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Climate Economic Analysis for Development, Investment, and Resilience

MEXICO ENERGY EFFICIENCY ASSESSMENT FOR GREENHOUSE GAS EMISSIONS MITIGATION

FINAL REPORT

Contract No.: AID-OAA-I-12-00038, Task Order: AID-OAA-TO-14-00007

8 January 2016

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Abt Associates Inc.

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ACRONYMS

ACEEE	American Council for an Energy Efficiency Economy
AFOLU	Agriculture, forestry, and other land uses
AMIMP	Mexican Association of Municipal Planning Institutes
BAU	Business as usual
C3	Consejo de Cambio Climático (Climate Change Council)
C3E	Clean Energy Education and Empowerment
CCAC	Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants (partnership of governments, intergovernmental organizations, representatives of the private sector, the environment community, and other members of civil society)
CE	Coordinación de Evaluación (Coordination for Evaluation, integrated by non-governmental climate change experts)
CEADIR	Climate Economic Analysis for Development, Investment, and Resilience
CEL	Certificados de Energía Limpia (Clean Energy Certificates)
CENACE	Centro Nacional de Control de Energía (GOM National Energy Control Center)
CESPEDES	Private Sector's Research Commission for Sustainable Development
CFC	Chlorofluorocarbons
CFE	Comisión Federal de Electricidad (Federal Electricity Commission, GOM-owned electric utility)
CH_4	Methane
CHP	Combined heat and power
CICC	Comisión Inter-secretarial de Cambio Climático (GOM Inter-Ministerial Climate Change Commission)
CKD	Capital Development Certificate
CNG	Compressed natural gas (CNG)
CO_2	Carbon dioxide
COA	Cédula de Operación Anual (Annual Operations Certificate issued by SEMARNAT)
CONACYT	Consejo Nacional de Ciencia y Tecnología (GOM National Council for Science and Technology)
CONAPO	Consejo Nacional de Población (GOM National Population Council)
CONAVI	Comisión Nacional de Vivienda (GOM National Housing Commission)
CONEVAL	Consejo Nacional de Evaluación de la Política de Desarrollo Social (GOM National Council for Social Development Policy Evaluation)
CONSAR	Comisión Nacional del Sistema de Ahorro para el Retiro (GOM National Commission

	for the Retirement Savings System)
CONUEE	Comisión Nacional para el Uso Eficiente de Energía (GOM National Commission for the Efficient Use of Energy)
CRE	Comisión Reguladora de Energía (GOM Energy Regulatory Commission)
DAC	Doméstica de alto consumo (Domestic high consumption, electricity rate class)
DANIDA	Danish International Development Agency
DCA	Development Credit Authority
ECOCASA	Programa de Cooperación Financiera para la oferta de Vivienda Sustentable en México (Financial Cooperation Program for the supply of Sustainable Housing in Mexico)
EMA	Mexican Accreditation Entity
EMS	Energy management systems
FAMERAC	Fabricantes Mexicanas de Energías Renovables A.C.
ESCO	Energy service companies
FIRA	Fideicomisos Instituidos con Relación a la Agricultura (GOM Agriculture-Related Trust Fund)
FIDE	Fideicomiso para el Ahorro de Eficiencia Energética (Trust Fund for Electricty Savings)
FIPATERM	Trust Fund for the Thermal Insulation Program
FONADIN	Fondo Nacional de Infraestructura (National Infrastructure Fund)
GBV	Gender-based violence
GDF	Mexico City Government
GDP	Gross domestic product
GEF	Global Environmental Facility
GHG	Greenhouse gases
GIZ	Gesellschaft für Internationale Zusammenarbeit (German Agency for International Collaboration)
GOM	Government of Mexico
GWP	Global warming potential
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
HFE	Hydrofluoroether
HDV	Heavy-duty vehicle
HVAC	Heating, ventilation, and air conditioning
ICLEI	Local Governments for Sustainability (formerly International Council for Local Environmental Initiatives)
IDB	Inter-American Development Bank

IEA	International Energy Agency
IEPS	Impuesto Especial Sobre Productos y Servicios (Special Tax on Products and Services)
IMCO	Instituto Mexicano para la Competitividad (Mexican Institute for Competitiveness)
IMPLANES	Institutos Municipales de Planeación (Municipal Planning Institutes)
INDC	Intended Nationally Determined Contributions
INECC	Instituto Nacional de Ecología y Cambio Climático (GOM National Institute of Ecology and Climate Change)
INEGI	National Institute of Geography and Statistics
INFONAVIT	Instituto del Fondo Nacional de Vivienda para los Trabajadores (GOM Institute of the National Fund for Workers' Housing)
INMUJERES	National Institute for Women
IoT	Internet of things
IPCC	Intergovernmental Panel on Climate Change
LAERFTE	Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética (Law for the Use of Renewable Energy and Financing for the Energy Transition)
LCOE	Levelized cost of energy
LEDS	Low Emission Development Strategies
LEED	Leadership in Energy and Environmental Design (certification program of the U.S. Green Building Council)
LGCC	Ley General de Cambio Climático (General Law on Climate Change)
LIE	Ley de Industria Eléctrica (Law of Electric Industry)
LPG	Liquefied petroleum gas
LULUCF	Land Use, Land Use Change, and Forestry
LVP	Light-duty vehicle
MLED	USAID/Mexico Low Emission Development project
MLP	Master limited partnership
MRV	Measurement, reporting, and verification
MXP	Mexican peso
N_2O	Nitrous oxide
NAICM	Nuevo Aeropuerto Internacional de la Ciudad de México (new Mexico City International Airport)
NAMA	Nationally Appropriate Mitigation Action
NOM	Norma Oficial Mexicana (Mexican Official Norm)
NREL	National Renewable Energy Laboratory (USG)
OECD	Organization for Economic Co-operation and Development

OPIC	USG Overseas Private Investment Corporation
PACCM	Programa de Acción Climática de la Ciudad de México (Mexico City Climate Action Program)
PACMUN	Plan de Acción Climática Municipal (Municipal Climate Action Plan)
PAEEDM	Programa de Ahorro y Eficiencia Energética Empresarial (FIDE's Enterprise Savings and Energy Efficiency Program, also known as Business Eco-Credit)
PEACC	Programa Estatal de Acción ante el Cambio Climático (State Climate Change Action Program)
PEACC-Y	Programa Especial de Acción ante el Cambio Climático del Estado de Yucatán (Special Climate Change Action Program for the State of Yucatan)
PECC	Programa Especial de Cambio Climático (Special Climate Change Program)
PEMEX	Petróleos Mexicanos (GOM-owned petroleum company)
PFC	Perfluorocarbons
PROCASOL	Programa para la Promoción de Calentadores Solares de Agua en México (Program for the Promotion of Solar Water Heaters in Mexico)
PROIGUALDAD	National Program for Equal Opportunity and Non-Discrimination Against Women
PV	Photovoltaic
REIT	Real estate investment trust
RENE	Registro Nacional de Emisiones (National Emissions Registry)
RTR	Rapid Transport to Resident
SAGARPA	Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (GOM Ministry of Agriculture, Livestock, Rural Development, Fisheries, and Food)
SE4ALL	Sustainable Energy for All
SE	Secretaría de Economía (GOM Ministry of Economy)
SEDATU	Secretaría de Desarrollo Agrario, Territorial y Urbano (GOM Ministry of Agrarian, Territorial, and Urban Development)
SEDESOL	Ministry of Social Development
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales (GOM Ministry of Environment and Natural Resources)
SENER	Secretaría de Energía (GOM Ministry of Energy)
SF_6	Sulfur hexafluoride
SHCP	Secretaría de Hacienda y Crédito Público (GOM Ministry of Finance)
SHF	Sociedad Hipotecaria Federal (GOM Federal Mortgage Society)
SIAT-PECC	Sistema de Información para la Agenda de Transversalidad-Programa Especial de Cambio Climático (GOM's Information System for Cross-Sectoral Agendas-Special Climate Change Program)
SISEVIVE	Sistema de Evaluación para Vivienda Verde (Evaluation System for Green Housing)

SLCP	Short-lived climate pollutants (black carbon, hydrofluorocarbons, methane, and tropospheric ozone)
SME	Small and medium enterprises
SNCC	Sistema Nacional de Cambio Climático (National Climate Change System)
SOFOM	Multiple Object Financial Societies (Sociedades Financieras de Objeto Múltiple)
SUM	Sustainable urban mobility (concept)
SWH	Solar water heating
TIIE	Tasa de Interés Interbancaria de Equilibrio (Inter-Banking Loan Rate)
TRACE	Tool for Rapid Assessment of City Energy
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
US$	United States dollar
USG	United States Government

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EXECUTIVE SUMMARY

STUDY PURPOSE AND METHODS

This report presents the findings of an assessment on energy efficiency, financing, and market mechanisms in Mexico conducted by a team from the United States Agency for International Development (USAID)-funded Climate Economic Analysis for Development, Investment and Resilience (CEADIR) project. The objective of the assessment was to identify promising activities that USAID/Mexico could support in a new project to reduce greenhouse gas (GHG) emissions from energy production, distribution, and consumption in Mexico from FY 2016 to FY 2021.[1]

This assessment focused on the identification and evaluation of opportunities to reduce GHG emissions in Mexico by increasing energy efficiency. It also focused on financing instruments to increase capital flows for low emission development and the technical and political feasibility of economic instruments that provide price signals to reduce GHG emissions. In addition, gender perspectives were mainstreamed throughout the assessment.

The CEADIR assessment focused on activities that are expected to be cost-effective, technically and politically feasible, and aligned with USAID's mandate and operational capacity, as well as scalable, sustainable, gender responsive, high impact, and reflecting private sector objectives. Prior to the CEADIR assessment of energy efficiency and carbon markets, the US National Renewable Energy Laboratory (NREL) completed an assessment of renewable energy opportunities and grid integration, which will provide input for the same USAID/Mexico project. Consequently, this report only discusses renewable energy tied to energy efficiency options or in the context of market mechanisms or financing.

The CEADIR assessment included a literature review covering Mexico's legal and institutional framework for climate change and energy efficiency. It also included meetings with stakeholders from governments, multilateral and bilateral donors and development banks, civil society organizations, private firms, and academia to discuss ongoing and planned efforts, lessons learned, and opportunities for potential USAID assistance. Most of these meetings took place during June 15-26, 2015, when two team members from USAID/Washington traveled to Mexico City to work with a USAID/Mexico mission staff member and the CEADIR team.

1. MEXICO'S CLIMATE CHANGE AGENDA AND FRAMEWORK

This assessment begins by summarizing the Government of Mexico (GOM)'s climate change and energy efficiency priorities, targets, policies, and laws; the institutional makeup and responsibilities for climate change programs; and the measurement, reporting, and verification (MRV) systems in place. The assessment first describes the GOM's agenda and framework and those of selected states and municipalities. The assessment also provides an overview of relevant financial institutions, market mechanisms, and gender issues.

Mexico has made significant progress in the adoption of an institutional framework for climate change action. A key milestone was the enactment of the 2012 General Law on Climate Change (LGCC), which distributed responsibilities among federal and subnational governments to tackle climate change mitigation and adaptation challenges. The law also established non-binding climate change mitigation goals. The 2015 Intended Nationally Determined Contribution (INDC) furthered the LGCC's goals by establishing that Mexico would

[1] The United States Government's fiscal year runs from October 1 through September 30.

unconditionally reduce its GHG and Short-Lived Climate Pollutant (SLCP) emission by 25 percent below business as usual (BAU) by 2030, and up to 40 percent contingent on international support (GOM, 2015).

Since the adoption of the first Special Climate Change Program in 2009, Mexican federal and subnational agencies have strengthened their capacity to develop climate change policies and programs, supported by sound scientific and technical analysis. Two successive federal administrations have successfully adopted climate change programs that integrate the main elements of Mexico's Low Emission Development Strategy (LEDS), including (1) a well-defined process with clear institutional roles and responsibilities; (2) a sound assessment of the current situation, including increasingly rigorous GHG inventories; (3) analysis of BAU scenarios and LEDS pathways; (4) prioritization of actions; and (5) implementation and monitoring of the Programa Especial de Cambio Climático (Special Climate Change Program, PECC). Subnational governments have also enhanced their capacity to develop LEDS, although more institutional development is needed.

Recommendations

The following actions could be undertaken to further develop Mexico's legal and climate change institutional framework:

- Support ongoing GHG mitigation efforts by providing assistance to enable the transition from climate change planning to implementation; assess whether federal, subnational, and private sector efforts are on the right path to meet medium-to-long term GHG mitigation goals; and integrate gender perspectives into climate change polices and finance.
- Strengthen the analytical underpinnings of LEDS by further developing institutional capacities to operate the National GHG Emissions Registry (RENE) and use its data to support policy development; conduct modeling and analysis to support Mexico in its transition toward a low-emission development trajectory; develop a set of gender-based indicators that can be integrated into Mexico's Climate Change Information System; and develop a framework for the next generation of climate change programs.
- Foster cross-sectoral coordination for LEDS by strengthening coordination between the energy and environment sectors; mainstreaming gender issues in clean energy and social policies; and increasing skills to facilitate climate financing.

2. ENERGY EFFICIENCY AGENDA AND FRAMEWORK

Mexico emitted 748 million tCO_2e of GHG in 2010. The energy sector was the largest source of emissions, contributing 67.3 percent of the total. Transportation fuels and electricity generation, which are included in the energy sector estimates, contributed 22.2 percent and 21.8 percent of total emissions, respectively (SEMARNAT, 2013). The energy sector is expected to contribute an even larger share of Mexico's total GHG emissions in the future. Under the BAU scenario, emissions from the transport sector would represent 27 percent of Mexico's total emissions in 2020, followed by industry (19 percent), electric power generation (16 percent), and oil and gas (11 percent).

Energy efficiency interventions can be among the most cost-effective alternatives to reduce GHG emissions in Mexico (MLED, 2013). However, available energy savings opportunities have not been capitalized on because of institutional and economic obstacles. Organizations with a mandate to promote energy efficiency in Mexico include the (1) Ministry of Energy (SENER), which is responsible for planning and setting energy and electricity policies; (2) National Commission for the Efficient Use of Energy (CONUEE), which issues recommendations and provides technical assistance on energy efficiency to firms, individuals, and national, state, and municipal governments; and (3) the Trust Fund for Electricity Savings (FIDE) and the Trust Fund for the Thermal Insulation Program (FIPATERM).

These organizations' efforts to advance energy efficiency in Mexico are hampered by (1) the existence of electricity subsidies; (2) the lack of a national energy efficiency goal; (3) weak institutional and financial capacity and legal mandates at the subnational level, as well as and limited GOM use of market mechanisms to advance energy and GHG mitigation and goals.

Recommendations

The following activities could help overcome existing energy efficiency obstacles in Mexico:

- **Rethinking electricity subsidies**. Electricity subsidies need to be reformed because their fiscal burden is unsustainable. While this is a sensitive political issue, USAID could provide assistance to explore options to reform these subsidies while protecting low-income households. These options include (1) economic analysis of the true costs of subsidies, including opportunity costs and fiscal impacts; (2) analysis of impacts on diverse stakeholders of reducing the subsidies and using means-tested compensating transfers or tax reductions; (3) reform the complex rate structure for different types and sizes of users; and (4) change the seasonal and regional differences in rates. USAID could also fund a communication and outreach strategy to help the population understand the true consequences and costs of the subsidies and policies to mitigate negative impacts on vulnerable groups.
- **Targeting interventions to different types of electricity users, recognizing their specific challenges.** High-consumption residential users, industry, and commercial firms do not currently benefit from electricity subsidies. Informational and behavioral programs for these customers could be effective in increasing their energy efficiency. Different interventions may be needed for small and medium enterprises (SMEs) that might face difficulty obtaining credit for profitable energy efficiency investments because of insufficient collateral or credit history or financial institution concerns about valuing the projected energy savings. Subsidies for electricity are particularly high for agriculture in Mexico. Yet, potential savings from investments in more efficient irrigation technologies could result in sizable energy and GHG emissions reductions and decrease over-pumping of the 25 percent of Mexico's aquifers that are overexploited.
- **Developing an energy efficiency roadmap**. USAID could assist CONUEE in the development of a national energy efficiency baseline, selection of key sectors where energy efficiency can be achieved with a net cost savings, planning and structuring of financing and market mechanisms to support the plan, and the establishment of a transparent, robust monitoring and evaluation system, including economic analysis of co-benefits.
- **Establishing markets for carbon emissions and energy savings**. USAID could help the GOM implement a cap and trade mechanism, based on LGCC provisions. It could help SEMARNAT develop the building blocks for the carbon market from electric power production. If the Energy Transition Law is enacted, support could also be provided to CONUEE and SEMARNAT to develop a market of energy savings "white" certificates.
- **Linking Mexico and California's energy markets**. There is good potential to link portions of Mexico's clean energy market to California's to reduce the total cost of reaching the environmental goals of both jurisdictions. USAID could support (1) the establishment of Clean Energy Certificate labeling; (2) a compatibility assessment between California and Mexican clean energy standards; (3) Mexican firms working to meet California's requirements; and (4) an analysis on whether the integration of these CELs markets would reduce the cost of achieving California's renewable energy goals—if yes, it would build an economic case for linking these markets.
- **Developing institutional capacities for the energy sector at the state level**. As a result of Mexico's energy reform, subnational government will have to play a more active role in areas such as

purchasing power from different suppliers, meeting clean energy requirements, and promoting the development of the energy sector within their jurisdictions. Only a few state governments in Mexico have a dedicated energy agency.[2] Support could be provided for the development of state and/or municipal agencies or commissions to adequately plan and implement state-level clean energy policies.

3. OPPORTUNITIES TO ENHANCE ENERGY EFFICIENCY AND REDUCE GHG EMISSIONS IN KEY SECTORS IN MEXICO

The largest GHG mitigation potential from greater efficiency is in Mexico's transport sector, followed by industry, waste, and buildings.[3] Except for waste, which includes the relatively costly improved treatment of wastewater, GHG reductions in these sectors can underpin the transition to low emission development, while yielding important economic benefits (MLED, 2013). Potential emissions reductions from municipal services (including waste management) and buildings would seem relatively modest; they were included in this assessment because they were viewed as priorities by stakeholders and could yield important co-benefits, including economic savings, improved local environmental conditions, and opportunities for private sector engagement. The CEADIR team's recommendations for GHG mitigation actions in these sectors are presented below in decreasing order of their GHG emissions reduction potential.

Transport and Urban Development

Road transport contributed 95 percent of the transport sector's GHG emissions in 2010. The growth of the transport sector's GHG emissions has been associated with increased motorization and urban sprawl. Between 1990 and 2010, Mexico's population increased at an annual rate of 2.5 percent while vehicle ownership grew at 3.6 percent and vehicle-kilometers driven at 7.7 percent (ITDP, 2013). Vehicle ownership continued to grow at a similar average annual rate between 2010 and 2014.[4]

Increasing fuel efficiency and fuel substitution can reduce GHG emissions over the medium term as owners replace their vehicles. However, these actions could be offset by increased vehicular use. Complementary transport and urban development interventions are needed to reduce GHG and air pollution emissions, as well as the congestion, noise, and traffic accidents that account for over 80 percent of the negative externalities generated by private vehicle use in Mexico's metropolitan areas (ITDP, 2013).

Recommendations

The activities below could successfully reduce vehicle use in Mexico's main urban areas and be scaled up to help Mexico reduce transport emissions:

- Reduce the use of private vehicles and improve the efficiency of the vehicle stock through scrappage programs, school bus programs and other shared transportation initiatives, parking meters and other demand management interventions, and improvements in efficiency of government-owned vehicle fleet.

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[2] These include Baja California, Hidalgo, Sinaloa and Sonora. http://www.conuee.gob.mx/wb/Conuee/comisiones_estatales_de_energia

[3] Mitigation from industry and buildings include direct and process reductions, as well as indirect reductions from decreased power consumption. Waste is considered a renewable source of energy by Mexican legislation; however, it is discussed in this memo because it was not covered in the NREL assessment on renewable energy and it is a priority for Mexico, as stated in the General Law on Climate Change and the climate change laws of Veracruz and Mexico City.

[4] INEGI. Estadísticas de vehículos de motor registrados en circulación. http://www.inegi.org.mx/est/lista_cubos/consulta.aspx?p=adm&c=8

- Improve accessibility, security, and quality of public transport through public transport integration, introduction of peak-pricing strategies, and reduction of gender-based violence (GBV) in public transport.
- Promote sustainable urban development to reduce the need for motorized vehicles through the development of financial mechanisms for denser urban development, facilitation of public-private partnerships (PPPs) for urban mobility, and mobilization of finance for public transportation and protected bicycle lanes.

Industry

Medium-sized businesses account for two-thirds of industrial electricity consumption in Mexico.[5] These firms also require more support than large industries, which have generally already invested in energy efficiency to increase their competitiveness, and have access to capital for investments and specialized technical assistance. Some large-sized firms even have dedicated energy teams.

Recommendations

The following activities could improve industrial energy efficiency, particularly for medium-size firms. These activities could be geographically focused in areas with a high density of industrial complexes, such as the Bajío, Mexico City and nearby states, and the Mexican states along the US border:

- Promote energy management systems (EMS) by helping key energy efficiency stakeholders assess the pros and cons of different energy efficiency standards and working with financial institutions to link credit lines to EMS so that results are monitored and transaction costs reduced.
- Expand energy efficiency insurance in other sectors and with other technologies, particularly by helping develop easily accessible and understandable standardized contracts that can be signed by medium enterprises and providers of energy efficiency technology.[6]
- Encourage energy efficiency gains by working with SMEs that sell to large firms interested in improving the energy and environmental performance of the suppliers and distributors in their value chains.
- Support energy audits and improved management by reducing carbon taxes if a firm has made substantial energy efficiency improvements.
- Help the federal and state governments set up financing windows for energy efficiency projects within a public-private trust fund for priority industries.

Municipal Services

Municipal services that generate GHG emissions include street lighting, water supply, and municipal solid waste and wastewater management. Solid waste and wastewater contributed 5.9 percent of national GHG emissions. In 2010, solid waste was the source of 53.5 percent of GHG emissions from waste, followed by those from

[5] According to the regulations for Mexico's SME Fund, medium commercial firms have 31-100 workers and sales of MXN 100.01 to 250 million (US $ 6.7-16.6 million/year); medium service firms have 51-100 workers and sales of MXN 100.01 to 250 million (US $ 6.7-16.6 million/year); and medium industrial firms have 51-250 workers and sales of MXN 100.01 to 250 million (US $ 6.7-16.6 million/year).
[6] Under an energy efficiency insurance, if the guaranteed energy savings are not realized, suppliers are required to fix the problem, and a part of their payment is retained as a guarantee. If achieved savings are too low, the participating firm can request the execution of a performance bond to recover its investment. Conversely, when savings exceed the agreed amount, additional benefits are shared between the suppliers and the firm.

municipal wastewater treatment at 23 percent and industrial wastewater treatment at 21.6 percent (SEMARNAT, 2013).

Recommendations

Opportunities to support municipalities in achieving GHG emissions reductions and energy savings include:

- Expanding power generation from solid waste management by providing municipal officials with access to technical resources, including technical assistance on available technologies and alternative financial and market mechanisms that can be adopted to fund this type of projects.
- Replicating best practices for energy efficiency improvements in public lighting and water pumping, potentially through the establishment of networks that provide technical assistance and on-the-spot support. Networks could include publicly-funded hotlines and information hubs or brokers that collect a fee for structuring the projects by bringing together different financial and technical service providers.
- Conducting rapid energy assessments for municipal buildings, and linking financial instruments and market mechanisms to realize the investment on energy savings in buildings with highest return of investment.
- Facilitating implementation of pre-identified projects by providing financial and technical support for feasibility studies, and leveraging financial resources, and reducing risks and transaction costs.

Buildings

Residential, commercial, and public buildings consumed 31 percent of Mexico's electricity in 2014, the second largest use after industry. Residential and commercial buildings also used fossil fuels, particularly liquefied petroleum gas (LPG), which comprised nearly 47 percent of fossil fuel use in buildings. Buildings were responsible for over 9 percent of Mexico's GHG emissions in 2010, 6.9 percent from residential buildings, and 2.4 percent from commercial and public buildings (SEMARNAT, 2013).

Recommendations

Key activities to reduce GHG emissions from buildings include:

- Deploying solar water heating (SWH) by bringing local governments together with installers to develop a program to install SWH in residential and commercial buildings; developing new financial and market mechanisms to make SWH more attractive (such as adding the cost of an assessment and installation to property's tax bills); and supporting programs for female-headed households that would be more likely to accept advice and services from female technicians.
- Establishing and enforcing energy-efficient building codes and strengthening the capacity of public officials, engineers, and architects to apply better construction techniques and energy-efficient equipment; developing a program for energy-efficient buildings in commercial and public buildings; analyzing current compliance gaps and identifying good practices and developing a strategic compliance plan; and supporting financial analyses and market assessments for energy efficiency (as is done by the US Department of Energy's Better Buildings Program).
- Promoting green certification by replicating successful programs in large cities and developing a building labeling program.

- Preparing plans for the development and rehabilitation of industrial, commercial, and residential buildings, including abandoned buildings; and supporting a policy dialogue to improve the regulatory environment and incentives for these investments or help identify financing sources.
- Consolidating and structuring financing for energy efficiency in buildings, by helping domestic institutions structure debt and leverage financing for energy efficiency in new housing and retrofits by bundling and standardizing interventions and scaling up financing mechanisms.

1. INTRODUCTION

This report presents the findings of an assessment of energy efficiency, financing, and market mechanisms in Mexico conducted by a team from the United States Agency for International Development (USAID)-funded Climate Economic Analysis for Development, Investment and Resilience (CEADIR) project. The objective of the assessment was to identify promising activities that USAID/Mexico could support in a new project to reduce greenhouse gas (GHG) emissions from energy production, distribution, and consumption in Mexico from FY 2016 to FY 2021.[7]

The assessment centered on the identification and evaluation of opportunities to reduce GHG emissions in Mexico by increasing energy efficiency. It also focused on financing instruments to increase capital flows for low-emission development and the technical and political feasibility of using economic instruments that provide price signals to reduce GHG emissions. In addition, gender perspectives were mainstreamed throughout the assessment.

Prior to the CEADIR assessment of energy efficiency and carbon markets, the US National Renewable Energy Laboratory (NREL) completed an assessment of renewable energy opportunities and grid integration, which will provide input for the same USAID/Mexico project. Consequently, this report only discusses renewable energy tied to energy efficiency options or in the context of market mechanisms or financing..

