2e to be avoided in the period to 2030.

Implementing a Low-Carbon Program in Mexico

High-priority interventions with low or negative net costs exist in the transport, electric power, energy efficiency, and forestry sectors but barriers to implementation prevent many from occurring rapidly or on a large scale.

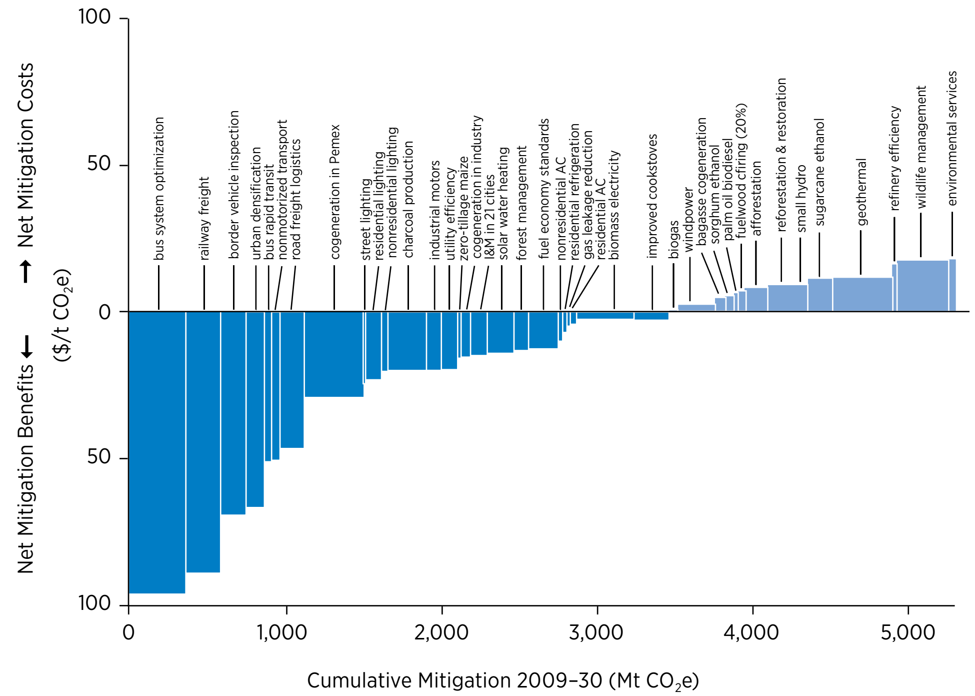
Policies and Investments Required for Low-Carbon Development

Regulatory, institutional, and market development barriers inhibit low-carbon interventions from being undertaken on a larger scale today. Two of the biggest challenges facing Mexico in moving to a low-carbon economy are:

(1) *Financing the generally higher upfront costs of low-carbon investments.* Many projects identified require higher upfront investment in plants and equipment despite positive net present values. Renewable energy investments generally have higher first costs, which are often compensated by lower operating costs. Initial investments in energy efficiency, for example as offset by fuel savings or savings in new generating capacity. But even if the discounted life-cycle costs are lower, higher upfront investment costs generally inhibit investment. The overall new investment required to achieve the low carbon scenario is around US$64 billion between 2009-30, or around US$3 billion per year, equivalent to about 0.4 percent of Mexico's GDP in 2008 (Tables 4, 5).

(2) *Policies and programs to overcome barriers.* There is considerable room to involve the private sector in financing investments in energy efficiency, renewable energy, and sustainable transport. Since the mid-1990s, the number of independent power producers for natural gas power plants has risen dramatically, which could be improved and extended to promote investment in energy efficiency, cogeneration, and renewable energy generation. Recent oil and gas industry reforms support greater efficiency and private sector investment.

Figure 6. Marginal Abatement Cost Curve



Examples of important policies for low carbon development include, but are not limited to:

- **Electric Power**—reforming energy prices, specifically residential electricity tariffs, and increasing the price of petroleum products (gasoline, diesel, LPG, fuel oil) and natural gas
- **Oil and Gas**—changing the rules that limit PEMEX from tapping its cogeneration potential and providing substantial electricity production to the grid

- **Energy End-Use**—changing public procurement rules to facilitate energy efficiency investments in schools, hospitals, government buildings, and municipal services
- **Transport**—increasing energy efficiency standards for both new and used vehicles; improving coordination between federal, state, and municipal governments, and between sector agencies at all levels of government for urban land-use planning and public transport; improving fuel quality and enforcing air quality standards
- **Agriculture and Forestry**—expanding forest management programs

Almost all of the MEDEC low-carbon interventions have been implemented in Mexico as commercial-scale investments projects or as pilot programs, thus, demonstrating their near-term feasibility. For many interventions, new policies, incremental investment financing, and other institutional and behavioral changes are needed to support the scale-up from an individual project to a wider program. Carbon market mechanisms could support some low-carbon interventions, however, most interventions would require new rules—a reformed Clean Development Mechanism or new mechanisms—to qualify for support.