1.1. METHODS

The assessment began with a review of the literature covering Mexico's legal and institutional framework for climate change and energy efficiency, as well as recent research on these topics conducted by domestic and international experts. The CEADIR team then met with stakeholders from governments, international and bi-lateral organizations, civil society organizations, private firms, and academia to discuss ongoing efforts in these fields, lessons learned, and opportunities for potential USAID assistance. Most of these meetings took place during June 15-26, 2015, when two team members from USAID/Washington traveled to Mexico City to work with a USAID/Mexico mission staff member and the CEADIR team. Additional meetings were held by the Mexico-based team members between July 2 and August 5, 2015, including meetings with state and municipal government officials from Mexico City, Veracruz, and Yucatan. The meeting attendees are listed in Appendix 1. Meeting and Attendees

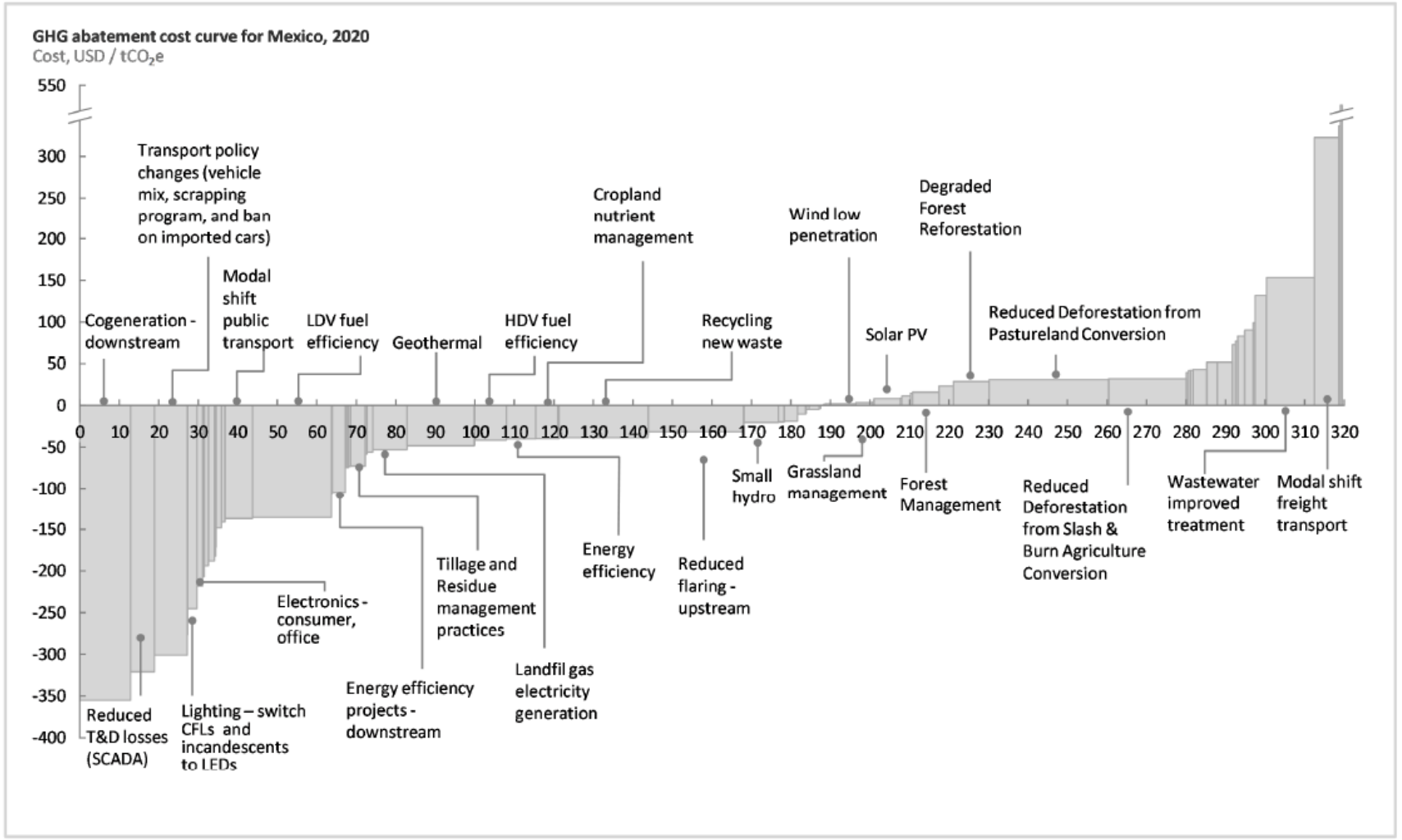
Based on the information from the literature review and stakeholder consultations, the CEADIR team identified a broad set of potential activities. The following principles were then used to set priorities for potential USAID support:

- **Cost-effectiveness and co-benefits:** the General Law on Climate Change (LGCC) requires the GOM to give priority to the least costly mitigation actions that also produce health and other co-benefits for the population. To ensure that USAID's support is consistent with Mexico's legal framework, this assessment began by reviewing existing cost-effectiveness analyses, including the USAID/Mexico Low Emission Development project (MLED) 2013 Marginal Abatement Cost Curve for Mexico (Figure 1).
- **Technical and political feasibility:** to ensure that identified opportunities are aligned with government policies and that proposed technological solutions can be implemented effectively in Mexico.

[7] The United States Government's fiscal year runs from October 1 through September 30.

- **Role for USAID:** based on the agency's mandate and capacity, as well as opportunities to fill gaps or build synergies with the efforts of multilateral development banks and bilateral donors.
- **Scalability and mitigation cost:** activities could be expanded at a reasonable cost and under widely available conditions so that a large volume of GHG emissions can be reduced.
- **Sustainability:** enabling stakeholders to continue the activities once USAID assistance ends.
- **Impact:** measurable and sizable GHG emissions reductions.
- **Private sector participation**: leveraging resources by acting as a catalyst and convener for private sector investment.
- **Institutional capacity development for LEDS**: enhancing cross-sectoral inter-agency coordination, educating stakeholders in clean energy about its role in climate change mitigation, and designing programs to maximize the emission reductions obtained, linking domestic clean energy activities with Mexico's Intended Nationally Determined Contributions (INDC) process and United Nations Framework Convention on Climate Change (UNFCCC) commitments.

Figure 1. GHG Abatement Cost Curve for Mexico, 2020



Source: MLED, 2013

2. OVERVIEW OF CLIMATE CHANGE AGENDA AND FRAMEWORK

This section summarizes Mexico's climate change and energy efficiency priorities, targets, policies, and laws; institutional responsibilities; measurement, reporting, and verification (MRV) systems; and gender issues. It first describes the federal government's agenda and framework and those of selected states and municipalities. Most subnational governments in Mexico do not have energy laws or agencies in place, although this may change in the future, and states and municipalities have benefited from donor support in identifying and funding energy efficiency improvements. This section also discusses financial and market mechanisms that can support Mexico's transition toward a low emission development pathway. The section concludes with recommendations for actions that USAID could support to strengthen Mexico's institutional framework for climate change and clean energy, expand financial and market mechanisms to scale up action to reduce GHG emissions from energy sector, and step up efforts for gender mainstreaming in climate change mitigation activities.

2.1. FEDERAL GOVERNMENT CLIMATE CHANGE PRIORITIES, TARGETS, POLICIES, AND LAWS

The Government of Mexico (GOM) has a relatively comprehensive institutional framework for addressing climate change. The General Law on Climate Change (LGCC) of 2012 defined the scope of Mexico's national climate change actions, the responsibilities of federal, state and local governments, and the institutional arrangements to meet the law's objectives.[8] The LGCC has non-binding, aspirational goals of reducing the country's greenhouse gas (GHG) emissions by 30 percent in 2020 relative to a business as usual (BAU) scenario and by 50 percent in 2050 compared to the year 2000. Achievement of these goals is contingent on financial and technological support from developed countries).[9]

Other aspirational goals established by the LGCC:

- By 2018, develop and build municipal infrastructure for the management of solid waste that does not emit methane into the atmosphere in urban centers with more than 50,000 inhabitants and, if feasible, generate electricity from the methane gas.
- Gradually develop a system of subsidies by 2020 that promotes use of non-fossil fuels, energy efficiency measures, and sustainable public transportation.
- By 2020, establish an incentive-based system that promotes profitable electricity generation through renewable energy by the Federal Electricity Commission (CFE).
- By 2024, generate at least 35 percent of electricity from clean energy sources. The LGCC did not define clean energy sources, but the 2014 Electric Industry Law has a broad definition that includes, among

[8] ELI (2012) contains an English translation of the full law and a summary in English is in IDLO (N.D.).
[9] The Law also includes adaptation goals and mitigation goals for the forestry sector, but these are beyond the scope of this assessment.

others, renewable energies, efficient co-generation, energy generated by thermal plants with CO_2 capture and storage processes, and others as determined by SEMARNAT.[10]

The LGCC established policy instruments for the short, medium, and long terms. Under the Special Climate Change Program (PECC), each national government administration is mandated to develop priority climate change mitigation actions for its six-year term of office. Mitigation actions included in the PECC may address energy use and generation, gas flaring and venting, transport, agriculture, forests, other land uses, industrial processes, and waste management. The National Climate Change Strategy has a longer time frame, with climate change goals for 10-, 20-, and 40-year periods and mitigation priorities based on abatement potential, marginal abatement cost, and in environmental, social, and economic benefits.

The LGCC also stated actions selected by the national government administration that would result in costs for the private sector or society in general and that lack international funding may be implemented in two phases. The first phase would focus on the development of national capacities, while activities and policies are voluntary. The second phase would consist of the establishment of specific emissions reduction goals, considering each sector's contributions to the country's GHG emissions and cost-effectiveness.

In compliance with the LGCC, the GOM published a National Climate Change Strategy in June 2013 and the PECC for 2014-2018 in April 2014. The 2014 PECC contained mitigation goals for GHG emissions with a 20-year and 100-year global warming potential (GWP) and methane and black carbon emissions reductions to be achieved by 2018. Table 1 shows the PECC's quantitative mitigation goals and the additional reductions that could be achieved through the implementation of identified, externally funded Nationally Appropriate Mitigation Actions (NAMAs) from 2014 to 2018. SEMARNAT is in the process of integrating a public NAMA registry. However, as of August 2015, the information about existing NAMAs and their status was not publicly available.

Table 1. Mexico's Mitigation Goals under PECC 2014-18 with and without Externally Supported NAMAs

	PECC Action Lines	Identified NAMAs	Total for PECC and NAMAs
GHG emissions reductions (GWP 100)	83.20 million tCO_2e/year	9.42 million tCO_2e/year	92.62 million tCO_2e/year
GHG emissions reductions (GWP 20)	95.97 million tCO_2e/year	18.91 million tCO_2e/year	114.88 million tCO_2e/year
Methane emissions reductions	161,724 tons/year	116,667 tons/year	278,391 tons/year
Black carbon emissions reductions	2,157 tons/year		2,157 tons/year

Note: GWP 100= Global Warming Potential for 100 years; GWP 20= Global Warming Potential for 20 years. The GHGs for both time frames include Carbon dioxide (CO_2), Nitrous oxide (N_2O), Fluorocarbons and Perfluorocarbons (HFC + PFC), Sulfur hexafluoride (SF_6), Methane (CH_4), and black carbon. Among these, methane and black carbon have an average life of less than 20 years and, consequently, contribute with a higher share of Mexico's GHG emissions with a GWP20 than that of GHG emissions with a GWP100.

Source: Adapted from GOM, 2014.

The Governments of Bangladesh, Canada, Ghana, Mexico, Sweden, and the United States and the United Nations Environment Programme (UNEP) established the Climate and Clean Air Coalition (CCAC). The CCAC stresses the importance of tackling Short-Lived Climate Pollutants (SLCP) because their "concentrations can be reduced in a matter of weeks to years after emissions are cut, with a noticeable effect on global temperature

[10] The definition of Clean Energy is provided with more detail in section 0 of this report.

within the following decades" (CCAC, 2014, p. 11). In addition to contributing to climate change, black carbon and ozone (O_3) have detrimental impacts on human health and O_3 damages plants and agricultural production. Black carbon is not currently part of the GHG reporting requirements for Parties to the UNFCCC, but the GOM has included it in its INDC.

The PECC includes 23 action lines that define specific institutional responsibilities and steps to achieve the long-lived GHG mitigation goals and four action lines for each of the methane and black carbon goals. However, the bulk of Mexico's mitigation goals could be achieved through just a few of these action lines. Five action lines could achieve more than 70 percent of the GHG mitigation goal with a GWP 100 and more than 60 percent of the GWP 20 mitigation goal (Table 2). Greater energy efficiency could achieve 10-12 percent of the carbon mitigation goals. Increasing treatment of municipal wastewaters could achieve close to 74 percent of the mitigation goal for methane (GOM, 2014).

Table 2. PECC Action Lines with Highest GHG Mitigation Potential

Action Line	Million tCO_2e/year*	Percent of Mitigation Goal (GWP 100)	Percent of Mitigation Goal (GWP 20)
3.2.1. Promote the diversification of the energy matrix with public and private investment in generation from clean energy sources	18.7	22.5	19.5
3.2.2 Substitute the use of diesel and fuel oil in the energy matrix with less carbon intensive sources	11.8	14.2	12.3
2.3.3 Promote livestock production with sustainable land and livestock practices	11.8	14.2	12.3
3.1.2 Promote energy efficiency through energy efficiency standards, public lighting, and federal government buildings, installations and vehicles**	9.7	11.6	10.1
2.3.1 Avoid GHG emissions from deforestation and forest degradation	8.8	10.5	9.1
Total	**60.8**	**73.0**	**63.3**

Note: * For all of these action lines, the GWP 100 is equal to the GWP 20.

** Energy efficiency standards refer to a broad range of areas, including appliances, buildings, motors, and lighting.

Source: Adapted from GOM, 2014.

The PECC set forth 8 lines of action with a gender approach and 11 strategies and 35 lines of action aligned with the National Program for Equal Opportunities and Non-Discrimination against Women (PROIGUALDAD). The main aim of these actions was to provide equal access for women in climate change adaptation actions and recognize the different vulnerabilities of women and men. However, these actions also aimed to promote gender equality in accessing renewable energy sources, incorporate gender perspectives in urban development, increase women's safety in public and non-motorized transportation, and provide equal access for women and girls to financial instruments for climate change adaptation and mitigation. In addition, the LGCC mandated that PECC-implementing agencies generate gender-disaggregated data for Mexico's climate change information system (GOM, 2014).

On March 30, 2015, Mexico became the fourth country to submit its INDC to the UNFCCC. Comparing the goals set by the LGCC and those of the INDC is not a straightforward task because each of them uses different timeframes. In addition, the INDC explicitly includes mitigation goals for SLCPs, which were not included in the LGCC. However, according to the INDC itself, the goals presented in the INDC are "consistent with Mexico's

pathway to reduce 50 percent of emissions by the year 2050, with respect to the year 2000, as mandated by the LGCC" (GOM, 2015: 2). Moreover, whereas all the LGCC's goals were non-binding, the INDC includes commitments to achieve some GHG reductions independently of any international support, as well as to increase such reductions if certain conditions are met (Table 3).

Table 3. Mexico's Unconditional and Conditional GHG Emissions Reduction Goals

Type	Mitigation Goal
Unconditional	Reduce 25% of its GHG and SLCP emissions below the Business as Usual (BAU) scenario for 2030. This commitment implies a reduction of 22% of GHG and a reduction of 51% of Black Carbon. The INDC implied a commitment to reach "a net emissions peak by 2026 and reducing the emissions intensity per unit of Gross Domestic Product (GDP) by around 40% from 2013 to 2030.
Conditional	The emission reduction commitments could be increased through a global agreement addressing international carbon prices, carbon border adjustments, technical cooperation, access to low-cost financial resources and technology transfer, all at a scale commensurate to the challenge of global climate change. If these conditions are met, emission reductions could increase to 36% for GHGs and 70% for black carbon in 2030.

Source: GOM, 2015.

The INDC anticipated emissions reductions in (1) energy, (2) industrial processes and product use, (3) agriculture, (4) waste, and (5) land use, land use change, and forestry. However, it did not provide information on the emission reductions from each of these sources. It also aimed to build synergies between mitigation and adaptation, particularly by implementing ecosystem-based adaptation actions that sequester carbon, such as reforesting watersheds. It stated that human rights and gender concerns will be incorporated in measures to achieve the INDC's objectives and recognizes women's role as key decision-makers regarding energy consumption. The INDC highlighted the need to incorporate a gender and human rights approach into capacity building, giving priority to the most vulnerable sectors and regions to reduce social inequality and the gap between women's and men's rights (GOM, 2015).

In addition to the climate change legal and policy framework, laws and regulations affecting energy production, distribution, and use are critical since energy generates more than 67 percent of Mexico's total GHG emissions. The recent and upcoming changes in Mexico's legal framework for the energy sector (particularly electricity and petroleum) will have major implications for GHG emission reductions.[11] In 2008, the Law for the Use of Renewable Energies and Finance for Energy Transition (LAERFTE) established Mexico's renewable energy goals, stating that no more than 65 percent of Mexico's electricity should be generated from fossil fuels by 2024 and 50 percent by 2050. However, Mexico's clean energy goals could become significantly more ambitious if an Energy Transition Law is adopted, based on the bill approved by the Chamber of Deputies in December 2014 and revised by the Senate in December 2015. The bill includes provisions for the establishment of planning and financial instruments that would significantly facilitate compliance with the 2024 clean energy goal. In addition, SEMARNAT would be required to develop a roadmap detailing the GHG emissions reductions that the electric industry would need to achieve in order to meet the LGCC's mitigation goals.

[11] BNEF (2014), PwC (2014), and White & Case (2013) summarized Mexico's historic energy reform that began in 2013 and are still underway.

2.2. SUBNATIONAL GOVERNMENTS' CLIMATE CHANGE PRIORITIES, TARGETS, POLICIES, AND LAWS

Under the LGCC, state governments are responsible for formulating, implementing and evaluating their climate change policies and promoting climate change mitigation and adaptation. The states' efforts must be consistent with the national policy and instruments. State governments have climate change mitigation and adaptation responsibilities in such areas as transportation and infrastructure, land use planning and urban development (in coordination with municipalities), and "special management wastes", which are defined by Mexico's General Law on Waste Prevention and Integrated Management (LGPGIR) as those generated as a result of productive processes and do not meet the characteristics of either hazardous waste or urban solid waste, or that are produced by a person or firm that generates 10 tons or more of waste per year. States are the only jurisdictions that have a mandate under the LGCC for climate change programs that promote gender equality and incorporate the needs of vulnerable populations.

Until 2015, municipalities had 3-year terms of office and generally limited resources and capacity in Mexico. Municipal officials elected in 2015 will be the first generation of such officials that may run for a one time reelection. In terms of climate change, municipal efforts must be consistent with federal and state climate change policies and instruments. Climate-related areas under municipal jurisdiction include: water supply and sanitation; local land use planning and urban development; natural resource management; municipal solid waste management; and public transportation.

As shown in Figure 2, all Mexican states have started to develop their State Climate Change Action Programs (PEACC).[12] This assessment reviewed the PEACC for the states of Veracruz and Yucatan as well as climate change frameworks for Mexico City and the Municipality of Xalapa in Veracruz State. These jurisdictions were identified as climate change action leaders.

[12] Several terms are used to refer to the State's climate change programs, including Climate Action Programs, Climate Change Action Programs, and Climate Change Mitigation and Adaptation Programs. The generic term PEACC is used in this assessment to refer to all of them, except when making reference to a specific program.

Figure 2. Status of State Climate Change Action Programs in Mexico

Note: PEACC planned PEACC under development PEACC completed
State GHG inventory under development State GHG inventory completed

Source: http://www2.inecc.gob.mx/sistemas/peacc/. Updated on August 1, 2014.

The State of Veracruz

Veracruz has been a leader on climate change actions among the states in Mexico and developed a Climate Change Program in June 2009. This program identified opportunities to mitigate GHG emissions, but did not include any quantitative goals. In November 2010, the Veracruz Congress passed the State Law on Mitigation and Adaptation to Climate Change Impacts.[13] This law provided guidance on climate change mitigation efforts, including:

- Improved solid waste management in urban areas with populations over 50,000 to reduce methane emissions.

[13] The Climate Change Law of Veracruz has been a model in other states, such as Baja California, which adopted its own law in June 2012. http://www.congresobc.gob.mx/legislacion/Parlamentarias/TomosPDF/Leyes/TOMO_VII/Leycamclim-2_27MAR2015.pdf.

- Public transport vehicles in all urban centers must comply with federal emission standards, must undergo emission inspections, and may be replaced by more efficient systems.
- Electricity generation for state facilities from clean sources.
- State promotion of energy efficiency measures, as well as innovation in clean technologies (arts. 7 and 29).

Veracruz's Climate Change Program and law assigned most mitigation and adaptation responsibilities to environmental agencies. In recognition of the cross-sectoral nature of climate change actions, the law was amended in July 2013 to distribute responsibilities more widely across state government agencies. Veracruz initiated efforts to mainstream climate change into the development agendas of key sectors through the Climate Change Sectorial Agendas for 2012-16. These agendas were integrated by state government officials with the support of the Centro Mexicano de Derecho Ambiental (CEMDA), academia, the private sector, and civil society organizations.

The agendas included 377 climate change actions to be implemented by 18 state agencies during the 2012-2016 administration. A total of 86 of these actions focus on climate change mitigation. The rest of the actions addressed (1) health impacts and social vulnerability to climate change, (2) climate change detection and follow up, (3) biodiversity, (4) economy, (5) water resources, and (6) coasts. The Government of Veracruz aims to mitigate 1.4 million tCO_2e/year through these agendas, especially through renewable energies, energy efficiency, integrated waste management, and sustainable mobility (GOV 2013). The State of Veracruz has also pioneered state-level efforts to integrate gender perspectives in its climate change actions. It has organized workshops for officials from various state agencies to better understand climate change-gender linkages, particularly in terms of reducing women's higher vulnerability to climate change.

The State of Yucatán

The State of Yucatan does not have a specific climate change law. However, it published a Special Climate Change Action Program for the State of Yucatan (PEACC-Y) in April 2014 (GOY, 2014). The PEACC-Y was developed with support from SEMARNAT, INECC, and the Inter-American Development Bank (IDB). It set a goal of mitigating 20 percent of its GHG emissions per unit of GDP by 2018 and 40 percent by 2030, relative to 2005. The baseline emissions intensity of the economy was1.13 tCO_2e per MXP 1000 in 2005. Meeting the PEACC-Y goals would reduce the emissions intensity to 0.23 tCO_2e/MXP 1000 in 2018, and 0.68 tCO_2e/MXP 1000 in 2030.

The PEACC-Y did not list the actions that will be implemented to meet its mitigation goals. However, it did identify industry and agriculture as priority sectors for mitigation, based on their contributions to the state's GHG emissions: industry (including electricity generation), commerce, and tourism comprised 41 percent of the state's GHG emissions in 2005. Agriculture, livestock, and forests generated 36 percent of the GHG emissions in 2005. In addition, the PEACC-Y referred to human settlements (urban planning, buildings, transport, and urban waste management) as relevant areas for both mitigation and adaptation. The Government of Yucatan is partnering with two other state governments, Campeche and Quintana Roo, on a Regional Climate Change Strategy for the Yucatan Peninsula. The three state governments, together with UICN's Global Gender Office, have developed guidelines to mainstream gender in the regional strategy.

Mexico City

Mexico City's Government published a Law on Climate Change Mitigation and Adaptation and Sustainable Development of the Federal District in June 2011. This law gave the city mayor responsibility for designing and implementing a municipal climate change policy and climate action program. It provided guidelines for climate change mitigation, including actions to generate energy from solid waste, sustainable transport systems, promotion of energy efficiency (specifically public lighting and sustainable buildings), and renewable energy.

Mexico City's Climate Action Program (PACCM) 2014-2020 was developed by the Centro Mario Molina and was one of the most comprehensive subnational programs in Mexico. The program included close to a hundred mitigation actions that could abate 8-10 million tCO_2e by 2020. A few actions comprised the majority of the mitigation potential (Table 4). Most of these mitigation measures have a positive net present value or marginal net benefits, but the investments needed exceeded the city government's financial resources (MCG, 2014). The PACCM incorporated gender equality as a guiding principle and included objectives and actions with a gender approach. These measures included the development of a land use plan for Mexico City with a gender perspective, a gender focus in efforts to prevent and treat illnesses associated with climate change, assessments of the linkages between gender inequality and climate change to inform public policies, and development of gender-specific climate change indicators.

Table 4. PACCM Actions with Highest GHG Mitigation Potential

Action	Mitigation Potential (Cumulative tCO_2e by 2020)
GIR3. Use of waste for energy generation*	2,361,934
EE2. Scrappage of refrigerators	1,242,424
FI3. Regulating freight transport	1,165,151
REC2. Substitution and scrappage of microbuses**	933,506
REC7. Implementation of new BRT ("Metrobus") corridors**	875,000
EE1. Modernize and improve the energy efficiency of the metro system**	439,524
REC1. Expansion of the metro's 12th line*	281,582
EE4. Foster continuous energy efficiency in the service sector	159,352
ER1. Modify construction regulations	150,207
GIR1. Incorporate sludge stabilization systems in wastewater treatment plants**	101,180
EE5. Energy savings program in the operation of wells and pumps in Mexico City's water system**	93,262
EE7. Energy efficiency in public lighting	88,188

Note: * Measure has positive net benefits ($/tCO2e)

**Measure has a positive net present value. The program does not specify the discount rate that was used in the analysis. The analysis is based on each action's benefits and costs over a six year period. Although it is an unusually short period for a benefit-cost analysis, it was used because six years is the duration of the city administration that adopted the program.

Source: MCG, 2014.

Xalapa, Veracruz

The City of Xalapa in Veracruz issued its Municipal Climate Action Plan (PACMUN) in 2012, with support from ICLEI (Local Governments for Sustainability), the British Embassy, the State Government, INECC, and SEMARNAT. The plan included a quantitative goal to reduce 16,436 tCO_2e during the 2011-2013 municipal administration. The PACMUN lists actions to be undertaken, but did not quantify the resulting emissions reductions. These actions include energy efficiency standards for new buildings, solar water heaters, and

rationalization of public transportation routes. These actions would complement other ongoing projects, such as the installation of energy-efficient public lighting (Government of Xalapa, N.D.).

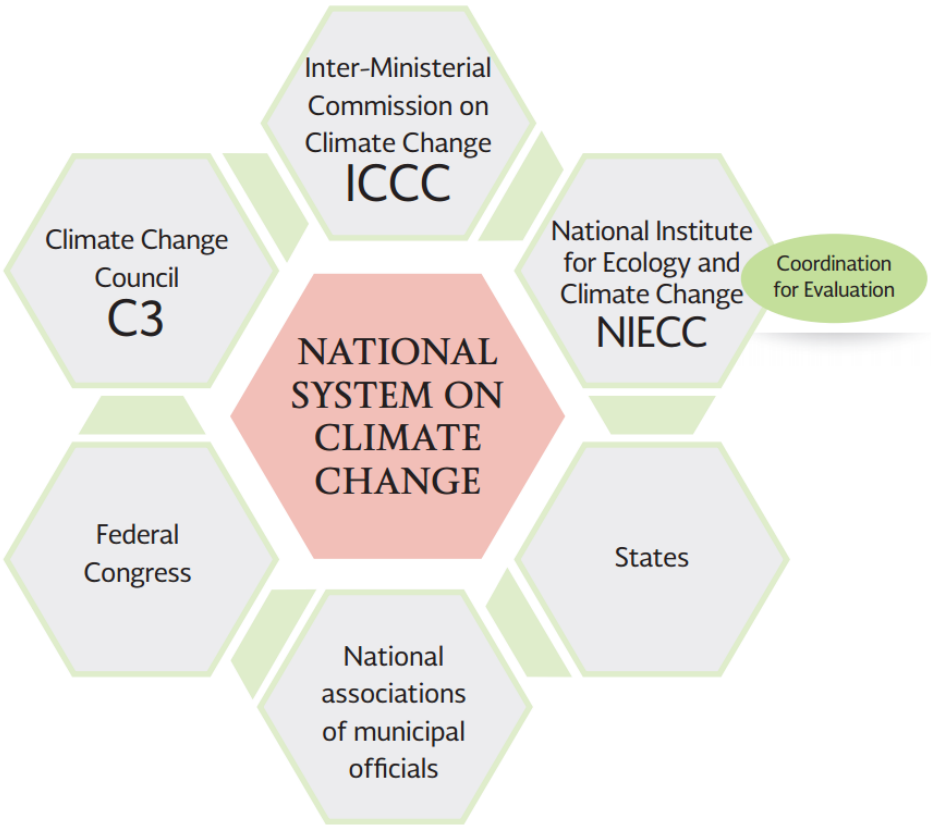
2.3. INSTITUTIONAL MAKEUP AND RESPONSIBILITIES FOR FEDERAL CLIMATE CHANGE PROGRAMS

The LGCC defines the institutional responsibilities for federal climate change programs. The main federal entities with responsibilities for designing, implementing, and evaluating climate change programs were:

- **Inter-Ministerial Commission on Climate Change (CICC):** This permanent coordinating body has representatives from 14 federal secretaries: Interior (SEGOB); Foreign Affairs (SRE); Navy (SEMAR); Finance (SHCP); Social Development (SEDESOL); Environment and Natural Resources (SEMARNAT); Energy (SENER); Economy (SE); Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA); Communications and Transportation (SCT); Public Education (SEP); Health (Salud); Tourism (SECTUR); and Agrarian, Territorial, and Urban Development (SEDATU). The CICC is chaired by the President, who can delegate this responsibility to the SEMARNAT. The CICC is responsible for formulating and implementing national policies on climate change mitigation and adaptation, and mainstreaming them into the corresponding sector programs and actions. The CICC is also responsible for approving the National Climate Change Strategy and for the elaboration and implementation of the PECC.
- **Ministry of Environment and Natural Resources (SEMARNAT):** This agency is responsible for developing climate change planning and policy instruments, including the National Climate Change Strategy, the PECC, and the National GHG Registry. SEMARNAT also heads the technical committee of Mexico's Climate Change Fund and has the legal authority to establish a voluntary emissions trading system to reduce GHG emissions. The SEMARNAT is responsible for ensuring that state climate change programs are consistent with the national institutional framework.
- **National Institute of Ecology and Climate Change (INECC):** This federal research organization was created by the LGCC to coordinate and carry out scientific and technological research and projects on climate change, environmental protection, and ecological preservation and restoration. It is part of the SEMARNAT. INECC is responsible for sector analysis and support for climate change strategies, plans, programs, and actions. INECC also provides recommendations to strengthen the climate change actions of federal, state, and municipal agencies.
- **Coordination for Evaluation (CE):** This coordinating body consisted of the head of INECC and six civil society advisors from the scientific, academic, technical, and industrial communities. The LGCC states that CE must evaluate Mexico's climate change policy every two years. This evaluation is submitted to the Mexican Congress and available to the public.
- **Climate Change Council (C3):** This permanent advisory body of the CICC included climate change experts from civil society organizations, academia, and the private sector. The C3's main responsibilities include (1) advising the CICC and providing recommendations on climate change studies, policies, actions, and goals; (2) promoting social participation through public consultations; and (3) monitoring progress on national and subnational climate change policies, actions, and goals.

The law created the National Climate Change System (SNCC), integrated by CICC, the C3, INECC, state governments, a representative from the legally registered associations of municipal authorities, and the national Congress (Figure 3).

Figure 3. Institutional Framework for Mexico's National Climate Change System



Source: GOM, 2013.

Four organizations have key responsibilities for energy efficiency. The Ministry of Energy (SENER) is responsible for planning and setting energy and electricity policies. The National Commission for the Efficient Use of Energy (CONUEE) issues recommendations and provides technical assistance on energy efficiency to all levels of government, firms, and individuals. It also sets energy efficiency standards. Two trust funds have implemented the majority of energy efficiency projects to date. The public-private Fideicomiso para el Ahorro de Eficiencia Energética (FIDE) is a Trust Fund for Electricity Savings. It promotes industrial and residential electricity conservation and has mainly focused on central Mexico to date. The Trust Fund for the Thermal Insulation Program (FIPATERM) initially focused on thermal insulation projects, but then played a role similar to FIDE in Mexico's northern and southern states.

2.4. EXAMPLES OF SUBNATIONAL CLIMATE CHANGE PROGRAMS

Veracruz State

Veracruz created the State Climate Change Council to set strategies for climate change mitigation and adaptation and coordinating actions with municipal governments and civil society. The state governor heads the council, but may delegate this role to the Ministry of the environment, who also acts as the council's technical secretary. The council also includes 12 other state secretaries, the state comptroller, and representatives from

the state congress, the Veracruz University, the State Center for Climate Studies, civil society organizations, and municipal governments. Other stakeholders, including federal representatives, may be invited to participate in meetings.

Yucatan State

Yucatan's Inter-Sectorial Climate Change Commission was created in June 2010 to coordinate the actions of state agencies in the formulation and implementation of climate change mitigation and adaptation policies, strategies, and actions. The commission is chaired by the state governor. The ministry of government acts as general coordinator and chairs the meetings in the absence of the governor. The ministry of urban development and environment is the commission's technical coordinators. The eight additional members are the state secretaries for planning and budget, health, education, social policy, public works, economic development, tourism promotion, and agriculture and fisheries.

Mexico City

The mayor of Mexico City is responsible for incorporating climate change in the city's development plan and development and implementation of climate change policies and programs. The city's ministry of the environment leads technical and policy work, including the elaboration of the city's GHG emissions inventory, overseeing progress in PACCM implementation, development of climate change mitigation projects, and approving the climate change programs of the 16 local, administrative subdivisions ("delegaciones"). Mexico City's Inter-institutional Commission of Climate Change fosters inter-agency coordination. It is chaired by the mayor, who may delegate this responsibility to the ministry of environment. The Commission has 34 additional members, including all the city government secretaries, heads of public transport agencies, and members of the local legislative assembly.

Xalapa City, Veracruz

Xalapa's PACMUN was prepared by representatives from 13 different departments, including those responsible for public works, lighting, urban development, water and sanitation, and economic development. The PACMUN team was headed by the Special Projects Unit and received technical support from the municipality's environmental coordination office.

2.5. FEDERAL MRV SYSTEMS

The LGCC mandates the federal government to integrate MRV of emissions in the national climate change planning, policy and economic instruments.[14] MRV is addressed in the national GHG inventory, National Registry for GHG emissions, and the PECC.

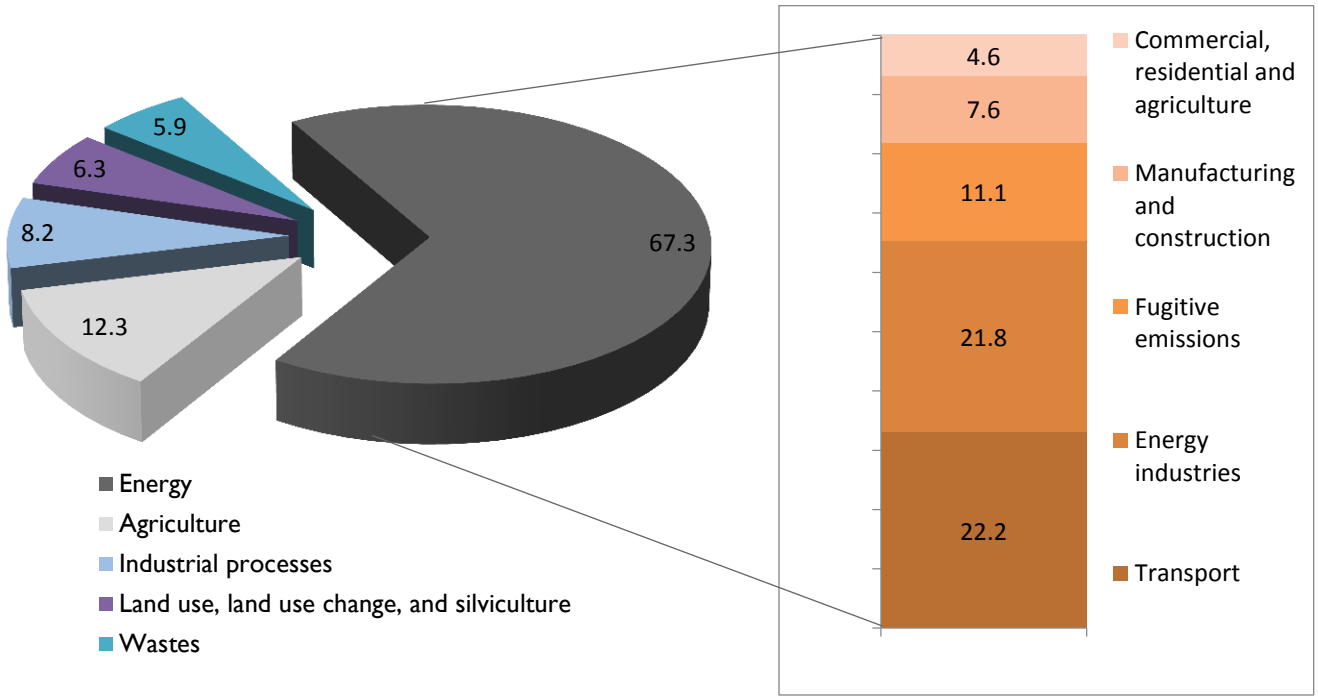
INECC is responsible for the national GHG inventory, using guidelines and methodologies approved by the UNFCCC and the Intergovernmental Panel on Climate Change (IPCC). GHG emissions from fossil fuels are estimated annually. Most other GHG emissions are estimated every two years, except for emissions from land use sources and GHG removal by sinks, which are estimated every four years.

[14] , MRV refers to "Measurement, Reporting, and Verification" for the UNFCCC and "Monitoring, Reporting, and Verification" for the LGCC; however, both refer to similar actions.

The National GHG Emissions Inventory for 1990-2010 is the most recent inventory publicly available (SEMARNAT, 2013). It included data on energy, industrial processes, agriculture, wastes, and land use, land use change, and forestry (LULUCF).

The national inventory estimated Mexico's total GHG emissions in 2010 at 748 million tCO_2e, an increase of 33.4 percent from 1990 (a 1.5 percent average annual growth rate). The energy sector contributed 67.3 percent of Mexico's GHG emissions, followed by agriculture; industrial processes; land use, land use change, and forestry; and wastes. Transport and electricity generation were the largest sources of emissions within the energy sector (Figure 4).

Figure 4. Mexico's GHG Emissions by Category, 2010 (percent of totals)



Note: Fugitive emissions are GHGs that are intentionally or unintentionally emitted during the extraction or processing of fossil fuels, as well as during their delivery to their point of use.

Source: SEMARNAT, 2013

Carbon dioxide (CO_2) comprised two-thirds of Mexico's GHG emissions. However, the emissions of methane and hydrofluorocarbons (HFC) grew at a faster rate than those of CO_2 between 1990 and 2010 (Table 5). The very high growth of HFCs reflects increased use of these substances in refrigerators and air conditioning in industry, homes, and automobiles as substitutes for chlorofluorocarbons (CFCs), which were phased out under the Montreal Protocol (SEMARNAT, 2013).

Table 5. Mexico's Emissions by Greenhouse Gas, 1990-2010

GHG	Emissions in 2010 (million tCO_2e)	Percent of Total GHG Emissions in 2010	Emissions Growth 1990-2010
Carbon dioxide (CO_2)	493.45	65.9%	23.6%
Methane (CH_4)	166.72	22.3%	59.8%
Nitrous oxide (N_2O)	69.14	9.2%	23.1%
Hydrofluorocarbons (HFC)	18.95	2.5%	2307%
Total	**748.25**	**100%**	**33.4%**

Source: SEMARNAT, 2013

Energy has been the largest contributor of GHG emissions since 1990 and its share grew from about 57 percent to 67 percent during the 20-year period. GHG emissions from industrial processes and waste more than doubled during this timeframe, while emissions from agriculture and LULUCF actually fell (Table 6).

Table 6. Mexico's GHG Emission by Source, 1990-2010

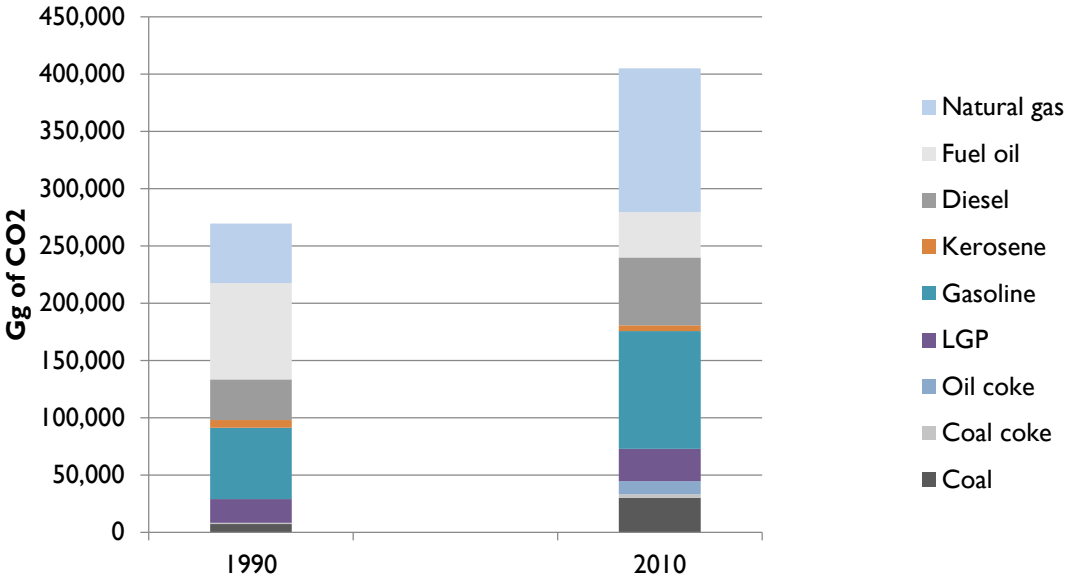
Source	Emissions in 1990 (million tCO_2e)	Emissions in 2010 (million tCO_2e)	Emissions Growth 1990-2010
Energy	319.17	503.82	78%
Industrial processes	30.27	61.23	102%
Agriculture	92.79	92.18	-1%
Land Use, Land Use Change and Forestry	101.26	45.67	-55%
Waste	16.53	44.13	167%

Source: SEMARNAT, 2013

The large share of Mexico's emissions from energy sector came from the country's reliance on fossil fuels. Natural gas, used primarily for electricity generation and manufacturing, contributed 30.8 percent of GHG emissions. Gasoline and diesel, mainly used in the transport sector, were the source of 25.2 percent and 14.6 percent, respectively, or 39.8 percent together, of GHG emissions from fuels. Although emissions from coal were relatively modest at 7.3 percent, they increased more than 324 percent between 1990 and 2010 (Figure 4) (SEMARNAT, 2013).

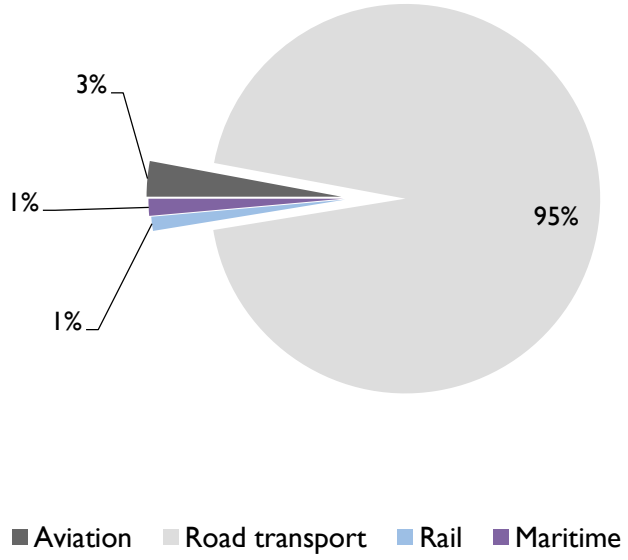
Emissions from transport grew 86.7 percent between 1990 and 2010. Transport generated 15.9 percent of Mexico's GHG emissions in 1990, rising to 22.2 percent in 2010. Road transport was responsible for 95 percent of the transport emissions (Figure 6).

Figure 5. GHG Emissions from Fuel Use, 1990 and 2010



Source: SEMARNAT, 2013

Figure 6. GHG Emissions by Transportation Mode, 2010



Source: SEMARNAT (2013)

Mexico has experienced some decoupling of economic growth and GHG emissions from energy. The country emitted 0.051 kg of CO_2e per MXP (GDP) in 1990 and fell 5.8 percent to 0.048 kg of CO_2e per MXP in 2010. GHG emissions grew at an average annual rate of 1.5 percent between 1990 and 2010, while economic growth

grew 2.5 percent per year. The reduced GHG intensity per unit of GDP is largely due to greater energy efficiency (SEMARNAT, 2013).

Mexico emitted 3.72 tCO_2e per capita from fossil fuels in 2012, about 20 percent below the world average of 4.51 tCO_2e per capita. Mexico's per capita emissions were the second lowest among the largest GHG emitters (IEA, 2014).

In compliance with the LGCC, SEMARNAT issued regulations for the National Greenhouse Gas Registry (RENE) in October 2014. Emitters of 25,000 tCO_2e per year or more will be required to report their emissions to SEMARNAT annually. This requirement will apply to large sources in the energy, transport, industry, waste, services, and agriculture and livestock sectors. According to SEMARNAT's estimates, approximately 3,000 emitters are likely to meet this threshold. RENE is also the official registry for emissions reductions in Mexico (SEMARNAT, 2014). Emissions reductions eligible for the registry include projects that have already been registered under the Clean Development Mechanism or voluntary carbon market certifications; and other projects validated by a certified organization, based on unpublished methods (SEMARNAT, 2015).[15]

RENE allows use of general emission factors for GHG emissions for most activities through. Mass balance methods are primarily used for activities involving fluorinated gases used to produce foams, sprays, and electronics. Emitters are required to include emissions from both mobile and fixed sources as well as indirect emissions from use of electricity and thermal energy (SEMARNAT, 2014).

Emitters must use the Annual Operations Certificate (*Cédula de Operación Annual* or COA) website to report their GHG emissions. This is the same reporting system used for Mexico's Pollutant Release and Transfer Registry. [16] Reporting to RENE for calendar year 2014 was originally expected to begin in the first quarter of 2015. However, at the end of July 2015, the COA web tool was still under development. SEMARNAT was still developing materials and training courses with GIZ support to help entities meet their reporting obligations under RENE.

To fulfill the verification requirements, reporting entities must have their measurements and emission estimation methods and data verified by a certified third party every three years. Emitters with over 1,000,000 tCO_2e must begin submitting a verifiers' opinion to SEMARNAT in 2016. Those with emissions between 100,000 and 1,000,000 tCO_2e are required to submit a verification report in 2017. Emitters with 25,000-100,000 tons of CO_2e will have to submit a verification report in 2018 (SEMARNAT, 2014). As of August 3, 2015, the Mexican Accreditation Entity (EMA) had certified only five Mexican firms and one Spanish firm as GHG verifiers.[17] The number of certified verifiers will need to increase to help ensure an accurate GHG registry.

The PECC's MRV contained over 200 lines of action with specific indicators of progress. Units responsible for implementing each line of action are expected to report their progress to SEMARNAT twice a year. In 2010, USAID's Mexico Competitiveness Project supported development of a web-based system for this information for the PECC 2009-2012—the Information System for Cross-Sectoral Agendas-Special Climate Change Program (SIAT-PECC.) In 2015, USAID's Mexico Low Emission Development (MLED) Project was supporting the development of new software to replace SIAT-PECC with a system specifically designed for the new actions, methods, and progress indicators adopted by the PECC in 2014. In addition, SEMARNAT had requested the support of the Danish International Development Agency (DANIDA) to refine the methods for the MRV of several lines of action, which would also be integrated into the MLED-developed software. GIZ was working with INECC in the development of MRV for policies and the INDC. These efforts will support the work of the Coordination for Evaluation.

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[15] Voluntary market certifications include: Gold Standard, Verified Carbon Standard, Plan Vivo, American Carbon Registry, Climate Action Reserve, and Climate, Community and Biodiversity Standards.

[16] This Registry is similar to the Toxic Release Inventory in the United States

[17] http://200.57.73.228:75/OVVGEI/OVV_GEI_acreditados.pdf

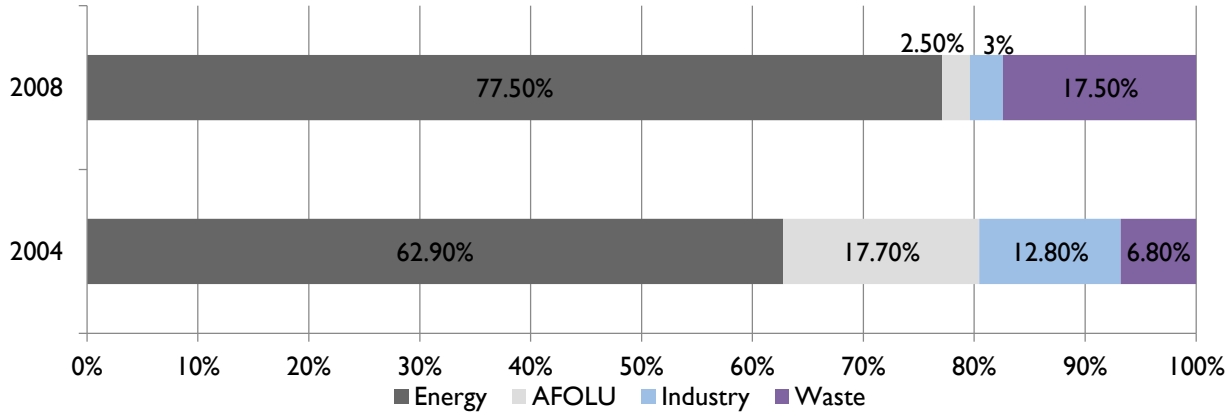
Mexico's GHG Program (Programa GEI México) is a partnership between SEMARNAT and the Private Sector's Research Commission for Sustainable Development (CESPEDES) to reduce GHG emissions. It has received technical support from the World Resources Institute and the World Business Council for Sustainable Development.[18] The program started in 2004 and initially only focused on reporting GHG emissions from firms, including the state-owned oil company, PEMEX. It subsequently expanded to include reporting on GHG emission reductions through projects verified by certified organizations. The number of firms reporting to the Programa GEI México increased from 15 in 2004 to 124 in 2012. In July 2015, CESPEDES, was also exploring opportunities for Mexican firms to participate in California's carbon market. The MLED Project was helping CESPEDES update its platform to make it compatible with RENE. Programa GEI has a broader scope than RENE because it includes direct emissions, indirect emissions from production of purchased materials, and fuels, as well as transport vehicles not owned or controlled by the reporting entity (CESPEDES, 2015).

2.6. SUBNATIONAL MRV SYSTEMS

Veracruz State

Figure 7 shows Veracruz's GHG emissions by sector in 2004 and 2008. Emissions grew from 27.3 million tCO_2e in 2004 to 44.7 million tCO_2e in 2008. Veracruz contributed about 8 percent of Mexico's total GHG emissions in 2008 (GOV, 2013), but the data are not comparable due to differences in the estimation methods used by the state and the national government. Energy generated 77.5 percent of the state's GHG emissions in 2008, mainly due to oil and gas operations and thermoelectric power plants.

Figure 7. Sources of GHG Emissions in the State of Veracruz, 2004 and 2008



Note: AFOLU = Agriculture, Forestry, and Other Land Uses

Sources: For 2004: GOV (2009); for 2008 http://www.veracruz.gob.mx/medioambiente/files/2014/01/Infograf%C3%ADa-Pol%C3%ADtica-en-Cambio-Clim%C3%A1tico-del-Edo-de-Veracruz.jpg

In mid-2015, Veracruz was developing an MRV system for GHG to monitor progress in implementing its climate change agendas, with support from GIZ. The state's climate change law required GHG emitters to report their emissions to the Ministry of Environment of Veracruz, unless they already had an obligation to report to RENE.

[18] http://www.geimexico.org/index.html

Since RENE will disaggregate data by municipality and state, it will report on the largest GHG emitters in the state.

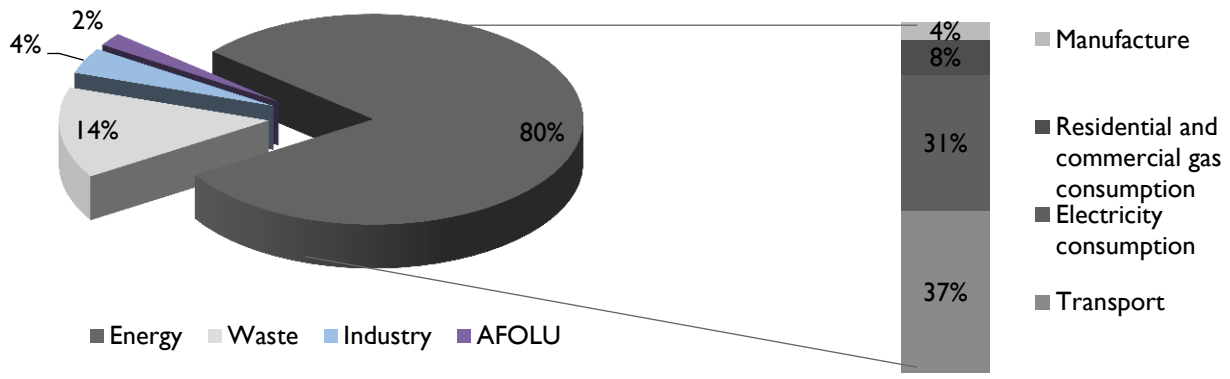
Yucatan

The State of Yucatan emitted about 10.9 million tCO_2e in 2005. The largest sources were energy for industrial combustion, electricity generation, commerce and services, transport, and residential use, totaling 59.3 percent of GHG emissions. Another 18.2 percent of the emissions stemmed from agriculture, 13.4 percent from other land uses and forestry, 5.8 percent from industrial processes, including solvents and halocarbons; and 3.3 percent from solid and liquid wastes (GOY, 2013). As of August 2015, Yucatan had not developed its own MRV system.

Mexico City

In 2012, Mexico City's GHG emissions amounted to 31 million tCO_2e, 5 percent of the country's total. Energy was the source of 80 percent of the city's emissions and the largest contributors were transportation, energy and electricity. Wastes comprised 14 percent of the city's GHG emissions, almost twice as much as the country as a whole (Figure 8). Mexico City had an operational MRV platform developed by the Centro Mario Molina to monitor progress on the implementation of its climate change program, but it was not accessible to the public.

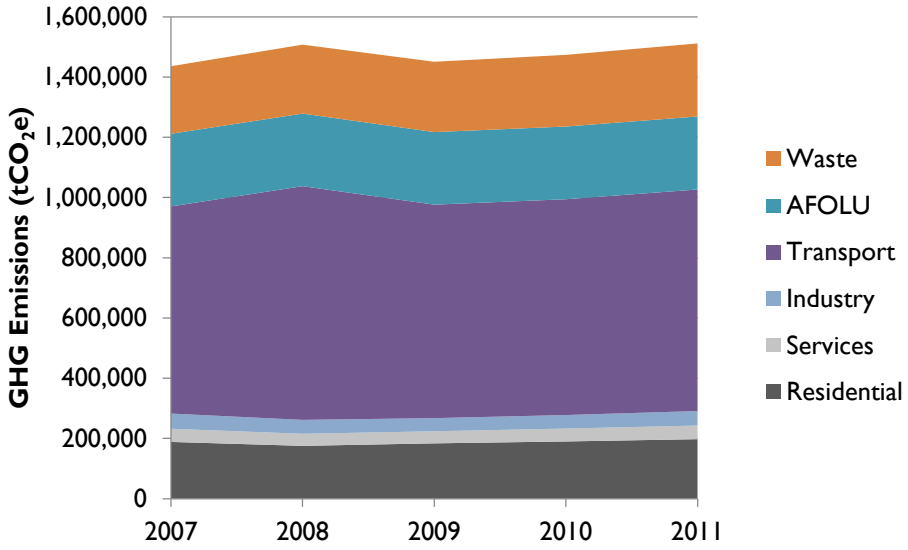
Figure 8. Sources of GHG Emissions in Mexico City, 2012



Xalapa City, Veracruz

GHG emissions in the Xalapa metropolitan area totaled 1.51 million tCO_2e in 2011. Transport contributed close to 49 percent of the local GHG emissions (Figure 9). Under a BAU scenario, Xalapa's emissions are projected to increase to 3.6 million tCO_2e in 2050. Xalapa's action plan developed under the IDB's Emerging and Sustainable Cities Initiative included a monitoring framework, but it focused on local environmental problems, urban development, and fiscal sustainability, rather than climate change mitigation.

Figure 9. GHG Emissions in Xalapa by Sector, 2007-2011



Source: Government of Xalapa, 2014.