Near-Term Actions

As the government of Mexico moves forward with its climate change mitigation program, it is important to prioritize near-term interventions. This study recommends that priority be given to interventions with the following characteristics:

- Significant emissions reduction potential
- Positive economic rates of return, including large co-benefits
- Successful demonstration at commercial scale in Mexico or internationally
- Low investment costs and the ability to obtain financing

Table 4: MEDEC Investment Requirements to 2030 (in US$ millions)

SECTOR	NEW INVESTMENT	FOREGONE INVESTMENT	NET INVESTMENT
Electric Power	21,406	10,933	10,473
Oil and Gas	4,637	1,482	3,155
Energy End-use	15,771	9,898	5,873
Transport	11,729	36,249	–24,520*
Agriculture and Forestry	10,928	3,699	7,230
Total	64,471	62,261	2,210

*Negative net investment implies that new investments under the low carbon scenario are less than the avoided investment under the baseline.

Table 5: Sources of Financing for Low-Carbon Interventions

PRIVATE SECTOR	HOUSEHOLDS	PUBLIC SECTOR*
• Commercial energy efficiency • Industrial energy efficiency • Industrial cogeneration • IPPs for renewables (wind, biomass) • Buses • Sugarcane bagasse cogeneration • Liquid biofuels	• Residential energy efficiency • Solar water heating • Zero tillage maize • New vehicles • Vehicle inspection and maintenance	• Street lighting • Public services efficiency • Reforestation and restoration • Transport infrastructure • Geothermal power • Oil and gas investments

*Worldwide, many public sector investments are financed through concession schemes with private contractors or operators, including for power generation, oil and gas, public transportation, and other public utilities (water and sanitation).

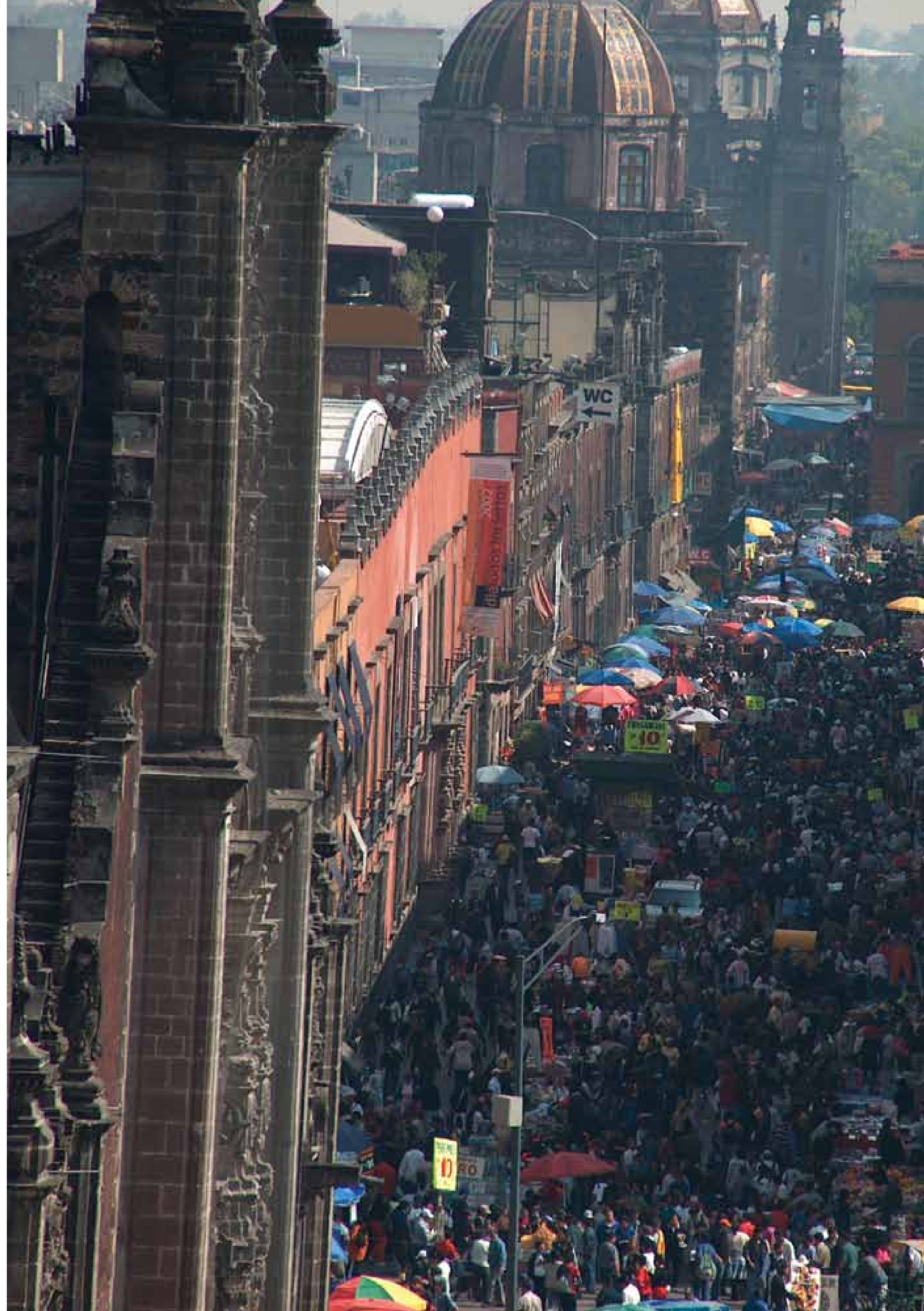
Based on these criteria, the high-priority actions with significant scale-up potential over the next five years include:

- **Electric Power**—wind farm development in Oaxaca and elsewhere based on CFE's pilots
- **Oil and Gas**—cogeneration in PEMEX facilities based on the project at Nuevo PEMEX
- **Energy End-Use**—an expansion of the efficient lighting and appliances programs developed by FIDE and SENER
- **Transport**—bus rapid transit based on projects in Mexico and piloted in other parts of Latin America
- **Forestry**—avoided deforestation based on the Los Tuxtlas project in Veracruz

In all cases Mexico will need to experiment and gain experience, especially with new investment mechanisms and regulatory policies. In prioritizing actions, Mexico should select measures that have positive economic rates of return, and social and environmental benefits (Table 6).

Table 6: MEDEC Investment Requirements to 2030 (in US$ millions)

INTERVENTION	TOTAL NEW INVESTMENT (IN US$ MILLIONS)	TOTAL EMISSIONS REDUCTION (MT CO_2E)	MAXIMUM ANNUAL EMISSIONS REDUCTION (MT CO_2E)	MITIGATION COST OR BENEFIT (US$/T CO_2E)	IMPLEMENTATION
Border vehicle inspection	0	166	11	69 (benefit)	ST
Bus rapid transit	2333	47	4	51 (benefit)	ST
Residential lighting	237	100	6	23 (benefit)	ST
Nonresidential lighting	420	47	5	20 (benefit)	ST
Utility efficiency	286	103	6	19 (benefit)	ST
I&M in 21 cities	0	109	11	14 (benefit)	ST
Forest management	148	92	8	13 (benefit)	ST
Improved cookstoves	434	222	19	2 (benefit)	ST
Bus system optimization	0	360	32	97 (benefit)	ST/MT
Nonmotorized transport	2252	51	6	50 (benefit)	ST/MT
Road freight logistics	0	157	14	46 (benefit)	ST/MT
Cogeneration in PEMEX	3068	387	27	29 (benefit)	ST/MT
Fuel economy standards	7145	195	20	12 (benefit)	ST/MT
Wind power	5549	240	23	3 (cost)	ST/MT
Afforestation	1084	153	14	8 (cost)	ST/MT
Reforestation & restoration	2229	169	22	9 (cost)	ST/MT
Solar water heating	4464	169	19	14 (benefit)	ST/MT
TOTAL	29,648	2,767	247		



ACRONYMS AND ABBREVIATIONS

AC	Air conditioner
BAU	Business-as-usual
CFE	Federal Electricity Commission (Comisión Federal de Electricidad)
CFL	Compact fluorescent lamp
CO	Carbon monoxide
CO_2e	Carbon dioxide equivalent
ESMAP	Energy Sector Management Assistance Program
FIDE	Fund for Electricity Savings (Fideicomiso para el Ahorro de Energía Eléctrica)
GDP	Gross domestic product
GHG	Greenhouse gas
I&M	Inspection and maintenance
IPP	Independent power producer
LEAP	Long-range Energy Alternative Planning model
LPG	Liquefied petroleum gas
LULUCF	Land-use, land-use change, and forestry
MEDEC	México: Estudio sobre la Disminución de Emisiones de Carbono
Mt	million tons
MT	Medium-term
PEMEX	Mexican National Oil Company (Petróleos Mexicanos)
$PM_{2.5}$	Particulate matter < 2.5 microns
REDD	Reducing emissions from deforestation and forest degradation
SENER	Ministry of Energy (Secretaría de Energía)
ST	Short-term
t	ton
TWh	terawatt-hour
US$	United States dollar

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The Energy Sector Management Assistance Program (ESMAP) is a global knowledge and technical assistance program administered by the World Bank that assists low- and middle-income countries to increase know how and institutional capacity to achieve environmentally sustainable energy solutions for poverty reduction and economic growth.

For more information on the Low Carbon Growth Country Studies Program or about ESMAP's climate change work, please visit us at www.esmap.org or write to us at:

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The primary developmental objective of Carbon Finance-Assist (CF-Assist) is to ensure that developing countries and economies in transition are able to fully participate in the flexible mechanisms defined under the Kyoto Protocol, and benefit from the sustainable development gains associated with such projects.

CF-Assist is a cosponsor of the Low Carbon Growth Country Studies knowledge program.

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