2.7. FINANCIAL INSTITUTIONS AND LOW-CARBON DEVELOPMENT

The main financial players in Mexico can be grouped under the following categories:

- **Commercial banks**. In Mexico, banking penetration is very low (Bekker, 2014). Over half of Mexican households do not have access to financial services at the national level, and in rural areas, it is 94 percent. Key factors underlying this low penetration of financial services include lack of knowledge about financial products and their benefits, as well as the distance from branch offices, particularly in rural areas (World Bank, 2012). About 20 percent of potential bank customers lack the necessary documentation to open an account and a similar share complained they were too far away from a branch. Commercial banks were often reluctant to lend to small and medium enterprises (SMEs), given the perceived and real risks associated with this line of business (EY, 2014). Although many of the commercial banks operating in Mexico are subsidiaries of American or European banks, where financial products are more sophisticated, information gaps and transaction costs limit the availability of loan financing for energy efficiency and renewable energy. The development bank NAFIN recently started offering training courses to build the capacity of commercial banks staff to assess energy-related projects.
- **Development banks**. The main national development banks that finance clean energy investments are BANOBRAS (public works bank), NAFIN (national financing bank), Sociedad Hipotecaria Federal (SHF, the Federal Mortgage Society), and INFONAVIT (National Institute for Workers' Housing Savings).[19] BANOBRAS has the specific mandate of financing municipal government projects, including public transit, street lighting, solid waste management, water pumping, and wastewater management (BANOBRAS, 2014). The Shared Risk Trust Fund (FIRCO-Ministry of Agriculture) and the Agriculture-Related Trust Fund (FIRA) are public and national trust funds that serve the agricultural sector and work as second tier banks through their authorized financial distributor network (commercial banks and

[19] SHCP. Catálogo Del Sistema Financiero Mexicano. 14 July 2015. Web. 24 July 2015.

financial service companies). NAFIN is key for public debt issuance and a potential partner for green bonds. SHF has a dual role as a second-tier bank providing loans to commercial banks for housing projects and a first-tier bank lending to real estate project developers. In both cases, financial products have been developed for the introduction of energy efficiency measures in their portfolio, including direct loans, bridge loans, guarantees, and revolving funds. INFONAVIT and SHF have roles in development and implementation of the Housing NAMA. INFONAVIT's Green Mortgage Program finances energy efficiency and water conservation measures in housing projects that receive public subsidies. SHF provides financing for private housing developers and home buyers.

- **Pension funds**. The regulation of pension funds in Mexico has become more flexible over the last 10 years, expanding beyond conventional instruments, such as treasury bonds and debt with high credit ratings, to newly available financial vehicles, such as Real Estate Investment Trusts (REITs) and publicly traded equity (shares). Pension funds have increased in importance from 1.4 percent of GDP in 2000 to 10 percent in 2014, as a result of different measures that have allowed more flexibility in the assets pension funds are allowed to hold, management fee reductions, and an increase in the population covered under a pension plan (CONSAR, 2014). Pension funds can now invest in sovereign bonds, corporate credit notes, publicly traded assets (such as corporate stock), and Capital Development Certificates (CKDs) (EY, 2014). CKDs are publicly traded financial instruments that represent equity in a firm or a trust fund that is generally used to finance infrastructure for up to 50 years. [20] Pension funds have a large potential to increase their investments in green sovereign bonds, corporate credit notes, and low-carbon CKDs. Despite the potential, most pension funds are still ill-equipped to understand and select projects and low-carbon investments with a good risk-reward relationship. There are two main types of risks (1) risks associated with the market—credit worthiness, business failure, and country risk; and (2) risks associated with new technologies and business models. In general, a favorable enabling environment for low-carbon investment reduces the actual and perceived risks through regulations and incentives (CONSAR, 2014; CPI, 2014).
- **Private equity funds.** Private equity funds have been growing rapidly in Mexico as a vehicle for raising capital before company stock is publicly traded. In the period between 2000 and 2005 there were only 25 private equity funds, managing less than US$ 4.5 billion.[21] As of July 2015, there were 143 private equity funds in Mexico, managing more than US$ 29 billion. These funds often closely follow US regulations because many are registered abroad. The regulation of private equity funds is still evolving in Mexico. One of the main challenges for private equity funds is the mismatch between the long periods of time associated with energy efficiency and renewable energy investments and the regulation that limits their duration to less than 10 years, including all steps from raising capital, project selection, investment financing, and closure. One regulatory constraint that has been eased is the requirement that pension funds diversify investments to reduce risks (CONSAR, 2014).
- **Multiple Object Financial Societies (Sociedades Financieras de Objeto Múltiple (SOFOM)).** SOFOMs are small non-bank financial institutions that lend to different consumer market segments. They are important in financing specific niches such as commercial vehicle fleets, freight transport fleets, and appliances. SOFOMs have been able to serve these niches because of the conservative lending policies of commercial banks. The Global Consumer Banking Survey 2012 showed that only 40 percent of potential customers went to a commercial bank for a personal loan and 21 percent for a mortgage

[20] Before a CKD is issued, a business plan has to be presented to qualified investors (mostly pension funds) through the Mexican stock exchange (BMV, 2015). CKDs are equivalent to the Special Purpose Acquisition Companies in the U.S. (Deloitte, 2010).
[21] The Mexican Peso (MXP) has depreciated against the dollar from 13.09 on September 1, 2014 to 16.9 on August 30, 2015. The average rate between September 1, 2014 and October 1, 2015 was MXP 14.97 = 1 US$. For simplicity, a rate of MXP 15 = 1 US$ is used throughout the report. Amounts in US$ are provided as a reference for readers' convenience.

because SOFOMs are more accessible for individuals (EY, 2012).[22] Depending on the market segment, they can charge interest rates equivalent to those offered by commercial banks (Table 7).

Table 7. Loan Rates in Public and Private Financial Institutions in Mexico

Bank / Institution	Type	Loan Rate
FIDE	Public	TIIE+5.0 = 8%
NAFIN (Eco-credit)	Public	14%
Banamex / Citi	Private	TIIE+3.9 = 8.9%
Banbajio	Private	TIIE+7.0 = 10%
Banorte	Private	TIIE+6.5 = 9.5%
BBVA	Private	TIIE+5.5 = 8.5%
Interacciones	Private	TIIE+8% = 11%

Note: TIIE = inter-banking loan rate (Tasa de Interés Interbancaria de Equilibrio).

Source: FIDE (2015a), NAFIN (undated), and Soy Entrepreneur (2014), based on the TIIE published by the Central Bank (Banco de Mexico, 2015).

2.8. OVERVIEW OF FINANCIAL INSTRUMENTS IN MEXICO FOR ENERGY EFFICIENCY AND RENEWABLE ENERGY

Clean energy investment growth in Mexico has been relatively slow through 2013. One reason for this slow growth was that climate change mitigation received small budget allocations at the federal and state levels. In 2013, SENER's budget for clean energy was less than 2 percent of the total federal budget (US$ 41 million). Similarly, the state-owned power utility, the Federal Electricity Commission (CFE), had a budget of less than 0.13 percent (US$ 2.7 million) for energy efficiency measures. The largest public fund had an allocation of US$ 18 million, approximately 0.86 percent of the national budget (Centro Mario Molina, 2013).

Most clean energy investments in Mexico to date have been funded through international donors, which supplied more than US$ 591.11 billion. Approximately12 percent of the donor financing was through grants and 88 percent was concessional loans). Mexico was one of the top 10 recipients of foreign aid to fight climate change (ODI, 2014). Donor grants have played an important role in supporting the development of the institutional framework for climate change, including the climate change law and strategy, as well as programs at the federal, state and municipal levels. These grants and loans have also funded research to identify potential climate change mitigation actions and their costs (Heinrich Böll Foundation, 2014). Investments in wind (around US$ 10 billion) represented the vast majority of the US$ 11.7 billion directed to clean energy between 2009 and 2014 (FOMIN et. al., 2015).

Seed funding, loan guarantees, concessional and non-concessional loans, and partial grants have been used by national development banks in agriculture (FIRA and FIRCO), large-scale wind energy (NAFIN), public transport (BANOBRAS), and housing (SHF). However, the availability of a partial external loan guarantee does not ensure that banks will provide loans. Consequently, important metrics for success of a loan guarantee include increases in loan volume, the number of new clients, the arrears and default rates, the utilization ratio, and the leverage rate. The utilization ratio is the amount of guarantee funding tapped divided by the guarantee fund. A high

[22] EY. 2012. Global Consumer Banking Survey 2012.

utilization rate indicates a large value of defaulting loans and the possible need for institutional, regulatory, loan product, and financing decision changes. The leverage rate is the amount of lending provided by the financial intermediaries divided by the potential amount under the guarantee (Table 8).

Table 8. Utilization and Leverage Rates for Selected Guarantee Programs in Mexico

Guarantee program	Public institution	Utilization rate	Leverage rate
FOSEFOR	FND	2.5%	1:10
FONAGA	FIRA	17.8%	1:70
FONAFOR	FIRA	25.1%	1:1.3
FONAGUA	FIRA	7%	1:40

Note: FND – National Development Financing Entity / FIRA – Agricultural-related Trusts / Fideicomisos Instituidos en Relación a la Agricultura

Source: IDB, 2014.

To date, the use of loan guarantees has been largely limited to agriculture, particularly irrigation water pumping and methane recovery (IDB, 2014). Available loan guarantees have not been completely used, mostly because of low demand for these financial products, associated with limited customer knowledge and institutional capacities for their promotion and use (WWF, 2015). The availability of government grants for agriculture and energy has also reduced the use of these financial instruments. For example, the Ministry of Agriculture offered grants for methane capture and use on pig farms while FIRA and FIRCO offered grants and loan guarantees (FIRCO, 2014).

USAID could provide Development Credit Authority (DCA) guarantees for commercial banks interested in clean energy lending in Mexico. A DCA guarantee program could help increase energy efficiency and renewable energy financing for small and medium enterprises and commercial land residential buildings. However, the impact of other loan guarantee programs in Mexico has been limited to date due to the competition from grants, financial and non-financial barriers, design criteria and sectoral focus, institutional and information challenges, and high market and credit risks (Table 9).

USAID could also support the development of green bonds for financing municipal street lighting, water pumping, and waste management. USAID could provide support to energy service companies (ESCOs). ESCOs are private companies that assess energy conservation potential and invest their own capital in energy technologies, usually with no up-front costs to their industrial, commercial, or residential customers. ESCOs either earn revenues from the energy savings over time or the leasing of equipment. Although ESCOs have been successful elsewhere (for example, with public building energy efficiency in the US and industrial energy efficiency in China), attempts to create ESCOs in Mexico have not been very successful to date.

Table 9. Barriers to Clean Energy Technologies in Latin America

Financial barriers	
Financial modeling challenges	Difficulty in assessing risks and uncertainty associated with electricity price variations in the lifespan of an investment
Upfront costs	Capital costs may be higher for clean energy technologies although operating costs may be lower
	Long payback periods
Lack of collateral	Difficulty in defining the collateral for an energy efficiency investment (lender versus service provider)
Bundling and scale	Difficulty in standardizing and bundling projects to scale up
Non-financial barriers	
Subsidies for energy consumption	Energy subsidies reduce incentives to invest in energy efficiency
Institutional capacities	Challenges in raising awareness on the importance of energy efficiency
	Limited capacity to assess financial and economic benefits and costs
	Little track record of successful clean energy investment management
Regulatory framework	Limited compliance with existing regulations and weak rule of law

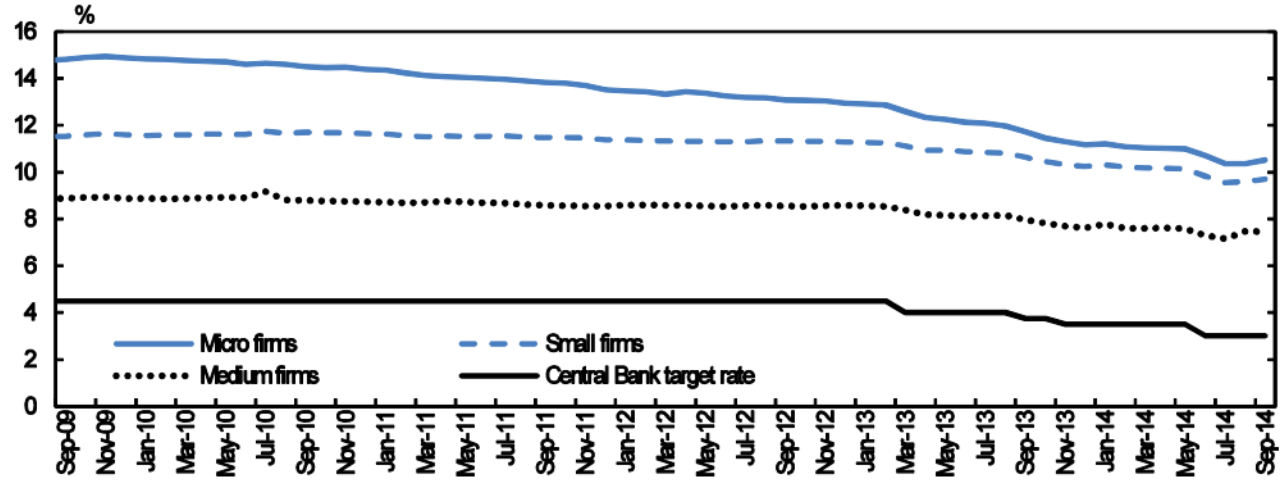
Source: Authors, based on IDB, 2014.

The GOM was also exploring additional financial instruments, including geothermal risk insurance facilities, risk insurance for ESCOs, and concessional loans for housing project developers with support from the IDB and KfW. These projects were expected to include a grant from the Clean Technology Fund to provide loan guarantees and apply an ESCO approach to financing and servicing the energy efficiency market. In addition, a local debt issue would help fund the project (IDB, 2015). These projects were still in their initial design phase (see chapter 3).

Several organizations offered loans to SMEs for energy efficiency projects. For example, FIDE provides loans and rebates for industrial motors and lighting and SHF finances housing developers. Although these development banks are backed by the Ministry of Finance (SHCP) and ultimately by the Mexican treasury, they generally charge higher interest rates than commercial banks because the development banks serve smaller and riskier clients. Commercial banks also have a lower cost of capital than development banks since they receive deposits from clients. Commercial banks can also have lower operating costs than commercial banks due to lower salary and staffing levels (NAFIN, 2014 and 2012; FIDE, 2013; Huidobro, 2014; OECD, 2015a).

Figure 10 shows the higher cost of capital for micro and small firms in Mexico.

Figure 10. Cost of Credit for Micro, Small and Medium Firms in Mexico (interest rates)



Source: OECD, 2015a

Public funds have been used to support energy policy and strategy development in Mexico, but there has been relatively little public funding for energy project implementation. Most public funds have come from the treasury allocations defined by SHCP and negotiated with state governors, particularly for flagship investments. The Ministry of Energy, Ministry of Environment and Natural Resources, Ministry of Agriculture, and the National Council for Science and Technology (CONACYT) have separate public trust funds capitalized either by allocations from SHCP or special levies, such as taxes on oil production.

Table 10 lists the key trust funds that can support the transition to a more energy efficient future. The most important was the Energy Transition Fund (Fondo para la Transición Energética y el Aprovechamiento Sustentable de la Energía, FOTEASE). About 60 percent of the US$ 344 billion managed by FOTEASE from 2009 to 2012 was used for a national home appliance substitution program (SE, 2012). About 2.1 percent of the FOTEASE was allocated for an energy-efficient municipal street lighting program that was not implemented by the end of 2012, according to the Federal Audit Office (SENER, 2012a). The overall impact of public funds could be improved by considering alternatives to grants and strategically leveraging additional financing to have greater impact on the market. For example, this could be done by providing seed capital for ESCOs, private equity ventures, and offering loan guarantees to private sector financial institutions.

Table 10. Public Funds for Clean Energy

- Fund for the Energy Transition and Sustainable Use of Energy (Fondo para la Transición Energética y el Aprovechamiento Sustentable de la Energía)
- Mexican Oil Fund (Fondo Mexicano del Petróleo)
- Fund for Universal Electric Service (Fondo de Servicio Universal Eléctrico)
- Public Trust Fund to Promote the Development of Suppliers and Contractors of the Energy Industry (Fideicomiso Público para Promover el Desarrollo de Proveedores y Contratistas de la industria energética)
- CONACYT-SENER Sectorial Fund for Energy Sustainability (Fondo Sectorial CONACYT-Secretaría de Energía- Sustentabilidad Energética)
- CFE-CONACYT Sectorial Fund for Energy Reserach and Technological Development (Fondo Sectorial para Investigación y Desarrollo Tecnológico en Energía)
- Technology Innovation Fund-Ministry of Economy and CONACYT (Fondo de Innovación Tecnológica-Economía-CONACYT)
- Sectoral Innovation Fund for Innovation (Fondo Sectorial de Innovación)
- Sectoral Fund for Environmental Reserach (Fondo Sectorial de Investigación Ambiental)
- Climate Change Fund (Fondo para el Cambio Climático)
- Fund for Scientific and Technological Development for the Promotion of Housing Production and Financing and the Growth of the Residential Sector (Fondo de Desarrollo Científico y Tecnológico para el Fomento de la Producción y Financiamiento de Vivienda y el Crecimiento del Sector Habitacional)
- Trust Fund for the Construction of a Revolving Fund to Finance the Thermal Insulation Program for Housing in the Valley of Mexicali, Baja California (Fideicomiso para la Constitución de un Fondo Revolvente de Financiamiento para el Programa de Aislamiento Térmico de la Vivienda en el Valle de Mexicali, B.C.)
- Trust Fund for Electricity Savings (Fideicomiso para el Ahorro de Energía Eléctrica)
- Guarantee and Promotion Fund for Agriculture, Livestock and Aviculture (Fondo de Garantía y Fomento para la Agricultura, Ganadería y Avicultura)

Access to finance is still an important challenge for doing business in Mexico, ranking after corruption, bureaucracy and tax regulations (PWC, 2015). In addition, knowledge and experience in the financial sector about financial vehicles and fiduciary requirements are limited, which can cause difficulties in matching available financial products with solutions that could trigger private investment. This problem is sometimes overcome by bringing in talent from abroad or other industries (Ariza, 2015).[23]

Most of the climate change-specific funding in Mexico comes from grants and concessional loans from international donors and multilateral development banks (ODI, 2014). Many of the development banks and commercial banks that already issue debt are beginning to explore the potential use of green bonds. For example, NAFIN and the IDB were designing the first green bond for geothermal energy IDB (UNDP, 2014; Priego, 2015). In general, there is a widespread need in public sector and the financial sector for the dissemination of experiences and lessons learned in the use of available financial instruments and market

[23] Interview with private equity funds managers (Adobe Capital) and Mexican Private Equity Association.

mechanisms to increase private investment in clean energy. Also, less restrictive financing terms and policies may be needed to help women-headed households and businesses cover the upfront costs of more sustainable energy services.

Real estate investment trusts (REITS), master limited partnerships (MLPs), and project securitization are examples of financial instruments that can support Mexico's transition to low-emissions development strategies.

- **Real Estate Investment Trusts:** REITs are securities listed in a stock market based on underlying real estate assets, either through properties or mortgages. They are a common financial vehicle for investing in the development and management of property in Mexico. They allow smaller investors to participate in the real estate market, benefit from special tax regimes, and maintain liquidity since they are publicly traded and can attract international investors.[24] REITs can provide higher yields than bonds and more consistent returns than other stocks and they have no maturity date. By law, they must distribute at least 95 percent of taxable income of the previous year to their shareholders. It is in the interest of REIT promoters to comply with the reporting standards of international investors. Some REITs have adopted energy performance practices and certifications, such as Leadership in Energy and Environmental Design (LEED) (GRESB, 2014).[25]
- **Master Limited Partnerships:** MLPs are a type of publicly traded limited partnership. A limited partner provides capital to the MPL and benefits from periodic income distributions from the resulting cash flow, while a general partner is responsible for managing the MLP and receives a compensation based on its performance. These are similar to REITs in that they enjoy a special tax regime and their liquidity and focus are looked after by investors. While REITs are typically considered financial sector investments, MLPs are generally found in the energy and natural resource sectors. Also, unlike REITs, MLPs are not required to pay out 90 percent of earnings as dividends to their shareholders.[26] Despite the good performance of the REIT model in Mexico, MLPs have not been legally defined in the country yet because restrictions on private equity funds limited their investment period to 10 years. Furthermore, fiscal regimes that govern MLPs in the US do not exist yet in Mexico and special tax privileges are not easy to obtain from the SHCP. However, it is foreseen that MLPs will become available in Mexico soon.

Project Securitization: Despite the oversubscription of some green bonds from other countries in the international market, Mexico has only issued one green bond to date.[27] The US$ 500 million bond was issued by NAFIN in November 2015 and was the first in Latin America to receive Climate Bond Certification. Proceeds from the bond will be directed to a portfolio of nine wind parks in Mexico. Climate-themed bonds totaled US$ 502.6 billion globally in 2014, including bonds used for financing the transition to a low carbon economy (Table 11). Most issued bonds have a lifespan (tenor) greater than 10 years, making them attractive for pension and insurance funds. The prerequisites for issuing green bonds are to have a responsible fiduciary institution and payment model (subject to a publicly available investment rating), and ensure that proceeds are used for verifiable low-carbon projects (Climate Bonds Initiative, 2015).

[24] "Real Estate Investment Trust (REIT) Definition." Investopedia. 25 Nov. 2003. Web. 30 Jul. 2015. <http://www.investopedia.com/terms/r/reit.asp#ixzz3hoJ0OG6O>.
[25] "GRESB: Bringing Sustainability to the Capital Market | U.S. Green Building Council." GRESB: Bringing Sustainability to the Capital Market | U.S. Green Building Council. 16 Apr. 2014. Web. 4 Aug. 2015.
[26] "What Is the Difference between a REIT and a Master Limited Partnership?" Investopedia. 20 Jan. 2015. Web. 28 July 2015.
[27] HSBC. 2015. Bonds and climate change the state of the market in 2014.

Table 11. Global Issuance and Use of Climate and Green Bonds

	Transport ($358.4b)	Energy ($74.7b)	Finance ($50.1b)	Buildings and Industry ($13.5b)	Agriculture and Forestry ($4.2b)	Waste and Pollution ($1.4b)	Water ($266m)
Number of bonds	1,000	736	430	130	42	29	2
Number of issuers	89	160	33	40	11	13	2
Bond size (average)	$466m	$122m	$146m	$117m	$106m	$60m	$133.5m
Largest issuer	China Railway	Hydro-Quebec	Eurofima	LG Electronic	Sveaskog	Darling Int	Cadiz Inc

Source: HSBC, 2015

The GOM has met the prerequisites to issue green bonds to finance housing projects through the two housing development banks (SHF and INFONAVIT). An IDB-funded project is supporting NAFIN to assess how green bonds can be used in Mexico (Berruecos, 2015). However, state and municipal governments in Mexico face difficulties in issuing green bonds due to limited institutional capacity, and difficulties paying the fees to project developer.[28] [29] As of September 2015, legislation was being discussed in Congress to limit the debt issuance by states and municipalities according to their actual capacity to create sources of revenue. Since the Treasury has been the bank of last resort when states and municipalities default on debt payments, there has been little incentive for subnational governments to manage debt properly (Reuters, 2015). Without a fiscal reform that transfers responsibilities for tax collection to municipalities and states, there are few incentives for the adoption of new financing instruments. Despite these limitations, there are good lessons learned and positive experiences that can be used to enhance a program on green debt issuance in Mexico:

- Through a Global Development Alliance with USAID, Evensen Dodge is helping Mexican states and municipalities aggregate relatively small projects into projects of over US$ 100 million that can attract institutional investors, establish checks and balances, reduce risks of corrupt practices, and set up public trust funds with investment committees. [30]
- The US Government's Overseas Private Investment Corporation (OPIC) provided a $250 million investment guaranty to support a local capital market bond issuance of US$ 315 million to be repaid by property registry fees in the State of Mexico.[31] This guarantee provided local capital markets investors with an AAA-rated investment-grade, fixed-rate, peso-denominated long-term asset.[32]
- Few states and municipalities are equipped to issue green bonds to finance clean energy projects. However, there are good examples and lessons learned from state and municipal

[28] USAID. 2013. Evolution of USAID/Mexico – Evensen Dodge International GDA Program.
[29] Farvacque-Vitkovic, Catherine; Kopanyi, Mihaly. 2014. Municipal Finances: A Handbook for Local Governments. Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/18725 License: CC BY 3.0 IGO.
[30] GDAs combine the assets and experiences of the private sector, leveraging their capital and investments, creativity and access to markets to solve complex problems facing governments, businesses, and communities. In Mexico, USAID has teamed up with Evensen Dodge International (EDI), a financial advisory firm. The USAID-EDI GDA Program focuses on developing and expanding domestic capital markets in Mexico and building the necessary links for sovereign or subsovereign public authorities to access them.
[31] OPIC provides financial products, such as loans and guaranties; political risk insurance; and support for investment funds, all of which help American businesses expand into emerging markets. By mobilizing private capital to help solve critical development challenges, OPIC advances U.S. foreign policy, and catalyzes revenues, jobs and growth opportunities both at home and abroad.
[32] "Raising Money for Municipal Upgrades in Mexico." *MBIA Insurance Corp.: Raising Money for Municipal Upgrades in Mexico*. 2014. Web. 4 Aug. 2015.

efforts to mobilize private investment. In general, however, state and municipal authorities did not understand how to approach the debt market and provide transparency in use of the proceeds. They are often ill equipped to approach financial institutions that also have limited capacity in the use of a variety of financial instruments.[33]

- **Energy Service Companies (ESCOs).** Mexico has been introducing minimum energy performance standards, labeling programs, and technical and managerial capacities to ensure enforcement and compliance. Despite the attractiveness of the model, there are several barriers to ESCO growth, including the low influence of the Mexican ESCO association (AMESCO), lack of supporting legislation, and continuing existence of electricity subsidies that distort incentives for energy savings (see section 2.9). ESCOs have had difficulties establishing long-term contracts and minimize risks related to fee collection (CONUEE, 2014).[34] Furthermore, the GOM expected that electricity prices will decrease with the energy production and transmission reforms, which would make it more difficult for ESCOs to perform well. Other barriers faced by ESCOs are the lack of legal certainty in fee collection and adequate financial instruments for public sector projects, including collateral and guarantees.[35]

  Private lenders have not yet demonstrated much interest in financing ESCOs, but USAID DCA guarantees could increase their willingness to enter this market. The IDB is implementing an ESCO initiative called Capital Markets Solution for Energy Efficiency Financing in Mexico with the development bank NAFIN and three ESCOs (Dalkia Energía y Servicios S.A. de C.V. ("VEOLUS"), ECON Servicios Energéticos Integrales S.A.P.I., S.A. de C.V. ("ECON"), and Point Verde Green Technology Solutions S.A. de C.V. ("PointVerde")). [36] The IDB will focus on ESCOs serving industries and will issue a green bond after a sufficient volume of financing has been warehoused. The project started in the second half of 2015.

- **Commercial Bank Loans**. A few commercial banks in Mexico have expressed interest in developing financial products for energy efficiency measures particularly for SMEs. With IDB support, Banamex (a subsidiary of Citibank) is developing a loan product for financing the purchase and installation of energy efficiency equipment by SMEs. The USAID MLED Project provided short-term training on energy efficiency lending to some Banamex sales staff in 2015.

  In general, bank decisions to issue loans and the design of the loan products have been based on borrowing firm's repayment capacity from business assets, not the savings in energy expenditures.[37] Moreover, neither banks nor SMEs have demonstrated a clear willingness to pay for the energy audits that would identify the potential energy efficiency measures that the firm could adopt or their impacts. DCA guarantees could be a good tool to increase the willingness of commercial banks and other private lenders to make energy efficiency loans. The Clean Energy Lending Toolkit developed for USAID can help commercial banks assess the market for energy efficiency financing.[38]

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[33] USAID. 2013. Evolution of USAID/Mexico – Evensen Dodge International GDA Program.
[34] CONUEE. 2014. Estrategia de transición para promover el uso de tecnologías y combustibles más limpios en el tema de ahorro de energía en industria. Foro Consultivo para la elaboración de la Estrategia de transición para promover el uso de tecnologías y combustibles más limpios. Available at: http://www.conuee.gob.mx/wb/Conuee/estrategia_de_transicion_para_promover_el_uso_de_t
[35] IDB. 2013. Capital Markets solution for energy efficiency financing. Project Abstract. Available at: http://www.iadb.org/en/projects/project-description-title,1303.html?id=ME-L1150
[36] IDB. 2013. Capital Markets solution for energy efficiency financing. Project Abstract. Available at: http://www.iadb.org/en/projects/project-description-title,1303.html?id=ME-L1150
[37] Joint Research Centre Institute for Energy and Transport. 2014. ESCO Market Report for Non-European Countries 2013. Available at: http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/reqno_jrc91689_ld-na-26886-en-n.pdf
[38] The Clean Energy Lending Toolkit was developed under the USAID Analysis and Investment for Low-Emission Growth (AILEG) Project. It is available at: http://pdf.usaid.gov/pdf_docs/pa00js5m.pdf

- **Loans from public-private trust funds**. FIDE is a private trust fund, managed by NAFIN and CFE, with industry chambers as technical associates. It is the main source of credit for energy-efficient appliances, industrial motors and lighting to the public and private sector. FIDE provides loans at interest rates equivalent to those of commercial banks (see Table 7), with the benefit of collecting fees through the energy utility bill. FIDE has structured these loans with a guarantee and an MRV system. FIDE has fiduciary capabilities that are attractive to GOM agencies concerned with energy efficiency such as CONUEE and SENER.

  In 2014, FIDE implemented, funded, and evaluated 294 distributed generation projects (132 PV residential, 161 in companies, and 1 in cogeneration) and 215 energy efficiency projects (69 in industry, 46 in services, and 100 in SMEs). In the same year, FIDE implemented the Eco-Crédito Empresarial Program, which supported 4,748 SMEs and resulted in the installation of 9,977 electric equipment sets, worth US$ 11.8 million (MXP 195 million). SENER was the supervising authority for the SME lending program and provided an incentive of 10 percent of the cost of equipment. The Ministry of Economy provided loan guarantees and CFE collected repayments through electric bills (FIDE 2015b).

- **Federal subsidies for housing**. GOM housing subsidies are aimed at the population that earns up to around US$ 700 per month, the equivalent of five months of earnings by someone being paid minimum wage. There were two main components of the Housing NAMA, managed by SHF and INFONAVIT. SHF offered concessional loans and incentives to housing project developers to keep social housing projects price low and change the standardized housing manufacturing process. This program was supported by the NAMA Facility (funded by the DFID and GIZ, as well as the IDB and the German Development Bank, KfW).

  SHF was looking for more innovative business models to streamline incentives in the residential sector, for example, by increasing lending to project developers and managers of rental housing. It expects that it would be easier to standardize energy performance contracts and secure financing if one owner is responsible for energy efficiency in multi-unit buildings. According to SHF, it is often difficult to interest building owners in retrofitting rental buildings with multiple owners with energy improvements because the tenants are responsible for paying the electricity bills. INFONAVIT managed demand-side programs that provided buyers with additional credit for energy efficiency improvements (including solar water heating systems, energy-efficient water heating systems, and building weatherization) and water-efficient appliances (such as low-flow faucets and two-step toilets).

- **Financing retrofits**. The Housing NAMA has a component for retrofitting existing housing; however, it mainly relies on the loans available from INFONAVIT and other development banks in Mexico for housing renovation.[39] This project was still under design, with the support of KfW.

[39] CONAVI. 2013. NAMA for Sustainable Housing Retrofit
http://www.conavi.gob.mx/images/documentos/sustentabilidad/3_NAMA_for_Sustainable_Housing_Retrofit.pdf

2.9. MARKET MECHANISMS FOR GREENHOUSE GAS EMISSIONS REDUCTIONS IN MEXICO

Electricity Subsidies Reduce Incentives for Energy Efficiency

Mexico's current pricing policy for electricity involves significant subsidies for most households. Only the 1.25 percent of residential users with the highest electricity consumption pays electricity rates above the marginal and average costs of generation and distribution—the "tarifa de alto consumo" or DAC (CIDAC, 2015). Approximately 18 percent of the revenue for electricity subsidies was generated from the high tariffs paid by commercial users and the DAC. The remaining 82 percent came from government transfers. CFE, the only power distribution utility in Mexico, has used its own assets to pay for the rest of the subsidy since 2002. In 2014, CFE lost MXN 45,000 million (US$ 3 billion), mainly because of the subsidies, which increased from about MXP 80,000 million (US$ 5.3 billion) in 2007 to MXP 112,000 million (US$ 7.46 billion) in 2013 (CIDAC, 2015). CFE's financial challenges will likely be exacerbated as a result of recent legal reforms because CFE will continue to service subsidized residential users while high-paying commercial consumers might choose a different power provider in the future (CIDAC, 2015). In addition, one of the GOM's main energy reform goals is to reduce the costs of electricity to increase the competitiveness of commercial and industrial users.

Since the threshold level of energy consumption for the higher DAC rate was not the same for all of Mexican households, even some high-consumption households are subsidized. The pre-DAC "allowance" varied by region and the season. Areas with hotter climates were allowed larger amounts of subsidized electricity before the DAC threshold is reached and these amounts are greater during the hottest months of the year. A household consuming 300 kWh/month in Mexico City paid the DAC tariff, but a household in coastal Sinaloa, would receive a subsidy of more than half of the cost during most of the year and 75 percent in the summer. A household in coastal Sinaloa would need to consume more than 800 kWh/month to lose the subsidy.

The varying DAC thresholds gave households with the highest consumption little incentive for efficiency investments. Twelve million of the approximately 31 million households connected to the grid subsidies rates based on average temperatures (tariffs 1A-1F)..

It is difficult to estimate the total value of Mexico's electricity subsidies. Since Mexico is heavily dependent on hydrocarbons for electricity generation (nearly 80 percent), the costs of generation moves in tandem with oil and gas markets and the exchange rate for the Mexican peso against the US dollar. Consequently, electricity subsidies in Mexico were much higher at the beginning of the current decade, when petroleum sold at over US$ 90 a barrel. Since then, the GOM slowly raised real domestic prices for electricity to reduce the subsidies. The subsidies were substantially lower, but still positive, in mid-2015 due to the fall of oil prices that started in late 2014; although this has been partly offset by a decline in the value of the Mexican peso.

CFE and CRE estimated the average cost of producing and distributing electricity in Mexico at MXP 2.70- 3.00 per kWh in 2014 when the average price of Mexico's crude oil was US$ 70 per barrel.[40] With international oil prices of US$ 50-55 per barrel in the first half of 2015, the average production and distribution cost for electricity would be MXP 2.50- 2.80 per kWh. Electricity rates below these costs reflect subsidies. For more than half a decade, block rates of electricity for household consumption in Mexico have been below that level in all regions and all seasons, except above the DAC threshold. The subsidies were approximately MXP 2.00 for the lowest-priced blocks and MXP 1.00 for the highest non-DAC rates. The total value of electricity subsidies for households in Mexico was more than MXP 80 billion (over US$ 5 billion) per year.

[40] Electricity in Mexico is generated mainly with fuel oil, natural gas and coal, in addition to its share of hydroelectricity, some nuclear and now renewables, so the marginal cost of generation would move according to the price of the first three inputs, and the average price according to the high fixed costs of the latter three, some of them already depreciated as in the case of large hydro.

Firms in the industrial and service sectors did not receive subsidized electricity rates. Service sector firms faced tariffs above MXP 3.00 while large industrial operations paid around MXP 2.4-3.00 if they used medium- or high-voltage electricity, which have lower distribution costs.

Agriculture received the most highly subsidized rates for electricity. Farms with formal water concessions for irrigation systems paid MXP 0.20-0.70 per kWh, a subsidy of more than 75 percent. Agricultural users in Mexico received more than MXP 10 billion (US$ 655 million) each year in electricity subsidies. Irrigation systems without a formal water concession represented about 10 percent of the number of farms (Rivero Cob and García Romero, 2011). These systems were generally considered illegal, but tolerated by federal agencies hoping to regularize them over time. They paid higher electric rates than formal sector irrigation (similar to the rates paid by the service sector) and have experienced the fastest increase in electricity prices over the last decade.

The informal sector irrigators have been subject to significant price increases (nearly doubling in five years), according to INECC and SEMARNAT in 2009 and 2010.

In 2010, a multi-agency task group was created to respond to these findings and SHCP agreed to set a policy of gradual increases in the electricity rates for informal section irrigation through relatively small, monthly increases. Three years later, these rates had crossed the no-subsidy point, with informal sector irrigation paying more than MXP 3.00 per kWh at its average block price. The National Water Commission and SEMARNAT have continued this policy because it gave informal irrigators incentives to undertake the paperwork and studies for legalization process or purchase a share of formal water concessions. The higher electricity rates provided an incentive for greater energy and water efficiency and an opportunity for government, civil society, and international organizations to learn about the process of increasing resource sustainability through pricing (Aguirre and Muñoz-Piña, forthcoming).

Reducing Fossil Fuel Subsidies

User subsidies of fossil fuels peaked in Mexico in 2011, with more than MXP 169 billion pesos in subsidies for gasoline and diesel and MXP 40 billion for LPG (OECD, 2011). That report did not estimate producer subsidies for fossil fuels, although they were considered low because PEMEX operated under a goal of providing income to the GOM and oil prices were high at the time. Budget transfers to PEMEX before the energy reform constituted the capital and operating costs of a government-owned firm and the profits were extracted by the GOM. The main source of producer subsidies for fossil fuels was the floating excise tax (reformed), which became negative under the combination of high international reference prices and domestically low prices and is expected to be reformed soon. It is counted within the general consumer subsidies.

Since 2010, Mexico pursued a policy of small, but steady increases in gasoline, diesel, and LPG prices for domestic fiscal reasons. In some years, these domestic price increases were too small to compensate for the increases in international prices (the basis for estimating the implicit subsidy), but eventually caught-up. By January 2014, the steady domestic price increases reached the threshold of zero user subsidies. The subsequent fall in international oil prices only augmented the reduction in the implicit subsidy. In July 2015, Mexico was well within the zone of no user subsidies for gasoline, diesel, and LPG. These fuels generated net positive revenues of over 0.5 percent of the country's GDP and fuel excise taxes amounted to more than 12 percent of the final prices of gasoline and diesel. Since petroleum prices are expected to remain low for at least the next 1-2 years, this situation is likely to hold, providing an opportunity for a deeper reform of fuel taxes.

There was a variable excise tax on gasoline, diesel, and LPG that is either, positive or negative, depending on market conditions and pricing policy. This was not the case for natural gas, coal, kerosene, and other fossil fuels where the government set prices based on the international market or allowed prices to vary freely with the domestic and international markets. There was no general excise tax for natural gas, coal, kerosene, and other fossil fuels beyond the value-added tax on all goods plus the carbon tax, if applicable.

Mexico's taxes on gasoline, diesel, and LPG have been far below the 1 percent of GDP common in European Union countries. However, Mexico has a variable excise tax policy that is countercyclical with oil prices. The variable excise tax automatically increases when domestic fuel prices stay the same while international prices fall. This excise tax helps to offset the reduction in government revenues when the value of oil exports fall. Public pressure may grow if international prices for gasoline are lower than the domestic price in Mexico, but the GOM has tended to resist the pressure to reduce fuel prices. Different fuel pricing for border cities has reduced opportunities for price arbitrage. When international reference prices for petroleum products grew faster than domestic prices—as they did over the past decade—the implicit subsidies increased, as there was little political interest in increasing domestic prices because of the government's surplus revenues from higher oil exports. This problem of large subsidies occurred in Mexico between 2000 and 2010.

Some sources recommended taxing fuels based on their negative environmental impacts (Coady et al, 2015; OECD, 2015b). This would create a "double dividend" because economic welfare losses are smaller when more taxes are applied to goods with larger negative externalities and government revenues are maintained at the same level (Jorgenson et al., 2013). And if government revenues increase, there can also be potential positive effects. For example, lower energy subsidies and higher energy taxes could allow the GOM to increase expenditures for climate change mitigation or adaptation activities.

Mexico was a net importer of gasoline and diesel. This makes implicit subsidies become expressed in hard cash, creating further fiscal imbalance. In June 2015, the value of Pemex's gasoline imports exceeded the value of its total exports of crude oil for the first time in more than 25 years. Pemex registered a negative trade balance, exporting US$ 1.9 billion in crude oil and importing US$ 2.0 billion in gasoline and petrochemical products. Gasoline purchases abroad increased to 412,000 barrels per day in June, 26.5 percent more than in the same month of 2014. Although this is due to problems in Pemex's invoicing system, its scheduling in refineries, and fuel theft from pipelines, it highlights the vulnerability of not having market-based fuel pricing.[41] This imbalance is likely to continue over the next decade until private investment in refining capacity begins to mature.

Fossil fuel subsidies have a strong linkage with an economy's carbon intensity. Higher fuel prices give firms and households more financial incentives to invest in energy efficiency and renewable energy. This applies to relatively minor actions (such as reorganizing logistics and scheduling, and more frequent maintenance) to major changes (such as fuel switching, production process reengineering, and technological change). The power of decentralized market force depends on the private information held by firms and households as well as public and private sector information dissemination. Fuel prices and taxes can also complement or substitute for actions mandated by government regulations that might otherwise suffer from incorrect estimation of private (financial) and social (economic) benefits and costs or inadequate knowledge of the context and particular circumstances.

The effects of fossil fuel price changes on carbon emissions can be estimated using the price elasticity of demand, which indicates how much the quantity of fossil fuel demanded would fall with a marginal increase in real prices. In Mexico, a one percent increase in real fuel prices would reduce the quantity demanded over the long run by 0.4-0.8 percent (Dahl, 2012; Antón-Sarabia and Hernández-Trillo, 2014). The real price increases of more than 20 percent over the past three years have induced substantial conservation of fossil fuels. The pace and magnitude of these adjustments can be supported by specific government and donor policies and programs.

Multiple conflicting forces have been at work in Mexico, predominantly the increasing demand for energy due to income growth. The income elasticity of demand measures the increased demand in the quantity of goods and services as a result of a marginal increase in per capita income. This measure reflects the direct demand for fuels and the indirect demand embodied in other goods and services. The estimated income elasticity of demand for fossil fuels in Mexico has been around one. In other words, a 1 percent increase in average income has increased

[41] El Financiero. http://www.elfinanciero.com.mx

fossil fuel demand by about 1 percent (Dahl, 2012; Burke and Nishitateno, 2013). In middle income countries, such as Mexico, the trend shows that increasing incomes increases fuel consumption, but the effects can be countered by increases in real prices, investments in energy infrastructure, and technological change that can reduce the carbon footprint per unit of GDP.

Fossil fuel subsidies have not been completely phased out in Mexico; some have been targeted at specific economic sectors while others were linked to energy excise tax revenues. For example, tax credits for agriculture and fisheries entered in operation when excise taxes become positive, as they are now, and could reduce the effects of consumers. Conversely, the variable excise tax in Mexico could potentially cause there to be general subsidies with very high oil prices. This situation could be altogether avoided if switched to a fixed, per liter tax, as it is established in most other OECD countries (OECD, 2011).

Clean Energy: Definition, Goals and Markets

Mexico faces a challenging tradeoff between cheaper energy and more sustainable energy. Over the past decade, this tradeoff diminished as oil prices increased beyond the US$ 100 per barrel and the costs of new and improved solar panels and other renewable energy technologies fell. However, the tradeoff remained relevant because of Mexico's regionally abundant supplies of inexpensive coal and its growing distribution network of low cost natural gas from southwestern US and Mexico. The growing interest in diversifying the national energy mix, reducing local and global pollution, and moving the technological frontier forward prompted the approval of Mexico's Renewable Energies and Energy Transition Support Law (LAERFTE) in 2008.

The enactment of LAERFTE was a fundamental first step, but it is important to note that the wording was aspirational with general policy lines and activities, but no specific obligations for the government. LAERFTE did have quantitative goals, such as setting a maximum of 65 percent of electricity from fossil fuel sources by the year 2024. However, there were no penalties or consequences for failing to meet these goals.

Mexico's goals shifted from offsetting a maximum percent of electricity from fossil fuels to defining percentages of electricity to be generated by clean sources. This change was reflected both in the 2012 LGCC and the 2014 Low of Electric Industry (LIE) that was part of the energy reform package.

Unlike the LGCC with its non-binding, aspirational goals, the LIE introduced a new market-based mechanism. It authorized the issuance of Clean Energy Certificate (CEL) to make it mandatory to produce or buy a certain amount of clean electricity. CELs are given to firms based on the volume of electricity generated in new facilities using any of the specified "clean energies". All energy supply firms (Suministradoras) and qualified and decentralized final users must demonstrate that a particular share of their total electricity consumed in a year is covered by clean energy certificates, or they face a monetary penalty. CELs can either be attached to electricity originally purchased under their own contracts from this type of sources or from certificates purchased from others using a nationwide secondary market. This market-based system aims to meet the clean energy national targets at the lowest possible total cost to producers. The monetary penalty stated in the law effectively becomes a price ceiling on the clean energy certificates.

SENER is responsible for defining the annual share of energy that must be covered by clean energy certificates for three-year periods. The LIE did not pre-commit to any particular long-term goal, but instead established these smaller three-year steps. It gave SENER the flexibility to adjust annual obligations within that period, but prohibited any reduction in the aggregate three-year goals that have been set. Together, the LGCC and LIE envision reaching the 2024 target through a series of increasing three-year goals. However, this is not an obligation, but a way of leaving responsibility with each subsequent administration. The Energy Regulatory Commission (CRE) was tasked with maintaining a registry of certificates and their transactions and defining the operation of the market.

The design of the CELs market drew from the experience of similar mechanisms in the European Union and United States, particularly the use milestones, avoidance of sub-goals by type of energy (set-asides or

multipliers), and a smaller role for previously built infrastructure. Although minimal government intervention in the market was anticipated, the moving three-year targets can be adjusted to avoid large upward or downward price spikes.

Mexico adopted a different definition of clean energy than most European countries and the United States, which emphasized renewable energy portfolio standards. Mexico included some types of nonrenewable energy in its definition of clean energy as "those sources of energy and electricity generation process whose emissions and wastes do not surpass the thresholds established in specific regulations". This definition includes:

1. Wind;
2. Solar radiation;
3. Ocean energy;
4. Heat from geothermal sites;
5. Biofuels covered under the Law for Development and Support of Biofuels;
6. Energy generated by methane and other associated gases in farms, wastewater treatment plants, and waste facilities, among others;
7. Energy generated by hydrogen through combustion or in fuel-cells;[42]
8. Hydropower;
9. Nuclear power;
10. Waste burning (urban or agricultural) whenever their process does not generate health damaging pollution by fulfilling regulation established by SEMARNAT;
11. Co-generation;[44]
12. Co-generation and other energy generation by sugar mills;[44]
13. Thermo-electric facilities using fossil fuels that have carbon capture and storage facilities (geological or biological);[44]
14. Other low-carbon technologies that meet international standards; and
15. Other technologies determined by SEMARNAT or SENER according to standards of energy and water efficiency, low emissions and waste generation, either directly, indirectly or through life-cycle analysis.

In theory, the market price for CELs should reflect the gap between the clean energy target and the current investment schedule. For example, if the current short-term target is close to the status quo, the CEL price will be near zero. Under-achievement of the target would cause the price for CELs to increase, providing an additional incentive for clean energy investments. If the additional incentive is sufficient, CEL prices would go down again. The maximum price for CELs would be the cost of the noncompliance penalty set in the law, which is between 6 and 50 days of minimum wage, or roughly between MXP 420 and 3,500 (US$ 28–230)[43].

There would be no "exemplary punishment" for not having enough CELs beyond the fine. Ideally, penalty would reflect the difference between the cost of generating electricity with clean energy and other energy sources. Price runs have been observed in several states in the US, when targets were too ambitious and specific technologies were privileged. This was the case of New Jersey, where prices increased threefold until the solar

[42] In order to be considered "clean", this technology must meets minimum efficiency standards established by CRE and the emission criteria established by SEMARNAT

[43] The actual amount to be paid is determined by the authority, taking into account factors such as the economic capacity of the non-complying agent, recidivism, and severity of the infraction, among other.

requirements were dropped. However, this is unlikely to happen in Mexico because of the broad definition of clean energy, the openness of the market, and the monetary fine.

This broad definition of clean energy was and will remain a contentious issue. Some groups believed nuclear energy should not be part of the list because of its risks and the problem of managing radioactive waste. Inclusion of co-generation in the clean energy definition encourages development of natural gas facilities that meet the energy efficiency requirements of CRE and environmental requirements of SEMARNAT, but emit greenhouse gases. In that case, the CELs would be useful as an energy diversification strategy, but not a low-carbon growth strategy. More challenges could arise, depending on the stringency of the efficiency and environmental standards for other energy sources, particularly biofuels, waste, hydrogen, and other technologies.

Linking the Electricity Market of Mexico and California

Several states in the US have clean energy goals that are limited to renewable energy. Unlike Mexico, US states have not counted nuclear energy and natural gas as options that deserve special stimulus. California has an ambitious goal of at least 33 percent of its electricity from renewable sources by 2020.

While the costs of generating electricity from photovoltaic and wind have fallen—and this trend is expected to continue—there are additional costs for dealing with variable, intermittent energy supplies on the grid. First, the marginal costs of purchasing land for utility-scale photovoltaics and wind may increase as their usage expands. Second, the intermittency of renewable sources presents a technical problem when they comprise large shares of total production. Unless pumped hydropower or lower-cost battery storage are feasible, the costs of back-up power or demand curtailment may raise the true costs of achieving California's renewable energy goals. Mexico and California could collaborate to achieve their energy and environmental goals at a lower total cost for both countries. The large border area offers great potential to link Mexico's clean energy efforts to California's. Three main options for achieving this include:

1. Greater integration of the energy markets on both sides of the border. Mexico is likely to have lower marginal costs of renewable energy generation because the country has not yet fully exploited its best renewable energy sources. If Mexico can export electricity generated with renewables and Californian law recognized this as contributing to its state goals, Mexico could increase renewable electricity production and achieve economies of scale. However, this will require political will and a supportive legal framework on both sides.
2. Linking the clean energy certificate markets for California and Mexico. This option would require negotiations and changes in current regulations because of the large differences in definitions of clean energy. A two-bin approach could unify the system, either at a national level or to create a specific goal for the shared airsheds.
3. Mexico could add labels to identify clean energy certificates that comply with the Californian guidelines. USAID could support the establishment of a renewable CEL labelling and verification system in Mexico. Since the GOM gives clean energy certificates to the generators and requires documentation of their eligibility, there would be no problem of double counting. The renewable energy certificates exported would not count toward the goals for qualified consumers and utilities in Mexico.

With all of these market integration options, there may be tradeoffs between employment and economic activity and clean energy targets that stimulate opposition. Economic analysis can especially answer these questions; in particular, computable general equilibrium modeling is important to communicate that it will not be a one-direction issue. Lower costs of reaching the renewable standards in California can actually boost employment as firms that use lower cost renewable electricity become more competitive than those that face higher costs.

Mexico's Carbon Tax

Under the fiscal reform of 2013 that took effect in 2014, Mexico introduced the Ley del Impuesto Especial sobre Productos y Servicios (IEPS). This law established an excise tax based on the carbon content of fossil fuels. This environmental tax had a key purpose of sending a price signal towards a lower-carbon economy and obtaining revenues from externalities. In this sense, it complemented the effect of subsidies reduction and fuel excise tax increases. As with all taxes in Mexico, carbon tax revenues cannot be earmarked towards a specific purpose. Instead, the carbon tax has contributed to the general expenditure of the federal government. An interesting feature of the legislation is that it allows for payment in kind through internationally recognized certificates of carbon emission reductions, taken at their market value. This does not diminish revenue generation, and it seeks to contribute to the growing internationalization of economic instruments for climate change mitigation. Table 12 summarizes the structure and estimated revenues from Mexico's carbon tax during its first year of application.

Table 12. Estimated 2014 Revenues from Mexico's Carbon Tax

Fuel	CO_2 Reduction Potential (Metric tons of Co2)	Tax (MX cents)	Tax per ton of CO_2 (MX pesos)	Estimated Revenues Generated, 2014 (MXP Billions)
Gasolines	2.27 t/ m^3	10.8 per ltr	44.05	4.6
Diesel	2.64 tons per m^3	13.1 per ltr	49.24	2.6
Natural Gas	1.92 tons per m^3	0.0 per ltr	0.00	0.0
LP Gas	1.68 tons per m^3	7.1 per ltr	41.67	0.9
Kerosenes	2.60 tons per m^3	12.9 per ltr	46.15	0.4
Fuel Oil	3.00-3.10 tons per m^3	14.0 per ltr	41.93	0.9
PetCoke	3.27 tons per ton	1.6 per kg	4.89	0.4
Coal	2.50 tons per ton (avg)	2.8 per kg	11.20	0.001
Total*				**9.7**
* Includes other fossil fuels.				

Source: SHCP. Ley del IEPS 2014. Ley de Ingresos de la Federación. Informe Tributario SAT 2014.

The tax per ton of CO_2 varied across fossil fuels. In 2013, there was a single fixed fee tax per ton of potential CO_2 set at MXP 73 per ton and excluding other greenhouse gases generated in the combustion process. However, the debate that followed in the Mexican Congress raised concerns about the price increase for high carbon fuels (such as coal and petroleum coke). This led to the current structure with a lower tax rate for coal and none for natural gas. The tax rates will be adjusted for inflation each year until 2018.

Mexico's carbon tax provided an economic signal for decentralized reductions of GHG emissions, but created economic and environmental distortions due to the lower taxes for coal and natural gas than other fuels.

2.10. GENDER MAINSTREAMING IN ENERGY AND CLIMATE CHANGE ACTIVITIES IN MEXICO

Over the last decade, Mexico has made important progress in the design of laws and policies to promote gender equality. The GOM has signed all the key international declarations and conventions on gender equality and women's human rights, such as the United Nations Charter and the Declaration of Human Rights, the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW, 1979), and the Platform of Action approved at the fourth World Conference on Women (Beijing, 1995). These instruments have also been adopted by subnational governments and nongovernmental organizations. However, there were still significant gaps in gender integration in Mexico's environmental, energy, and climate change, particularly for energy. The absence of gender considerations in the legal framework for energy was troubling because most of the legal and regulatory instruments in this sector had been adopted over the past few years. Furthermore, the GOM had committed to implementing over 50 decisions on gender equality adopted by the UNFCCC convention (Burns and Patouris, 2014).

Legal Framework

Gender equality is enshrined in Mexico's Constitution. Article 1 stated that all persons shall enjoy the rights recognized by the constitution and international treaties to which Mexico is a party (this would include the UNFCCC and international treaties on women's human rights and gender equality). Other relevant laws included the 2006 General Law on Equality between Women and Men, which aimed to ensure equal opportunities through the adoption of policies, programs, projects and compensatory instruments, and affirmative action. The 1983 Planning Law mandated including equal rights between women and men in government planning. The 2014 Law of Budget and Fiscal Responsibility required use of gender equity criteria in the allocation of federal resources. It also mandated federal programs to report their progress in gender equity through specific indicators. The LGCC compelled state governments to develop climate change programs that aim to achieve gender equality and represent populations most vulnerable to climate change. However, none of the following energy laws addressed gender equality: (1) the 2008 Law for Sustainable Use of Energy, (2) the 2012 Law on the Use of Renewable Energies and Financing of Energy Transition, (3) the Law of the Electricity Industry of 2014, and (4) the Energy Transition Bill under discussion in Congress.

Policy Framework

The National Development Plan for 2013-2018 mandated inclusion of gender as a cross-cutting issue in all of the administration's sectoral, institutional, regional, and special programs. To advance this commitment, the GOM adopted the National Program for Equal Opportunity and Non-Discrimination against Women for 2013-2018 (PROIGUALDAD). This program defined the strategies that the GOM will use to help achieve equality between women and men. It elaborated 11 strategies and 35 action lines on the environment, sustainable development, and climate change (including renewable energies, transport, and housing). Strategy 5.5 stated the importance of gender mainstreaming in environmental and sustainability policies, including the legal framework on environmental issues. Action Line 5.5.2 referred to the need to align and coordinate federal programs and foster inclusive green growth with intercultural and gender perspectives. PROIGUALDAD also promoted actions to create a safe environment for women and girls in transportation. Based on PROIGUALDAD, both the National Climate Change Strategy and the PECC for 2014-2018 included specific lines of action on gender equality and climate change.

Public policies for the energy sector have not fully incorporated gender-sensitive approaches. The National Energy Strategy (2013-2027) only mentioned the importance of gender in expanding energy access to disadvantaged communities. The Energy Sector Program (PROSENER) for 2013-2018 discussed the importance

of gender equality and non-discrimination, stressing the importance of complying with the legal framework on the subject matter. However, PROSENER lacked a comprehensive gender approach and did not explicitly recognize women as active economic agents. It only specified low-income women as beneficiaries in action line 4.6.5 on "consolidating basic electricity and sanitation infrastructure benefiting women in highly marginalized areas".

The Special Program for the Use of Renewable Energies published in April 2014 recognized the legal framework on non-discrimination and equality, but did not include any specific course of action on gender mainstreaming. A gender lens is critical in implementing this program since it constitutes one of the main vehicles to promote women's access to green jobs, technology, and income opportunities. Similar gaps existed in the National Program for Sustainable Use of Energy 2014-2018 and FIDE's energy efficiency programs.

Institutional Framework

In 2014, SENER created a Gender Equality and Non-discrimination unit. This unit is very small and has no substantive powers to mainstream gender perspectives in energy policy. Despite the existence of this gender unit, SENER does not have an explicit role in the implementation of PROIGUALDAD, like other secretaries such as SEMARNAT. In July 2015, the unit initiated a project to train women electricians specializing in installation of rooftop photovoltaic (PV) systems in Mexico City and the states of Mexico and Morelos. The project aims to certify 60 women who can install and maintain PV systems connected to the grid. It promotes renewable energy, encourages women to adopt occupations traditionally pursued by men, and increases women's opportunities for self-employment and economic advancement. However, the continued implementation of the project after 2015 was uncertain since SENER's Internal Oversight Body was assessing whether the unit's legal mandate was restricted to actions within the public administration or whether it could support actions that benefit individual citizens.

In 2015, the Network for Gender in the Energy Sector was created under the leadership of the Director of the Gender Equality and Non-discrimination Unit. This network includes a focal point from each of the government agencies in the energy sector. Its main focus is promoting cultural change to support gender equality within the sector.

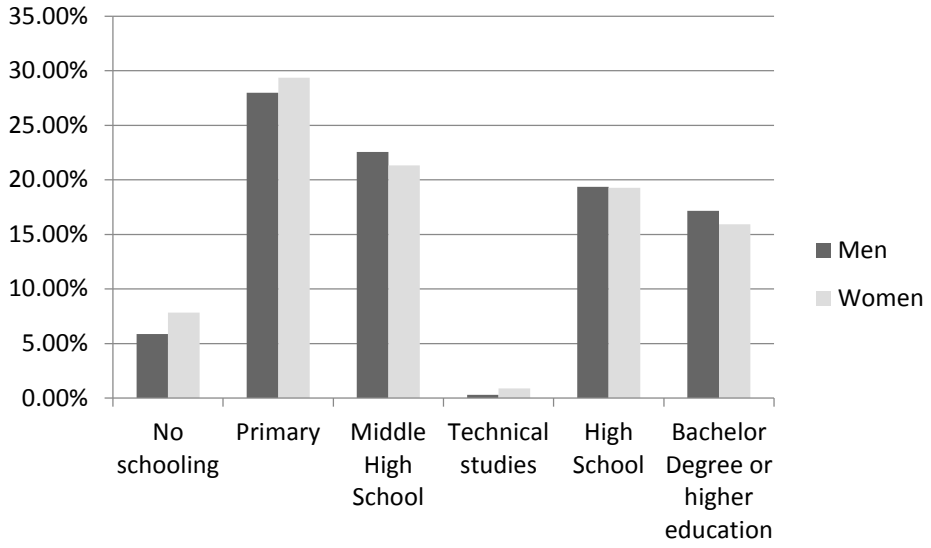
Mexico's 2015 budget ("Programa de Egresos de la Federación") included an allocation of around MXP 9 million (US$ 600,000) for gender equality in the energy sector, around 0.04 percent of the energy budget. The Gender Equality and Non-discrimination Unit is developing indicators to monitor progress in achieving gender equality in energy. The various public trust funds for energy did not include any earmarked resources for gender equality. However, Mexico's Climate Change Fund included gender criteria. According to the PECC, the Fund and other financial sources must set priorities for gender, transparency, and efficiency criteria in their operations. International climate change funds have also incorporated gender criteria. Financial mechanisms linked to the UNFCCC (such as the Climate Investment Funds and the Green Climate Fund) require funded governments to adopt a gender approach in the development and implementation of their activities.

Gender Mainstreaming in Scientific Research, Innovation and Technological Development

Mexico has achieved important progress in educational equity between women and men, although disparities remain. The most recent census, conducted in 2010, found that a higher share of the female population attended primary school or had earned a technical degree. The shares of the male and female population attending school were roughly the same. However, a larger share of the female population between 3 and 29 years of age had no schooling at all. In addition, completion of middle and high school and earning of bachelor or graduate degrees was higher among males than females (Figure 11). However, there has been little progress in the technical areas relevant for energy professionals. Women represented only 16 percent of senior management positions in Mexico's science and technology sector (PNUD-ONU Mujeres, 2014). Centro GEO (2014) found that women

represented only 35 percent of all personnel in public organizations addressing energy in Mexico. Only 23 percent of the staff in these organizations with graduate studies were women. On average, men earned 37 percent more than women. Only 26 percent of management positions in the energy sector were held by women.

Figure 11. Education Levels among Men and Women in Mexico (percent of the population between 3 and 29 years of age)



Source: INEGI, 2011. "Censo de Población y Vivienda 2010. Cuestionario Básico". http://www3.inegi.org.mx/sistemas/TabuladosBasicos/Default.aspx?c=27302ands=est

One of the main objectives of Mexico's recent energy reform is to increase investment and employment (SENER, 2015). The GOM estimated that the reforms will create 500,000 jobs in Mexico by 2018 and 2.5 million more by 2025. The reforms created new regulatory agencies, such as the National Energy Control Center (CENACE). They also expanded the mandate of existing ones, such as the Regulatory Energy Commission (CRE). CRE is responsible for maintaining a well-functioning electricity market, (Woodhouse Lorente Ludlow, 2015). These agencies will need to increase their capacities to fulfill their recently expanded mandates. Due to the gender gaps in science and technology, affirmative action might be necessary to strengthen the capacities of women and create conditions for their active participation in the energy sector, including in research, innovation, and regulatory and business activities.

Mexico´s Participation in International Initiatives to Mainstream Gender into Energy and Climate Change Actions

Mexico is an active participant in international energy initiatives. Many of these include strong gender components that the GOM might consider incorporating into its policies and programs. For example, Sustainable Energy for All (SE4ALL) brings together leaders from all sectors of society to promote universal energy access and renewable energy and energy efficiency. SE4ALL has identified gender equality as one of the critical pathways for a successful transition to sustainable energy for all by 2030. UN Women and UNIDO (2013) prepared a guidance note that identifies gender-energy nexus, including (1) gender sensitive policies, leadership, and participation; (2) green employment opportunities; and (3) sustainable entrepreneurship.

In 2010, the Clean Energy Education and Empowerment (C3E) Initiative was launched by a Clean Energy Ministerial that included the 23 state governments. Launched as a network of national-level actions, C3E was trying to enable greater gender diversity and women's leadership in clean energy globally through an International C3E Ambassador Corps made up of senior executives, academicians, and thought-leaders, and through the online community forum C3Enet.org, which connected women in clean energy around the globe through the sharing of ideas and events on clean energy.[44] The United Nation's Sustainable Development Goals represented yet another international forum with a strong gender perspective that might influence the GOM's efforts to mainstream gender in energy issues.

Other International Organizations Mainstreaming Gender in the Energy Sector

GIZ had one of the most active programs to mainstream gender in energy sector activities in Mexico. Under this initiative, GIZ partnered with the large conglomerate Grupo Salinas to train 27,000 employees and raise awareness among clients about energy efficiency in savings. Both efforts targeted women and included tailored guidebooks and other communications materials. GIZ also supported vocational training in Mexico City and the State of Mexico to build the capacity of women as qualified human resources for renewable energy and energy efficiency projects. Women participants in this project (independent from the SENER project) earned certification in nine standards, including energy savings, efficient lighting systems, energy management systems, and management and operations of building energy systems. GIZ is also working with governmental counterparts to try to introduce a regulation that requires all contractors working in this field to have certified staff.

2.11. OPPORTUNITIES TO STRENGTHEN MEXICO'S CLIMATE CHANGE FRAMEWORK

Since the development of the first Special Climate Change Program (PECC) in 2009, federal and subnational agencies have strengthened their capacity to develop climate change policies and programs, supported by sound scientific and technical analysis. Two different federal administrations have successfully adopted climate change programs that integrate the main elements of Mexico's LEDS, including (1) a well-defined process with clear institutional roles and responsibilities; (2) a sound assessment of the current situation, including increasingly rigorous GHG inventories; (3) analysis of BAU scenarios and LEDS pathways; (4) prioritization of actions; and (5) implementation and monitoring of the PECC. Subnational governments have also enhanced their capacity to develop LEDS, although more institutional development is clearly needed.

Key areas where USAID was not currently working but could provide technical assistance to strengthen Mexico's climate change institutional framework are discussed below:

- **Transition from climate change planning to implementation**. All states and more than 200 municipalities have completed their climate change programs or plans. However, many of the key actions needed to reduce GHG emissions have not been implemented due to lack of technical skills to develop feasibility and detailed project designs and attract private finance, especially for municipalities. As a result, opportunities for waste to energy projects, energy-efficient public lighting, and improved energy efficiency in water and sanitation utilities have not been carried out.

  USAID could support establishment of formal certification system for municipal staff competency in energy efficiency, energy recovery from wastes, and MRV methods. USAID could also help develop specially written materials, organize online classes and conferences, and have experts on call to provide assistance to municipalities. The certification system could build on energy efficiency trainings provided

[44] http://www.cleanenergyministerial.org/Our-Work/Initiatives/Women-in-Clean-Energy

by the National Commission for the Efficient Use of Energy (CONUEE) to municipal officials in the State of Mexico and be available for municipal officials from across Mexico.

For the first time in over a century, municipal officials elected on or after July 2015 will be eligible to run for reelection. The greater continuity of municipal administrations could increase local governance capacity and incentives for sound use of public resources needed for long-term projects.

- **Integration of federal, subnational, and private sector efforts to assess whether the country is on the right path to meet its medium- and long-term GHG mitigation goals.** In its INDC, Mexico committed to unilaterally reduce its GHG and SLCP emissions by 25 percent below BAU for the year 2030 and up to 40 percent if it receives additional international support (GOM, 2015). Meeting these goals will require climate change mitigation actions by federal and subnational governments and the private sector. However, there is currently no framework in place to integrate all of these actions. The PECC only includes federal government goals and subnational government goals are included in state and municipal climate change programs. Some private sector emissions reduction projects are registered in the Programa GEI, run by the think-tank CESPEDES, and could soon report to the National GHG Emissions Registry (RENE). Integrating all these efforts would require the harmonization of GHG mitigation goals, MRV methods, and the establishment of a platform to report progress periodically, perhaps building on the platform SEMARNAT used to monitor its PECC.
- **Integration of gender perspectives in climate finance.** Major international climate finance mechanisms such as the Green Climate Fund, the Climate Investment Funds, and the Global Environment Facility have gender policies and action plans. Mexico's national and state climate funds require equal access to climate finance for women and other vulnerable groups, but this still needs to be translated into operational criteria. USAID/Mexico could collaborate with USAID's Gender Equality for Climate Change Opportunities initiative to help the GOM develop a gender-sensitive financing strategy—with operational guidelines and capacity development of staff and women's groups—and increase women's participation in climate finance negotiations.

2.12. STRENGTHEN ANALYTICAL UNDERPINNINGS OF LEDS

- **Capacity to operate the National GHG Emissions Registry (RENE) and use its data to support policy development.** As of August 2015, the GOM was developing the electronic platform to make RENE operational. However, many challenges remain, including the incorporation of additional sources (for example, landfills), better methods to estimate GHG emissions, incorporation of stronger rules and procedures in emissions reduction projects, and the analysis of data to inform policy making. Analysis of the emissions registry data could support enforcement by identifying facilities that report significantly different emissions than other facilities with similar characteristics. USAID could provide support to help SEMARNAT tackle these challenges. USAID could also provide technical and financial support to enable civil society and business organizations to report to RENE and benefit from the data.
- **Modeling and analysis capabilities to support Mexico in its transition toward a low-emission development trajectory.** USAID could help SEMARNAT and the National Institute of Ecology and Climate Change (INECC) understand potential paths to achieve the INDC's goals and consider alternative scenarios and investment and business plans for the sectors with the largest GHG emissions. INECC has requested support to strengthen their capacity to use Computable General Equilibrium models to evaluate the net economic and cross-sectoral impacts of achieving the INDC goals, which would be instrumental to convince other sectors of the benefits of pursuing low carbon growth. USAID and NREL have previously supported the development of these capabilities and are well positioned to

provide additional assistance. To complement modeling efforts, USAID could improve institutional capacity to evaluate the effects of various policies in Mexico.

- **Development of gender-based indicators for Mexico's Climate Change Information System.** Mexico's PECC and the INDC include gender-differentiated strategies and actions. INECC and SEMARNAT have highlighted the need to develop indicators to gauge progress on how the needs of women are being addressed in relation to climate change mitigation and adaptation. USAID could provide technical assistance to support SEMARNAT, INECC, the National Institute for Women (INMUJERES), and the National Institute of Geography and Statistics (INEGI) to develop the indicators, identify how data would be collected and reported, assess how it could be integrated into Mexico's National Climate Change Information System, and convene experts in universities and diverse civil society stakeholders.
- **Development of a framework for the next generation of climate change programs.** The GOM and state governments are legally required to elaborate a climate change program at the start of each administration. USAID could help distill the lessons learned from the first generation of programs developed after the adoption of the General Law on Climate Change (LGCC) in 2012 to strengthen the design and implementation of new programs. This assistance could include comparisons of the USAID's support and it could look at how climate change programs have mainstreamed gender perspectives and the effects of gender-differentiated actions. USAID could also help assess the mechanisms used to allocate public finance and attract private funds to implement GHG mitigation actions.

2.13. FOSTER CROSS-SECTORAL COORDINATION FOR LEDS

- **Coordination between the energy and the environment**. Further modeling and forecasting of adoption rates for renewable energy and increased energy efficiency. The energy sector needs tools to assess the costs and reliability meet the goals of generating at least 35 percent of Mexico's electricity from clean sources by 2024 and 50 percent by 2050. The environment sector's priority is to understand how the energy sector might contribute to meet the country's GHG mitigation goals. While these needs might not be identical, USAID could support the establishment and strengthening of a modeling task force with representatives from both of these sectors to better understand the benefits and limitation of alternative models, assess potential trade-offs between policy goals, and support better coordination between both sectors.
- **Mainstreaming of gender in clean energy and social policies.** Most of the attention to gender in Mexico's energy policies and programs has focused on promoting the use of efficient cook stoves in rural areas. Social programs do not support the promotion of energy savings in households in general and female-headed households in particular. USAID could help integrate energy efficiency, gender equality, climate change, and social policies, working in collaboration with SEMARNAT, INMUJERES, SENER, and the Ministry of Social Development (SEDESOL). These efforts could be informed by the lessons from Uruguay's Canasta de Servicios Program, which improved low income households' access to electricity, gas, and water services.[45]
- **Increasing skills to facilitate climate financing**. USAID could help financial institutions assess opportunities to finance clean energy investments and develop the capacity of officials in the energy and climate change sectors to understand investors' needs. USAID could provide additional support to initiatives already underway. Examples include the creation of a group for the development of green

[45] http://www.dne.gub.uy/-/programa-canasta-de-servicios-rindio-cuentas

bonds led by the British Embassy in conjunction with the Stock Exchange and the Mexican Banking Association, or IDB's collaboration with NAFIN on climate bonds, and other activities of credit rating agencies, investment banks, and private equity funds. USAID could also strengthen its dialogue with banking institutions by customizing to Mexico's context and translating the Clean Energy Lending Toolkit, which could detect additional barriers or opportunities for improvements.

Technical Assistance to Strengthen the Energy Efficiency Legal and Institutional Framework

Organizations with a mandate to promote energy efficiency in Mexico include SENER (responsible for planning and setting energy and electricity policies); CONUEE, (issues recommendations and provides technical assistance on energy efficiency to firms, individuals, and all levels of government); and FIDE and FIPATERM (trust funds for energy efficiency projects). These organizations' efforts to advance energy efficiency in Mexico have been hampered by three main institutional obstacles: (1) the existence of electricity subsidies; (2) the lack of a national energy efficiency goal; and (3) weak institutional capacity and mandates for clean energy at the state level. In addition, the GOM could significantly expand the use of market mechanisms to advance GHG mitigation and energy efficiency goals. The following paragraphs discuss opportunities for USAID support in these areas.

Electricity Subsidies

Demand-side issues are important for energy consumption, given the continued existence of some electricity subsidies. USAID could assist in the following areas:

1. Electricity subsidies were very costly and the coincidence of institutional reforms in electricity production and distribution and low oil prices provides a good opportunity to change the system without a huge impact on final electricity prices for consumers or with mitigating measures for low-income people. USAID could support market studies, modelling, and the discussion on policy options, with an emphasis on the effect of incentives for energy savings at the margin. Some of the current options that need exploring are (a) means-tested transfers compensating subsidy reductions, (b) block-structure modifications on size and price, and (c) redefinition or elimination of the seasonal and regional rate differences.
2. Households with relatively high consumption of electricity are paying the higher DAC rates and typically have higher incomes and a greater incentive to invest in energy efficiency The DAC structure has block rates that rise significantly in the last increment, which might help focus households on the potential savings. However, some households may not be aware of the potential energy cost savings and capital, maintenance, and replacement costs (Gillingham et al., 2009; Ekandand Söderholm, 2010). Households may also be concerned about the risks of new technologies and service providers. Consumers below the DAC level of consumption might not be aware of the threshold or how changes in their circumstances might make them liable for substantially higher unsubsidized rates. Smart-metering, ESCOs, energy loans awareness, landlord-rental deals and other creative structures can reduce the problem of a slower-than-expected reaction to price signals. Electricity subsidies are not available for the industrial and service sectors and these users might be good candidates for energy efficiency activities.
3. Agriculture presents a serious challenge for energy efficiency because high level of subsidies for electricity reduces the incentives to participate. Muñoz and Aguirre (forthcoming) found that the additional investment in energy-efficient irrigation technology resulting from the elimination of electricity subsidies could reduce 980,000 tons of CO_{2e} emissions per year. It would also contribute to full long-term recovery for 25 percent of Mexico's overexploited aquifers and a reduction of the overexploitation rate for the rest from the current 170 percent to 130 percent. The continuing high subsidy for electricity in agriculture makes the private profitability of investments in more efficient irrigation lower than the social

profitability. This divergence in profitability provides a justification for increasing donor support for modernizing irrigation systems for low-income farmers in areas with water scarcity or aquifer overexploitation. Rural poverty can be reduced if donors help informal irrigators achieve full compliance by purchasing water concessions from formal irrigation systems. While this approach would help make agriculture more resilient to increasing drought risks from climate change, it would also expand eligibility for subsidized electricity rates for irrigation.

4. Households below the DAC threshold also face a distortion between the private and social profitability of energy-efficiency investments. While donors could support interventions, such as appliance scrapping or retrofitting of lighting, grants or concessional financing may be needed to stimulate interest. However, donors should be careful to ensure the additionality of GHG emission reductions. Government agencies and nongovernmental organizations may need training to avoid non-additionality problems and understand the differences between private and social costs and benefits. The capacity of SMEs to invest in energy efficiency is limited, unlike larger firms or higher households, because of credit constraints—an inability to obtain credit for profitable investments because of lack of collateral or other restriction. Some solutions have been proposed for easing this constraint elsewhere in the document and with more detail. USAID could provide training and technical assistance on identifying the size and extent of these constraints. Donor and partner agreements could help approach and collaborate mainly with those sectors that are more vocal in approaching agencies, not necessarily the ones most at need.

USAID could also convene discussions between CFE, the development bank NAFIN, technology providers, and customers. NAFIN can structure debt issuance and risk reduction facilities, like those provided by the World Bank or the IDB. CFE could collect repayments through electric bills and technology providers would be responsible for implementation. The proceeds of green bond proceeds could be used to fund rebates for residential energy conservation. USAID could also work with SHCP and CFE to assess options for reforming electricity subsidies for agricultural users. For example, electricity subsidies could be replaced with financing for investments in efficient irrigation technologies.

Energy Efficiency Goals

The lack of a mandatory energy efficiency goal has limited Mexico's efforts to date, but this could change if the Energy Transition Law is enacted. The Chamber of Deputies approved the bill in December 2014 and the Senate on December 2, 2015. However, the Senate modified the bill, and will therefore need to be approved by the lower chamber again. This law would mandate the adoption of the Special Energy Transition Plan, which would set a national energy efficiency goal. CONUEE and SENER would be responsible for defining a road map to achieve the goal. It would also significantly change Mexico's institutional and policy environment for clean energy and open up new avenues for possible donor assistance. If the bill is approved, USAID could help CONUEE fulfill its expanded mandate, including the development of the national energy efficiency baseline, identification of key sectors where energy efficiency gains can be achieved most easily, development of an energy efficiency plan, identification of financial and market mechanisms to support the plan, and establishment of a transparent and robust monitoring and evaluation framework.

Market Mechanisms for GHG Reductions and Energy Efficiency

Important opportunities exist to link Mexico's and California's clean energy markets. California has some of the most ambitious renewable energy goals in the US. There is potential to link some portions of Mexico's clean energy market to California's market to reduce the total cost of reaching the environmental goals in both jurisdictions. USAID could support the following activities to facilitate integration of these two clean energy markets:

- Support the establishment of a Clean Energy Certificate labeling and verification system in Mexico to support exports of energy or the certificates. The most feasible option to achieve the integration of

these markets would be to link the clean energy certificate markets in the two jurisdictions. However, California and Mexico define clean energy differently. Since the GOM issues clean energy certificates to energy generators and requires proper documentation, double-counting would not be a problem.

- Support technical compatibility for California and Mexico grids. California's Rule 21set the technical requirements for connecting solar electricity to the grid. The California Public Utilities Commission and California Energy Commission has formed a working group to revise the rule, in part to promote smart inverters that can better manage voltage variations from solar distributed-generation resources. USAID could support translation of the lessons and technical definitions of California's advanced inverter standards and help link the markets in Mexico and California. USAID could support the technical studies that would allow SENER to harmonize its standards (Normas Oficiales Mexicanas) with those of California.
- Help Mexican companies interested in exporting electricity to meet the criteria for California's renewal portfolio standard. USAID could support development of a checklist of requirements for meeting California's renewable portfolio standards and rapid assessments of compliance with the standards. Compatibility with CELs is desirable, but not necessary for the system to work. However, it is essential to have procedure for avoiding double-counting in both systems.
- Support analysis of the effects of integrating the two markets for renewable energy or CELs markets on the cost of achieving California renewable energy goals. This could include analysis of economic impacts through computable general equilibrium modeling or employment effects, which could also inform any policy debate on the issue to avoid opposition or misconceptions.

The Energy Transition Bill has provisions to establish a carbon market for electricity sector, which would be regulated by SEMARNAT. If the law is enacted, USAID could Help CONUEE and SEMARNAT develop a market for energy savings certificates known as "white certificates". These certificates are "tradable instruments that represent the avoidance of a defined amount of energy use" (Institute for Building Efficiency, 2011). Governments in Australia, Europe, India, South Africa, and many states in the United States have implemented energy savings certificate programs. USAID could help CONUEE and SEMARANT assess the advantages and disadvantages of setting up a system of energy savings certificates in addition to the CELs. USAID could also help document best practices from other countries on eligibility, pricing and trading, and measurement and verification for the energy savings certificates.[46] Activities for developing a market for energy savings certificates would be similar to for CELs, but the focus is on energy demand rather than supply.

Energy Efficiency at the State Level

As of August 2015, only four state governments in Mexico had a dedicated energy agency: Baja California, Hidalgo, Sinaloa and Sonora.[47] As a result of Mexico's energy reform, subnational government will have to play a more active role in areas such as purchasing power from different suppliers, meeting clean energy requirements, and promoting the development of the energy sector within their jurisdictions. Support could be provided for the development of state and/or municipal agencies or commissions to adequately plan and implement state-level clean energy policies.

As a result of the recent energy reforms, the state governments of Morelos, Veracruz, and Yucatan have established formal and informal coordination mechanisms across agencies to promote the development of energy projects. Agencies for economic development and environmental protection will lead those efforts in these states. USAID could state agencies or commissions develop their capacity to plan and implement clean energy policies, building on its experience working with the Baja California State Commission. In 2012, USAID

[46] http://www.institutebe.com/energy-policy/energy-saving-certificates.aspx
[47] http://www.conuee.gob.mx/wb/Conuee/comisiones_estatales_de_energia

supported preparation of an energy profile for Baja California that included alternative scenarios and addressed renewable energy and energy efficiency laws and programs.[48]

Workforce Development

The GOM has supported human resource development in the energy sector, as part of its efforts to stimulate green jobs. These activities have included programs with GIZ and SENER to train and certify women as renewable energy and energy efficiency technicians. GIZ was also helping the GOM design a regulation requiring all energy contractors to have certified staff. Donors could help by expand programs that integrate technical and university education for both women and men and involve private firms to help match the demand and supply for the desired skills. Furthermore, USAID could work with INMUJERES and the Ministry of Labor to promote a gender equality certification, which has proved useful in countries such as Brazil and Uruguay. In developing these efforts, donors could incorporate lessons from similar activities, such as:

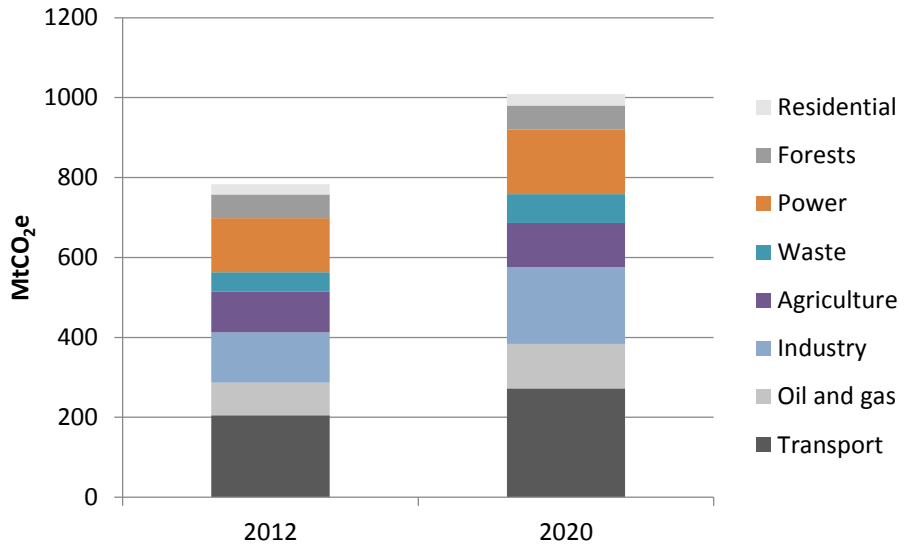
- The US DOE Guidelines for Home Energy Professionals established a national residential energy upgrade standard and promoted a skilled and credentialed workforce. These guidelines addressed standard work specifications, advanced professional certifications for workers, and accredited training programs (NREL, 2015).
- ACEEE's Building Training and Assessment Center (BTAC) program worked with three types of higher education institutions to develop the energy efficiency workforce: (1) university-level BTACs educated building engineers and researchers on the design and operation of energy-efficient buildings; (2) satellite BTACs trained building technicians in troubleshooting building operations through community colleges and trade schools (including continuing education); and (3) Centers of Excellence. BTAC universities that were established leaders in building energy efficiency served as resources to other BTACs and were given financial resources for travel, mentoring, and maintaining a network of educators.
- An ongoing collaboration between the IDB and the private company, Optima Energia, which established a certification system based on a voluntary Mexican standard for gender equality in the workspace. The company implemented an internship program and women are expected to comprise at least half of the interns selected each year.[49]

[48] http://www.energiabc.gob.mx/files/public/pdf/PerfilEnergeticoBC2010-2020.pdf
[49] http://blogs.iadb.org/sectorprivado/2015/08/20/mujeres-en-el-sector-de-la-energia-renovable-negocios-sostenibles/

3. POTENTIAL USAID ACTIVITIES IN ENERGY EFFICIENCY

This chapter focuses on opportunities to support Mexico's efforts to achieve its climate change mitigation goals relating to clean energy and the roles and responsibilities assigned to various national and subnational government institutions. Mexico emitted 748 million tCO_2e of GHG in 2010. Energy sector was the largest source of emissions, contributing 67.3 percent of total emissions. Energy for transportation produced 22.2 percent of total emissions and electricity generation was 21.8 percent (SEMARNAT, 2013). Energy is expected to contribute an even larger share of Mexico's total GHG emissions in the future. Under the BAU scenario, emissions from transportation would represent 27 percent of Mexico's total emissions in 2020, followed by industry at 19 percent, electricity generation at 16 percent, and oil and gas at 11 percent (Figure 12).

Figure 12. Mexico's GHG Emissions by Source, 2012 and 2020



Note: 2020 emissions under the BAU scenario.

Source: SEMARNAT, 2014

In decreasing order, the largest GHG mitigation potential from greater energy efficiency in Mexico is from transportation, followed by industry, waste, and buildings.[50] Transport and industry are projected to contribute an even larger share of GHG emissions in the future under a BAU scenario. Energy efficiency gains in transport, industry, and building can often reduce economic costs over the long term (Table 13). Improved waste management, particularly wastewater treatment, increases net costs but provides other co-benefits. Although the potential GHG emission reductions from municipal services (including waste management) and buildings are

[50] Mitigation from industry and buildings include direct and process reductions, as well as indirect reductions from decreased power consumption. Waste is considered a renewable source of energy by Mexican legislation; however, it is discussed in this memo because it was not covered in the NREL assessment on renewable energy and it is a priority for Mexico, as stated in the General Law on Climate Change and the climate change laws of Veracruz and Mexico City.

relatively modest, key stakeholders listed them as priorities because of the fiscal impacts and environment and health benefits.

Table 13. 2020 Estimated GHG Mitigation Potential in Key Sectors in Mexico

	2020 abatement potential (Million tCO_2e/year)	2020 abatement potential relative to BAU	Weighted average abatement cost (US$ /Tco_2e)
Transport	55	-20%	-79
Waste	44	-61%	12
Industry	19	-8%	-37
Buildings	9	-12%	-90

Note: This table provides figures for selected sectors. As such, they are not meant to inform the selection of specific measures, but to show the results of previous work that has helped to prioritize key sectors from a GHG emissions reductions perspective.

Source: MLED, 2013

The following sections contain the CEADIR team's recommendations for GHG mitigation actions in the above sectors in decreasing order of their GHG emissions reduction potential.

3.1. TRANSPORT AND URBAN DEVELOPMENT

Mexican states and municipalities share responsibilities for policies and laws that shape how cities develop their GHG emissions. The LGCC gives state governments climate change mitigation and adaptation responsibilities in transportation and infrastructure, land use planning and urban development (in coordination with municipalities), and special management wastes.[51] Municipalities have jurisdiction over water supply and sanitation, local land use planning and urban development, natural resource management, municipal solid waste management, and public transportation. Thus, subnational governments influence most of the land use planning processes that affect GHG emissions. However, close coordination among federal, state, and municipal governments in Mexico is needed to achieve emissions reductions in transportation, urban planning, and municipal services requires.

Main Sources of Energy Consumption

GHG emissions from transport were mainly from fossil fuels. About 95 percent of the total transport emissions were from road transport and the rest from air, rail, and maritime transportation. GHG emissions from road transport were 157 million tCO_2e per year in 2010. GHG emissions from road transport increased at an annual rate of 3.2 percent between 2000 and 2010 and comprised the fastest-growing source in Mexico. Gasoline was the most widely used transportation fuel and generated 115 million tCO_2e, 69 percent of the total GHG emissions from fossil fuel consumption. The next largest source of GHG emissions in transportation was diesel at 43 million tCO_2e, 26 percent of fossil fuel emissions (SEMARNAT, 2012). The rest of this section focuses on road transport because of its substantial share of GHG emissions and the potential for emission reductions through domestic policies, unlike air and maritime transport emissions, which would require coordinated international actions.

[51] Special management wastes are defined by Mexico's General Law on Waste Prevention and Integrated Management (LGPGIR) as those that are generated as a result of productive processes and do not meet the characteristics of either hazardous waste or urban solid waste, or that are produced by a person or firm that generates 10 tons or more of waste per year (LPGIR, art. 5).

The increase in road transport emissions was associated with greater motor vehicle use due to urban population, income growth and urban sprawl. Between 1990 and 2010, Mexico's population increased at an annual rate of 2.5 percent, vehicle ownership at 3.6 percent, and vehicle-kilometers driven at 7.7 percent (ITDP, 2013). Vehicle ownership continued to grow at about the same average annual rate between 2010 and 2014.[52] Daily work commuting within cities was the main source. Low-income residents of social housing constituted approximately 35 percent of all road distance travelled; they often travel longer distances because of the location of social housing on the outskirts of cities. Many rely on shared private automobiles that are often older than average,[53] (CTS Embarq Mexico, 2011). The total number of people living in metropolitan areas is projected to increase from 63.8 million in 2010 to 78 million in 2030 (GOM, 2014).

Energy Efficiency Potential

Energy consumption and GHG emissions from transport can be reduced through urban planning that encourages denser settlement patterns close to employment centers and public transit hubs ("smart growth"). Higher population densities also favor a shift from private cars to public transportation and greater use of non-motorized transportation (walking and biking). Increasing fuel efficiency and fuel substitution in personal vehicles can reduce GHG emissions over the medium term as owners replace their cars over time. However, the gains from energy efficiency and fuel substitution could be offset by increased personal vehicle use. Complementary transport and urban development interventions are needed to reduce GHG and air pollution emissions and the congestion, noise, and traffic accidents associated with private vehicle use in metropolitan areas (ITDP, 2013). A shift to energy-efficient transport networks and denser urban development is a medium-to-long term endeavor. However, it should receive priority support because transport and urban development patterns will largely determine Mexico's carbon emissions pathway.

Transport Demand Reduction through Dense and Multiple Urban Land Use

Over the last 30 years, the country's population doubled, but the footprint of cities increased sixfold. This rapid urbanization contributed to the large increase in GHG emissions and air pollution from transportation and the decrease in the productivity of urban workers because of the greater commuting time. In addition, urban sprawl has accentuated social inequality, with lower income people increasingly moving to peri-urban areas, where land costs for housing are lower, but distances to jobs, friends, and families may be longer. In Mexico City, 3.3 million person-hours are lost every day in commuting, resulting in economic losses of MXP 33 billion. The number of motor vehicles in Mexico is expected to increase from 30 million in 2013 to 70 million in 2030. On average, a low-income household spends 44 percent more on road transport than on electricity and LPG combined—up to 25 percent of total household expenditures (CTS Embarq, IMCO, CMM, 2013).

More than 78 percent of the national population resides in cities. The 93 urban centers with populations over 100,000 produce more than 80 percent of GDP. Hence, a sustainable, low-carbon city design could profoundly affect Mexico's development (CTS Embarq, IMCO, CMM, 2013).

Urban sprawl increases operating and maintenance costs of public infrastructure and services for water, electricity, sewage, municipal solid waste recollection, security, and public spaces. Denser cities could reduce

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[52] INEGI. Estadísticas de vehículos de motor registrados en circulación. http://www.inegi.org.mx/est/lista_cubos/consulta.aspx?p=adm&c=8

[53] Social housing refers to the homes that can be bought by low-income households, taking advantage of government subsidies. As discussed in section 3.8, federal government housing subsidies are part of the national housing policy and are aimed at the population that earns less than 5 times the minimum wage. New homes that can be bought with the subsidies have a value of between 60 and 200 times the minimum wage. http://portal.infonavit.org.mx/wps/wcm/connect/61166c82-ce95-444f-97e4-6b3695a20450/MMS_Vivienda_nueva.pdf?MOD=AJPERES. Developers have built the majority of new social housing units in peri-urban areas because of lower land costs . However, the costs of providing public infrastructure for housing in the urban periphery and the transport costs for residents are often significantly higher (CMM, 2014).

infrastructure investment costs by 30 percent and operating and maintenance costs by 68 percent. These cost savings would have substantial fiscal benefits for financially strapped municipal governments. More than 70 percent of municipalities were in financial default (CTS Embarq, IMCO, CMM, 2013, p. 15).

Other anticipated benefits of denser urban development and improved access to public and non-motorized transportation include health improvements from reduced air pollution and improved opportunities for physical activity, which could reduce Mexico's severe obesity problem (CTS Embarq Mexico, 2011). Air pollution in Mexico's urban areas resulted in around 15,000 premature deaths and cost around 4.8 percent of GDP (INEGI, 2012; Clean Air Institute, 2013).

Mobility and Transport Networks

Although private vehicles were a significant source of GHG emissions and other externalities, most of the country's population depends on public transportation. In Mexico City, 70 percent of the population regularly used public transport. Women comprised 47-51 percent of public transportation users, highlighting the importance of mainstreaming gender in transport policies and investment. Women often use public transportation services differently than men, as they usually ride shorter distances and make more frequent stops to conduct errands. In most Mexican cities, the various modes of public transport are not integrated. As a result, users have to pay a separate fare every time they switch from one mode to another and timetables and connections are not harmonized. This lack of integration increases the costs of using public transportation and creates safety risks for women. Both men and women depend on public transportation services to increase their productivity and access to improved health, employment, and education opportunities. However, women face greater risks when they use it, thus calling for gender-responsive strategies to improve public transportation. A 2015 survey on the quality of public transport in the Mexico City Metropolitan Area found that 68 percent of respondents had been sexually harassed while using public transport.[54] Women reported the largest number of attacks at bus stands and other waiting places for public transport.

Over the last two decades, the public rapid transport network in Mexico doubled from approximately 250 km to a little over 500 km (Hook, 2014). Although these investments in the metro subway, bus rapid transit, and light rapid transit) have increased the volume of services from 3 km per million urban residents in 2007 to 5 km in 2014, the quality of public transport services remained low.

The Rapid Transport to Resident (RTR) ratio measures kilometers of transit infrastructure per million residents. Mexico's RTR ratio was 8.4, below the level of Brazil at 10.3 and Colombia at 10.1. Most of the investments in rapid transport were concentrated in a few cities—Guadalajara, Mexico City, Monterrey, Leon, Puebla, Tuxtla Gutierrez, and Villahermosa (En Movimiento, 2013).

In 2013, more than MXP 87 billion (US$ 5.8 billion) from Mexican federal funds was invested in urban mobility. About 74 percent of the funds were used to expand and maintain road infrastructure. Sustainable urban mobility (SUM) received a minor share of the investments—11 percent for public spaces, 10 percent for public transportation, 4 percent for pedestrian infrastructure, and less than 1 percent for bicycle infrastructure.[55] In 2011, the distribution was even more skewed in favor of road infrastructure, which received 87 percent of the urban mobility investments. These investments were unevenly distributed geographically. About 50 percent of the investments in mobility were for sustainable options in Veracruz, Tecomán and Mérida, and 82 percent in Ocotán, but the share was less than 5 percent in half of Mexico's metropolitan areas. The cities of Matamoros, Puerto Vallarta, Piedras Negras, and Minatitlán spent their entire transport budgets on highways and roads

[54] http://elpoderdelconsumidor.org/transporteeficiente/reprobado-en-materia-de-seguridad-el-transporte-publico-de-la-ciudad-de-mexico/
[55] Sustainable Urban Mobility is defined as the capacity to move from one place to another, which is sustainable when it includes multi-modal, safe, and efficient transportation that promotes reductions in the use of private motorized vehicles and that is undertaken under conditions of equality in roads and in the public spaces of a consolidated urban area, improving the quality of life of the population, increasing economic productivity, and contributing to mitigate climate change through the reduction of GHG emissions (SEDATU, 2015).

(Garduño, 2014). Since transport infrastructure is long-lived and has feedback effects on residential and employment patterns, it can have long-term effects on the GHG emissions trajectory (Garduño, 2014).

Fuel Substitution and Energy Efficiency of Automobiles

Denser urban development can significantly reduce the demand for motor vehicle transport. When combined with improved public transportation networks, smart growth can significantly reduce GHG emissions in the medium-to-long term. However, in the short-to-medium term, it is important to increase energy efficiency, promote carbon-reducing fuel substitution, and invest in public transit improvements that can be implemented relatively quickly.

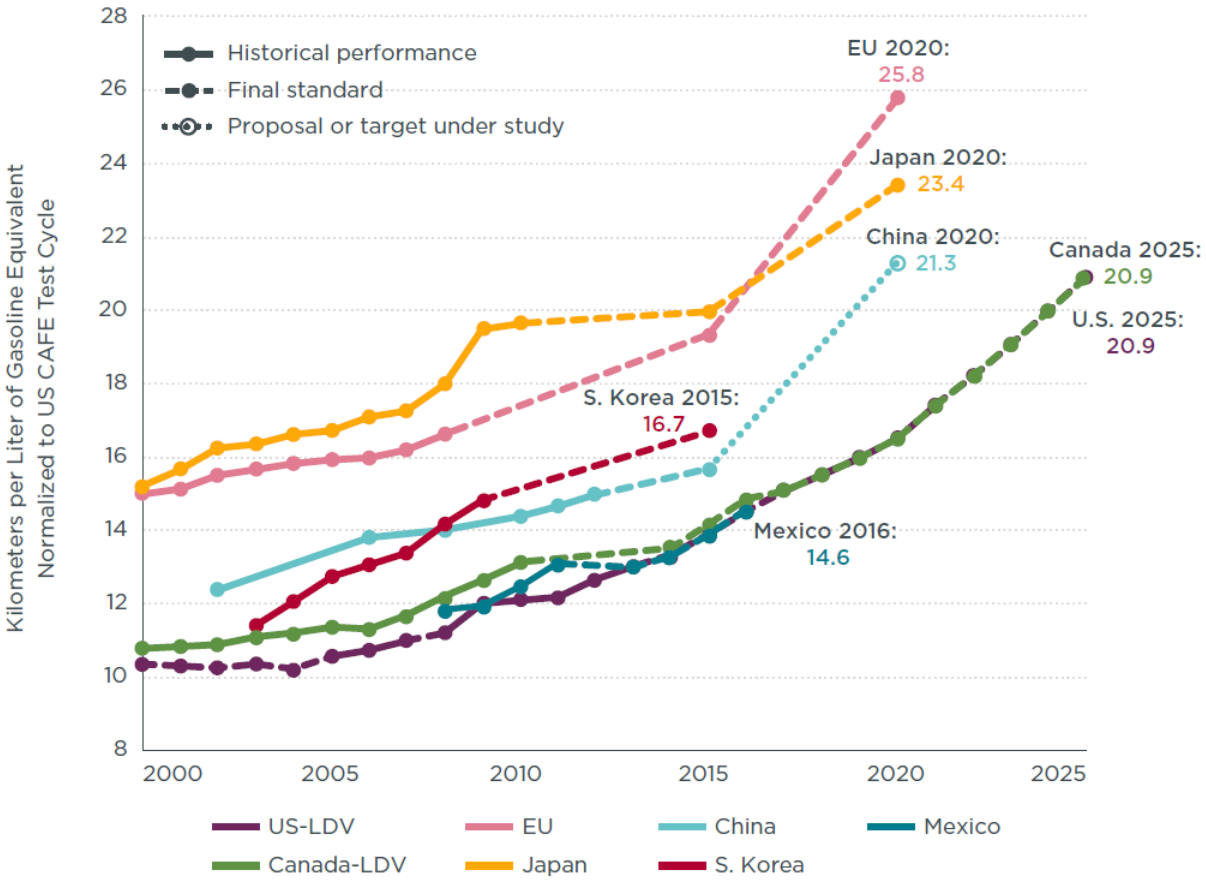
Several initiatives in Mexico have aimed to substitute gasoline and diesel with lower carbon alternatives, such as compressed natural gas (CNG) or electric or hybrid electric cars. In 2010, Nissan introduced the Leaf electric car and the Nissan Power 88 program. Nissan and some local governments financed electric car battery chargers. It also supported zero emission taxi pilots in Mexico City and Aguascalientes, which enabled 70 taxi drivers to acquire a Nissan Leaf at a reduced cost (Hybridcars, 2013). Nissan Power 88 was slowly expanding in Mexico with the installation of charging stations in key areas of the two cities. General Electric, Schneider, and ABB also joined the program.

The Mexico City Government was promoting the adoption of electric cars by exempting them from vehicle ownership taxes ("tenencia"). There was also a proposal in the Mexican Congress to exempt electric vehicles from the value-added tax. Nissan was negotiating with CFE so that owners of Leaf vehicles could obtain the T2 commercial electric rate, which is 50 percent below the rate for high consumption residential users (GreenScreen, 2015). Since vehicle manufacturing is one of Mexico's most important economic activities, the promotion and deployment of electric vehicles could increase the value added in vehicle manufacturing. However, an initial assessment of these initiatives concludes that results have been limited to date. Electric cars still represent less than 1 percent of total sales cars in other countries, such as the United States, that have invested more heavily in infrastructure for these vehicles (CEM, EVI, IEA, 2013). This does not mean that there is a negative outlook for electric cars, but that they are not an option that is likely to achieve significant GHG emissions reductions in the short term.

In 2013, SEMARNAT approved a standard to regulate CO_2 emissions from light-duty vehicles with a weight of 3,857 kg or less (NOM-163-SEMARNAT-ENER-SCFI-2013). This standard aimed to reduce fuel consumption of new light vehicles from the 2011 average of 14.9 km/L to 13.09 km/L. This standard is expected to reduce GHG emissions by 50 tCO_2e per year and also decrease morbidity and mortality from poor air quality. The health co-benefits were valuated at MXP 4 billion per year (US$ 266 million per year) (SEMARNAT, 2012b) (SEMARNAT, 2012). As Figure 13 shows, Mexico's 2013 standard was similar to the Canadian and US standards, but lower than the standards of the European Union and some Asian countries (ICCT, 2013).

In late 2014, the GOM published draft emissions standards for heavy-duty vehicles (NOM-044-SEMARNAT-2014). The draft NOM proposes to raise the standard from either EPA04 or EUROIV to EPA10 and EUROVI. To meet these standards, heavy-duty vehicles (HDVs) must use ultra-low sulfur diesel, which was not yet available in Mexico. The GOM plans to make this fuel available throughout Mexico in 2017 and begin enforcing the new standard in 2018.

Figure 13. Fuel Efficiency Standards for Light-duty Vehicles in Mexico and Selected Countries



[1] China's target reflects gasoline vehicles only. The target may be higher after new energy vehicles are considered.
[2] US, Canada, and Mexico light-duty vehicles include light-commercial vehicles.
[3] Mexico does not include early action credits for MYs 2012 and 2013 but does include full application of other credits.

Note: LDV = Light-Duty Vehicles.

Source: ICCT, 2013.

Implementation Barriers for EE in Transport and Low Carbon Urban Planning

Urban planning to reduce transport demand and facilitate public transport and policies to promote motor vehicle fuel efficiency and fuel substitution all face important structural barriers and require the coordination of diverse stakeholders. These options are hampered by the limited leadership and capacity of urban planning enforcement in Mexico. There was also no consensus about what constitutes a sustainable and low-carbon city. Lack of coordination among different governmental entities has resulted in fragmented and dysfunctional land use and transport systems. There has been little regional coordination among municipalities that are part of the same urban agglomeration, and decision making for urban development has been dominated by short-term local interests (CTS Embarq, IMCO, CMM, 2013).

Federal funding for transport and urban planning have been limited and the three-year single term of office for municipal governments is too short to develop complex infrastructure projects. Most municipal governments had weak planning, financing, and implementation capacities. Municipal officials will be able to seek reelection starting in 2018. A decentralization process aiming to devolve greater power to municipal governments over the

last 15 years has not had the anticipated results since many states and municipalities with little technical capacity embarked on agendas and policies that undermined federal strategies and objectives (Garduño, 2014). In addition, many subnational governments accumulated huge debts that could not be repaid. As a result, the GOM is working to reverse the previous decentralization process. Other institutional barriers included the limited capacity of local government to regulate individual concessions for public services as well as politicization and corruption of public officials.

Other Stakeholder Activities in Energy Efficiency

The Ministry of Agrarian, Territorial and Urban Development (SEDATU) has several programs to influence land use planning. Its Habitat Program links social policy objectives to urban development and territorial management to improve the quality of life of marginalized populations (SEDATU, 2015).[56] An evaluation concluded that this program provided wider access to basic urban infrastructure (water, sewage, and electricity) and improved the urban environment by facilitating private investment in homes. However, the program was generally unable to generate social capital in urban areas (CONEVAL, 2013a).

SEDATU's Consolidación de Reservas Urbanas (Consolidation of Urban Reserves) Program) was launched in 2014 with a budget of MXP 250 million (US $16.6 million). It has been one of the most important efforts to make cities more compact, productive, competitive, inclusive, and sustainable. It also promoted mobility to improve quality of life. It offered subsidies of up to MXP 40,000 (US$ 2,650) per apartment for vertical, low-income housing that increases urban density, following the same criteria as the housing subsidies described in chapter 2 (SEDATU, 2014). A performance evaluation of this program has not yet been completed. The Rescate de Espacios Públicos (Recovery of Public Spaces) Program invested to increase security in public spaces (i.e., public parks, sports and leisure areas, and lighting) in marginalized areas of cities and metropolitan areas. This program was in its third year. A preliminary assessment indicated that it has increased public perception of security in the areas where it operated. Renovated public spaces have become important leisure areas for the local community, as documented through perception surveys conducted as part of an evaluation by the National Council for Social Development Policy Evaluation (CONEVAL, 2013b).

A few state governments foster smart and low-carbon cities. Some municipalities that shared similar problems and were part of the same city or metropolitan area have established Municipal Planning Institutes (IMPLANES). These public organizations have supported urban infrastructure planning and development with civil society participation. The Mexican Association of Municipal Planning Institutes (AMIMP) has representatives from more than 50 IMPLANES and promotes the exchange of technical information and experiences among its members. AMIMP also advocates for increasing funding for municipal planning and development.

NGOs and think tanks such as Centro Mario Molina, CTS Embarq, Instituto Mexicano para la Competitividad (IMCO), and the Institute for Transport and Development Policy (ITDP) have support from the British Embassy and the French Development Agency for detailed assessments on urban planning and sustainable mobility at national and local levels. One study concluded that green low-income housing development in peri-urban areas was not sustainable because GHG emissions caused by transportation exceeded the modest energy- and water-efficient technologies installed (CMM, 2014). As a result of this and other evaluations, the Green Mortgage Program revised its incentives for developers to develop low-income housing units for infill areas, as evidenced in the rules of operation for federal housing finance and subsidies. Subsidies for new homes outside of urban containment areas are limited to a lower ceiling equal to 25 months of the minimum wage (compared to 33

[56] Mexico's National Population Council (CONAPO) defines marginalization as the lack of social opportunities and absence of capacities to develop them, as well as lack of access to basic services. CONAPO has developed a marginalization index to identify marginalized municipalities in Mexico. It is integrated by nine indicators: (1) share of illiterate population; (2) share of the population that did not complete primary school; (3) share of homes without access to sanitation; (4) share of homes without electricity; (5) share of homes without water supply; (6) share of crowded homes; (7) share of homes with a dirt floor; (8) percentage of the population in localities with population under 5,000; and (9) percentage of the population with income levels of up to two minimum wages (CONAPO, 2013).

months for homes inside urban containment areas). Outside urban containment areas, higher scores are required for the home's location and sustainability of its surroundings (SEDATU, 2014). The effects of these relatively small changes on urban sprawl have not yet been evaluated, but are likely to be small.

GIZ also contributes to energy conservation through its support of the Road Freight Transport NAMA. GIZ's support included lessons on energy-efficient driving, fuel-saving technologies, and fleet upgrades for owners of six to thirty trucks. These owners controlled 60 percent of the total number of heavy-duty vehicles in Mexico. The estimated mitigation potential of this NAMA is 7.9 million tCO_2e per year through 2050 (GIZ, 2013b).

The World Bank supported CONAVI's work in designing the Urban NAMA (The Innovolve Group, 2012). This NAMA aims to reduce GHG emissions from public services such as solid waste management, water supply and sanitation, street lighting, electricity generation, heat generation, and public transportation (Point Carbon, 2012). The agency sought US$ 1.5 million in World Bank funding for the first phase and an additional US$ 4.5 million for implementation (CONAVI, 2015).

The private sector has developed several NAMAs for transportation. The Mexico NAMA Facility, an NGO supported by CESPEDES, developed the Car Fleet Renewal NAMA. In March 2015, Mexico's Climate Change Fund awarded approximately MXP 4 million (US$ 260,000) for implementation of this NAMA. It will enable three large private firms (FEMSA, BIMBO, and CEMEX) to use natural gas vehicles and is expected to eliminate 133 tCO_2e per year (México NAMA Facility, 2015). [57] Table 14 describes other transportation NAMAs under development.

[57] FEMSA is the largest bottler of Coca Cola products worldwide, the second largest shareholder of Heineken Breweries, and operates the OXXO convenience stores, among other lines of business. BIMBO is a large firm that sells bread and other food products. CEMEX is one of the largest companies that sell cement, concrete and other building materials.

Table 14. Transportation NAMAs under Development

Name	Objectives	Implementing Agency
Enhancing Vehicle Renovation and Operating Efficiency of Federal Vehicles	Support two federal programs: the Program for the Modernization of the Federal Motor Carrier Fleet and the Clean Transportation Program (similar to the US Smart Way Program)[58].	SEMARNAT
Mexico's Energy Efficiency Program for Freight Vehicles	Increase the energy efficiency of the domestic freight vehicle fleet by encouraging training and adoption of energy-efficient driving techniques and technologies to reduce emissions by 290 million tCO_2e.	SEMARNAT
Federal Mass Transit Program (PROTRAM)	(1) Capacity development; (2) development of methods for project evaluation and cost-benefit analysis including co-benefits; and (3) development of integrated transport systems, including integrated mass transit corridors (BRT), multimodal integration, low-carbon technologies, and vehicle scrapping. This NAMA will receive funding from the Clean Technology Fund and is expected to reduce 6.4 million tCO_2e.	SEMARNAT
Optimization of the Conventional Bus System in the Valley of Mexico City	Improve the bus system in the Valley of Mexico City by improving the institutional and regulatory framework, rationalizing routes and concession management, conducting public outreach, and implementing a transport monitoring system.	N/A
Public Transport Route Optimization and Vehicle Fleet Renovation	Increase the efficiency of public transport operations in 56 metropolitan areas to reduce GHG emissions and other pollutants by restructuring public transport routes and replacing public transport vehicles over 12 years old.	SEMARNAT

Source: Adapted from http://www.transport-namadatabase.org/

Opportunities to Foster Smart and Low Carbon Growth in Cities

Identification of Flagship Projects that Could Trigger Sustainable Urban Development

Mexico City, Puebla, and many cities near the border between Mexico and the US are undertaking some large development projects that have significant implications for their long term sustainability. The new Mexico City International Airport (NAICM) will cover 4,431 hectares and serve 50 million passengers per year in its first stage and 120 million at full capacity. The projected investment cost is MXP 169 billion (US$ 11.3 billion) during its first phase from 2015 and 2020 (SCT, 2015). The NAICM will have positive and negative impacts on ground transportation, water supply, waste management, and electricity generation. The Mexico City government and *Grupo Aeroportuario de la Ciudad de México* (a company created by the federal government to build and operate the airport) are responsible for planning for ground transportation. At the end of July 2015, the project did not include any significant investments in public transportation (IMCO, CTS Embarq, CEMDA, 2015). The city had not yet decided how the 750 hectares of the current airport will be used after the new airport opens.

Border cities (such as Tijuana-San Diego, Cd. Juarez-El Paso, Piedras Negras-Eagle Pass, Nuevo Laredo-Laredo, and Reynosa-McAllen) are among the most important commercial and industrial hubs in the world. More than US$ 1 billion worth of goods cross through these borders every day. The security, quality of life, and

[58] Launched in 2004, SmartWay® is an EPA program that helps the freight transportation sector improve supply chain efficiency. See: http://www3.epa.gov/smartway/about/index.htm

sustainability of these cities and crossing is a national priority (Wilson, 2013). The Urban Affairs Association has been collaborating on urban policy research for border cities, with the participation of El Colegio de la Frontera Norte, UC-San Diego, and Woodbury University.

Role for USAID in Sustainable Urban Mobility and Low Carbon Urban Planning

USAID could support the following activities to help Mexico reduce transport emissions, expanding activities that have successfully reduced vehicle use in Mexico's main urban areas. Because the vast majority of the transport sector's GHG emissions originate from private vehicles, the recommended activities have three complementary goals: (1) reduce the use of private vehicles and improve the efficiency of the vehicle stock; (2) improve security and quality of public transport; and (3) promote sustainable urban development to reduce the need for motorized vehicles.

1. Reduce the use of private vehicles and improve the efficiency of the vehicle stock

- **Scrappage programs**. Replacing old vehicles with newer models can result in important reductions of GHG emissions as long as the old vehicles are not transferred to other people. The Government of Mexico City estimated that a substitution and scrappage program targeting microbuses could result in cumulative reductions of 933,506 tCO_2e between 2014 and 2020 (GDF, 2014). An additional 1,165,151 tCO_2e could be reduced if freight transport vehicles in Mexico City met more stringent emission standards. This could also be achieved by replacing old vehicles with newer ones equipped with diesel exhaust fluid technology.[59] Mexico successfully implemented scrappage programs in the past for both public and freight transport, but on a limited scale. Key challenges to scaling up the scrappage include insufficient resources to provide subsidies that are larger than what owners receive from selling their vehicles to others; difficulties in attracting the large number of SMEs that would not renew their vehicles in the absence of the program; and the high degree of informality in the transportation sector (ICCT, 2015). USAID could provide assistance to development banks and commercial banks interested in financing these programs and assess the potential role of government policies and fees for vehicle registration and taxation. USAID could build on the experience of the freight transport NAMA supported by GIZ, which ends in 2015 and has reached about 70 SMEs. In addition, USAID could help local and federal governments design and implement vehicle inspection and maintenance programs and designated "low-emission zones" that prohibit entry of high-emitting vehicles.
- **School bus program.** In 2010, the Mexico City Government (GDF) estimated that 20-25 percent of all vehicles driven early in the morning were used to transport children to school. About half of the children attending a private school were transported in private vehicles, with an average of one child per vehicle. In 2011, the GDF required private schools with more than 670 students to use of school buses to reduce pollution and traffic congestion. The program gradually increased to incorporate smaller schools and about 60 schools participated by 2014.[60] An early evaluation found that buses consumed about 50 percent less fuel than the private vehicles they replaced, resulting in lower emissions of GHG and local air pollutants (CMM, 2011). A later evaluation found that the program continued to result in lower GHG emissions, but other arrangements such as the use of vans instead of buses and carpooling could yield even larger reductions (CMM, 2014a).

[59] In late 2014, the Government of Mexico published for public consultation the draft NOM-044-SEMARNAT-2014 which sets the emissions standards for heavy vehicles. The draft NOM proposes to raise heavy-duty vehicles' compliance standard from either EPA04 or EUROIV to EPA10 and EUROVI standards. In order to meet these standards, vehicles must use ultra-low sulfur diesel, which is currently not available in Mexico. The Government's plan is to make this fuel available throughout Mexico in 2017 and begin enforcing the new standard in 2018.

[60] http://www.sedema.df.gob.mx/sedema/index.php/movilidad-sustentable/movilidad-escolar

USAID could support the replication of this program in other cities, including the design, promotion of women's participation, facilitation of the participation of private bus companies, and strengthening of methods to measure the GHG emission reductions. It could also work with firms to develop similar schemes in other parts of Mexico City that are difficult to access by public transportation and have a large number of companies (such as the Santa Fe area).

- **Parking meters**. Pricing policies for public parking can be an important strategy for reducing private vehicle use, since parking charges are paid on a trip-by-trip basis.[61] Increases in parking fees have reduced GHG emissions from vehicles.[62] In 2012, the Mexico City Government installed parking meters in some of the city's most congested areas. As of August 2015, parking meters were operational in 13 different areas. Although the program's effects have not been quantified, public surveys suggested that the meters have reduced congestion and increased pedestrian safety.[63] In Mexico City, 30 percent of parking meter revenues have been used to improve local neighborhoods. In 2014, the Polanco neighborhood government invested more than MXP 29 million (US$ 1.9 million) collected by the meters.[64] USAID could support other local governments in the design and operation of parking metering, attracting private sector participation, efficient and transparent use of collected fees, and enforcement strategies.
- **Improvements in the efficiency of government vehicles**. CONUEE's Energy Saving Program for Public Administration has a component for public vehicle fleets, under which it aims to improve the maintenance and operation of more than 105,000 vehicles owned by federal agencies (CONUEE, 2015a). These efforts could be replicated at the subnational level. Municipal and state governments in the Yucatan operate around 18,000 vehicles. About 10 percent of the state's expenditures are used to buy vehicle fuel. This does not include the maintenance costs of state vehicles, which could also be reduced by replacing the oldest vehicles with more energy-efficient models. USAID could help establish new financial mechanisms to support these government vehicle replacements, such as leasing, and help identify the vehicles best suited for replacement (e.g., ambulances, patrol cars, and garbage trucks, which are often left idling during trash collection).

2. Improve the security and quality of public transport

- **Public transport integration**. Public transport systems in Mexican cities are not coordinated. As a result, users pay a fee every time they switch from one public transport mode to another. In addition, the timetables and connections among operators are not harmonized. In the State of Mexico alone, lack of integration among different means of public transportation increases costs paid by users an average of 10 percent. The higher costs to users also discourage some people from using public transportation, reducing its potential for GHG emission reductions. [65] Other Mexican states and cities may have similar problems, but lack of assessments precludes such a conclusion. São Paolo, Brazil and Madrid, Spain have successfully coordinated their public transport systems and increased public transport use. Public transport integration in the State of Mexico could result in a cumulative reduction of 9,800 tCO_2e in 10 years (ITDP, 2012). USAID could support technical advice for fare collection and validation technology (public transport cards, validation machines, and card re-charging booths); financial analysis to estimate the effects of fee integration on public transport use; establishment of trust funds for efficient and transparent management and distribution of revenues; and strategies for increasing ridership and service quality.

[61] http://www.fhwa.dot.gov/environment/glob_c5.pdf
[62] http://www.wsdot.wa.gov/research/reports/fullreports/765.1.pdf
[63] http://www.parametria.com.mx/carta_parametrica.php?cp=4558. These findings are consistent with those of studies conducted in the US and other countries, which also suggest important reductions of GHG emissions (ITDP, 2012)
[64] http://www.ecoparq.df.gob.mx/docs/transparencia/2014/Polanco2014.pdf
[65] http://mexico.itdp.org/documentos/10-estrategias-de-movilidad-para-un-estado-de-mexico/

- **Introduction of peak-pricing strategies.** Since the 1970s, many cities in the U.S. have introduced differential time-of-day fares to influence public demand on public transport systems.[66] Mechanisms include discounts for off-peak times or surcharges during peak periods. Peak-pricing strategies were not being used in Mexico, despite evident congestion in public transport during peak hours. USAID could help local governments analyze, communicate, and implement peak-pricing. USAID could help assess opportunities to invest additional resources collected through surcharges to improve public transport infrastructure as well as opportunities to address the potential social and gender-differentiated effects of these measures. For example, lack of safe transport during off-peak hours can cause girls to drop out of night schools.
- **Reduction of gender-based violence (GBV) in public transport.** The World Bank has been working with the Government of Mexico City to develop a pilot strategy that would reduce GBV in public transportation and improve service quality. Although many transit users see gender-exclusive services as reducing problematic encounters, most do not view them as a solution for the root causes of GBV and prefer to address the problem through a combination of interventions like social marketing, mobile phone reporting, and service upgrades. USAID could support a communication campaign to foster better social behavior among passengers; promote the use of cell phone applications to allow users to report offenses; and support the development of additional technology. These efforts could be implemented in Mexico City in coordination with the Viajemos Seguras (Travel Safely) Program and replicated in cities such as Guadalajara and Monterrey.[67] USAID could also expand efforts to fight GBV in non-motorized transports, such as bike shares. About 40 percent of Mexico City's Ecobici Program's users are women, who tend to ride shorter distances and make more frequent stops and mode changes to conduct errands. USAID could also work with organizations such as "Mujeres Bici" to develop gender equality criteria for the expansion and improvement of infrastructure. Also, supporting public transport integration, as discussed above, would contribute to the reduction of GBV, as a large number of attacks reported by women using public transport occur at bus stands and other waiting places.

3. **Promote sustainable urban development:** Denser urban development, with mixed land uses and different modes of public transportation, is seen as a strategy to offset motorization rates and reduce vehicle use in the medium-to-long term. For example, tying denser urban development in the city of Merida could reduce GHG emissions 40 percent by 2030 compared to the BAU scenario, when considering emissions from transport, buildings, and public lighting (CMM, 2014). While achieving dense urban growth is admittedly a long-term process, USAID might consider supporting it because urban sprawl is practically irreversible and has a significant impact on the country's emissions pathway. The following paragraphs discuss opportunities for USAID support to promote denser urban development, public transportation, and other forms of sustainable mobility, such as non-motorized transportation.
    - **Development of financial mechanisms for denser urban development**. Real Estate Investment Trusts (REIT) are publicly traded financial instruments that are required to regularly report their performance to investors. REIT performance is based on the dividends they generate through the properties they own, rent, and manage. It is in the best interest of REITs to obtain land at low cost and control management and energy expenses. Local authorities are often the owners of vacant lots and the sole authority to promote the re-use and development of vacant or underserved areas by promoting investment. Local authorities could work with REITs to promote the densification of central areas of cities by offering special tax regimes or leasing land under the condition of the introduction of social housing and public transport infrastructure. USAID could help federal and local governments facilitatie stakeholder dialogues in densely populated areas, where

[66] http://www.lta.gov.sg/ltaacademy/doc/13Sep059-Gwee_Time-BasedPTFarePricing.pdf
[67] http://www.inmujer.df.gob.mx/wb/inmujeres/programa_interinstitucional_viajemos_seguras_en_el

parties from diverse sectors can participate by investing and using assets assembled under a low-carbon urban plan. Stakeholders should be invited to participate in these dialogues ,including local residents and NGOs.

- **Facilitation of public-private partnerships (PPPs) for urban public transit**. Mexico City has successfully used PPPs for construction and operation of its Bus Rapid Transit (BRT) system. The city provided dedicated lanes and funded station construction, while the private sector provided the buses and operators. The BRT companies are generally paid based on the distance travelled, rather than a flat rate for a trip. PPPs are also underway for shared bike systems. Shared bicycle users typically pay a membership and user fees, which may not be subsidized. Additional revenues are obtained from advertisements.[68]

  Shared car services may be solely privately run (like Zipcar in the US and Carrot in Mexico City) or could involve PPPs (particularly for electric vehicles such as Econduce's scooters). [69] [70] Shared car services can also be financed through private equity funds since municipal authorities often lack the resources to fund a publicly-owned fleet. USAID could support the improvement of transport concessions under performance-based contracts; selection and evaluation factors could include quality, routes, areas served, and customer satisfaction. Another opportunity for PPPs is to expand the use of new technologies, such as sensors to collect and analyze data on bus stops, traffic bottlenecks, or air pollution to improve transport management. The University of Chicago and Argonne National Laboratory's Array of Things is providing real-time, location-based data about Chicago's environment, infrastructure and activity to researchers, the public, and policy makers. This collaboration will install sensors in 2016 and 2017 to collect data on air pollution, traffic, and pedestrian flow in Chicago, which will support actions to reduce traffic congestion and improve pedestrian safety.[71] USAID could also support replication of Mexico City's security camera and seismic alert alarms.

- **Mobilization of finance for public transportation and bicycles.** USAID could provide technical assistance to set up or reform trust funds to finance public motorized and non-motorized transport as part of integrated mobility strategies. The National Infrastructure Fund (FONADIN) was the most important source of public funding for public transit projects besides federal transfers to states. It also provided technical assistance grants to state and municipal authorities for feasibility studies and establishment of PPPs for urban development projects. USAID could support the reform of FONADIN's operating rules to promote larger and more expedient investment in public transportation, safer bike lanes, and other infrastructure to expand the use of bicycles and shared bike programs. In particular, USAID could support the implementation of existing transport-oriented development plans, such as those prepared by ITDP Mexico with MLED support for Aguascalientes, Guadalajara, and the Mexico City Metropolitan Area.[72] These plans combine interventions to promote denser urban development, more efficient and cleaner public transportation, and reduced use of private vehicles. USAID could help scale up financing for motorized or non-motorized public transportation through a mixture of instruments and market mechanisms for capitalization of trust funds. A first step for public transportation would be the development of local revenue streams for municipalities that can be supplemented with fees from

[68] "SmartBike - Clear Channel." Clear Channel. 25 Apr. 2014. Web. 4 Aug. 2015. http://www.clearchannel.com.mx/smartbike/
[69] http://carrot.mx/
[70] https://econduce.mx/
[71] https://arrayofthings.github.io/
[72] http://mexico.itdp.org/noticias/itdp-publica-documentos-para-implementar-proyectos-dot/

construction permits, parking lots, and land value capture.[73] A PPP model can integrate public transportation, transit-oriented development, and real estate development. USAID could work with the BANOBRAS development bank to provide financing and technical assistance to states and municipalities on partnership models. It could also help NAFIN provide loan guarantees and issue climate finance for public transportation.

3.2. INDUSTRY

Industry emits GHG emissions directly through its processes and indirectly through electric power consumption. Approximately 99 percent of direct industrial CO_2 emissions in 2010 were concentrated in five sectors: (1) cement (47.5 percent) (2) limestone and dolomite (29.6 percent), (3) iron and steel (12.1 percent), (4) lime (6.3 percent), and (5) ammonia (3.2 percent) (SEMARNAT, 2013).

The indirect industrial emissions from electric power consumption were 65 million tCO_2e in 2010 (SEMARNAT, 2012). Industries consumed approximately 30 percent of the total energy generated and imported. The industrial share was larger for electricity than for other energy types. In 2014, industries purchased 128 PJ of electricity, 57 percent of the national total. Between 2000 and 2010, industrial electricity consumption grew at an average annual rate of 3.8 percent; it is expected to increase at 4.3 percent per year between 2013 and 2027 (SENER, 2013a). Medium-scale enterprises accounted for two-thirds of industrial energy consumption.[74]

Development agencies working in Mexico found several obstacles to working with large companies. Mexico's large industrial companies, particularly in high-emitting sectors, compete in international markets and have generally already invested in energy efficiency to increase their competitiveness. These companies have access to capital for investments and specialized technical assistance—in some cases through dedicated energy teams. Large companies are generally unwilling to share detailed information about their industrial processes and emissions with development agencies because of concerns that the information could be accessed by competitors or regulators. For these reasons and because medium enterprises consume a large share of electricity, the following section focuses on energy efficiency in SMEs.

Consumption by Small and Medium Enterprises (SMEs)

Electricity Consumption

Following Mexico's recent reforms, the utility CFE was responsible for generating electricity, while another utility, CENACE, operated the transmission grid. SMEs paid different rates for electricity depending on their consumption and broad sector, but not their subsector, number of employees, or sales amounts. SMEs tend to pay industrial tariffs OM and HM, commercial tariffs T2 and T3, or the agricultural tariff T9 (GIZ, 2012a). Industrial SMEs used approximately 40 percent of total SME consumption of electricity. Appendix II. Average Price of Electricity Tariffs in Mexico shows the average price for electricity tariffs in Mexico.

[73] These types of mechanisms have been successfully used by several Mexican states. See ITDP México, 2015. *Instrumentos para el Desarrollo Orientado al Transporte. Hacia Ciudades Bajas en Emisiones.* http://mexico.itdp.org/wp-content/uploads/Instrumentos-para-el-Desarrollo-Orientado-al-Transporte.pdf

[74] There are different definitions of Small and Medium Enterprises in Mexico. According to the regulations of the Mexican SME Fund, micro enterprises have up to 4 workers and sales of up to MXN 4 million/year (US $ 260,000/year); small commercial firms have 11-30 workers and sales of MXN 4.01 to 100 million (US $ 260,000 – 6.7 million/year); small service and industrial firms have 11-50 workers and sales of MXN 4.01 to 100 million (US $ 260,000 – 6.7 million/year); medium commercial firms have 31-100 workers and sales of MXN 100.01 to 250 million (US $ 6.7-16.6 million/year); medium service firms have 51-100 workers and sales of MXN 100.01 to 250 million (US $ 6.7-16.6 million/year); and medium industrial firms have 51-250 workers and sales of MXN 100.01 to 250 million (US $ 6.7-16.6 million/year). BANAMEX sets a threshold of US$ 10 million per year to determine what firms are eligible to borrow from its SME loans.

Electricity consumption of SMEs varied with their specific activities technology choices, and local climate. Typically, industrial SMEs used 45 percent of their electricity consumption for electric motors and other production equipment, followed by 15.4 percent for compressed air, 11.0 percent for lighting, 8.7 percent for refrigeration, and 6.5 percent for heating, ventilation, and air conditioning (HVAC). These represented 78.2 percent of the total electricity consumed by SMEs; the rest was used in water pumping and office appliances and equipment. Commercial SMEs used 36.7 percent of total electricity consumption for lighting, 19.4 percent for HVAC, 15.8 percent for refrigeration, and 12.3 percent for office appliances and equipment. SMEs that provide services used 44 percent of their electricity consumption for lighting, 29 percent for HVAC, and 17 percent for office equipment (GIZ, 2002).

Thermal Energy Consumption

National statistics for thermal energy consumption have not been disaggregated for SMEs. GIZ used aggregated information from the National Energy Balance to estimate the thermal energy consumption of SMEs from fossil fuels. It estimated that SMEs consumed 450 PJ of thermal energy in 2013. This total includes 250 PJ for industrial SMEs, 80 PJ for commercial SMES, and 120 PJ for agricultural SMEs (GIZ, 2012a). For industrial SMEs, natural gas provided 72 percent of the thermal energy, followed by diesel at 14 percent, and LPG at 12 percent. Agricultural SMEs obtained 94 percent of their thermal energy from diesel fuel, and commercial SMEs obtained 80 percent of their thermal energy from LPG and 13 percent from natural gas (SENER, 2013b).

The end uses of thermal energy varied across the industrial, commercial, and agricultural sectors. While the end uses of thermal heat were not monitored by the GOM, the most common uses included steam production and water heating and cooking; and dryers, ovens, and other direct heat applications for processes (GIZ, 2012a).

Energy Efficiency Potential for SMEs

Upgrading and Retrofitting Electrical Systems

Upgrading and retrofitting electrical equipment and appliances in SMEs can save energy, although the savings potential varies by type of SME. Typically, industrial SMEs can achieve up to 30 percent savings through lighting changes. A 20 percent savings can often be achieved through HVAC systems, and 15 percent through compressed air and water pumping. Premium electric engines can save up to 5 percent, with an additional 20 percent reduction from electronic variable speed drivers. Retrofitting office equipment could reduce energy consumption 3-15 percent (GIZ, 2012a).

Commercial SMEs could achieve a 30 percent reduction in energy use through LED light bulbs and electronic ballasts. They could obtain a 20 percent energy savings from HVAC systems, but there were no energy efficiency standards for HVAC equipment in Mexico. Building weatherization, especially through thermal insulation and installation of refractive film on windows and control equipment could further increase this savings. A 30 percent energy reduction can usually be obtained by replacing old refrigeration systems. However, FIDE documented cases with a 70 percent energy savings from new refrigeration systems. The major energy efficiency opportunities for agricultural SMEs include retrofitting of lighting and pumping, with savings of up to 30 percent in both cases (GIZ, 2012a).

Retrofitting electrical systems and equipment could achieve overall savings of more than 14 percent, which is approximately 13,524 GWh per year and would reduce GHG emissions by 6.8 million tCO_2e (Table 15).

Table 15. Potential Savings from Retrofitting Electrical Systems in SMEs

Type of SME	Potential Savings	Energy Savings (GWh)	Emission Reductions (Million tCO_2e/yr)
Commercial	19%	2,386	1.2
Industrial	11%	7,546	3.8
Agriculture	30%	3,582	1.8
Total	**14%**	**13,524**	**6.8**

Source: (GIZ, 2012a).

Upgrading and Retrofitting Heat Generators

Steam generators and boilers were the most common thermal energy technology used by SMEs in Mexico, followed by dryers, water heaters, ovens, and cookers. Retrofitting or replacing this equipment could result in a 10-15 percent energy savings—the equivalent of 45-67.5 PJ and approximately 4.2 million tCO_2e per year (GIZ, 2012a).

Energy Management Systems

An energy management system (EMS) is a continuous process that includes setting energy management policies and goals, systematically identifying opportunities to achieve additional energy savings, tracking implementation of improved technologies and practices, and continuous monitoring of energy consumption. An EMS does not refer to a particular standard; it refers to the use of best practices to define an energy management policy, establish energy saving goals, and systematically identify the best energy saving measures. An EMS can help decision makers implement efficiency measures and monitor their results. Moreover, the continuous monitoring of energy use can allow SMEs to improve the behavior and decision making of their employees with respect to energy use (CONUEE, 2014). There was no information about the performance of EMS in Mexico. However, in the US, an EMS for buildings has achieved energy savings of 40 to 70 percent through smart demand management (Saeed Kamali, 2014).

Implementation Barriers

The major challenges for implementation of energy efficiency measures in SMEs were limited financial and managerial capacity and insufficient information and resources. Most SMEs lacked the management systems to properly plan, implement, and control change that could lead to energy savings. Many SMEs had limited access to financial instruments, which, coupled with unsteady cash flows, results in the postponement of investment decisions, including those on upgrades and retrofit projects. While most SMEs in Mexico understand the importance of improving their productive capacity, few have placed high priority on energy efficiency investments, although this could affect their long-term viability (Magallon, 2013). This is especially true for enterprises receiving electricity subsidies that reduce the returns on these investments.

Many SMEs did not trust energy efficiency audits and technology providers. SMEs also placed a higher priority on investments that expand production capacity, particularly when complex and subsidized electricity rates distort incentives for energy savings. Banks also reported difficulties identifying trustworthy firms to conduct energy audits at a reasonable cost. Although some loan products were available for energy efficiency investments by SMEs, most do not cover the cost of energy audits. Other key barriers included lack of funding for engineering studies on industrial process changes, high upfront costs, and the long payback period of some investments (Magallon, 2013).

Other Stakeholder Activities in Energy Efficiency

The GOM supported energy efficiency projects for several decades, with donor and development bank support. Recent examples included FIDE's Energy Efficiency Program, the Enterprise Savings and Energy Efficiency Program (PAEEEM, also known as Business Eco-Credit), and the Integral Energy Efficiency Financing Program for the Agro-industrial Sector of the Fideicomisos Instituidos en Relación a la Agricultura (FIRA).

FIDE's Energy Efficiency Program support comes from the CFE, the IDB, and the World Bank. This program has provided technical support and financing for the residential, commercial, and services sectors (some targeting SMEs), and municipalities.[75] The loan size, interest rates, and repayment periods varied with the creditworthiness of the entity and have changed over time. FIDE also offered rebates for purchases of recommended equipment from approved suppliers. FIDE focuses on energy-efficient lighting, air conditioning, refrigeration, high efficiency motors and solar water heating. It also supports cogeneration and renewable electricity generation of up to 500 kW (FIDE, 2015c). In 2014, FIDE supported 215 energy efficiency projects and 294 distributed generation projects from renewable energy sources for companies and the residential sector.

Business Eco-Credit was based on a UK program implemented by the Carbon Trust. FIDE and CFE implemented the existing Massive Business Eco-Credit ("Eco-Credito Empresarial Masivo") with support from SENER, SE, NAFIN, and KfW. This program financed the upgrade and retrofit of equipment such as electric motors, commercial refrigerators, lighting, HVAC, and other electric appliances and energy efficiency devices that did not require sophisticated energy savings assessments. FIDE provided loans up to MXP 400,000 (US$ 25,000) for four years with interest rates between 8-10 percent depending on the creditworthiness of the SME and loan. FIDE's interest rates were often higher than those of commercial banks. However, FIDE did not add fees often charged by commercial banks, which makes FIDE's loans cheaper. FIDE loans were repaid through electricity bills. FIDE focused on SMEs under commercial tariffs T2 and T3, which included butcher shops, hotels, restaurants, hospitals, warehouses, offices, sporting clubs, malls, schools, and supermarkets, among others (FIDE, 2015). In 2014, FIDE provided 1,220 loans, mainly to retrofit refrigerators and install efficient lighting. Since its inception in 2013, the Massive Eco-Credit has helped more than 10,000 SMEs and mobilized approximately MXP 400 million (US$ 25 million) in energy saving investments (FIDE, 2015d).

A second potential line of credit, the Tailored Business Eco-Credit ("Eco-Credito Empresarial Individualizado"), has been under design for most of 2014 and 2015, with planning support from GIZ, USAID, and the IDB. The tailored program will target SMEs firms under a wide range of electricity tariffs and those that require larger energy efficiency investments and customized energy audits. FIDE plans to certify the energy auditors and provide the financing to certified suppliers. FIDE expects to establish an MRV system to monitor the savings of the program. NAFIN offers to provide financial guarantees to FIDE and any other financial intermediary willing to finance energy efficiency projects for SMEs.

In 2013, FIRA began designing an Integral Energy Efficiency Financing Program for the agro-industrial sector in Mexico, with IDB and DANIDA support. This program for agriculture and the food and beverage value chain would include energy efficiency insurance. The Climate Innovation Lab concluded that energy savings insurance guarantees are one of the most useful ways to scale up energy efficiency investments. FIRA would provide financing and use innovative mechanisms, such as performance contracts and guarantees between SMEs and technology suppliers. If the guaranteed energy savings are not realized, suppliers will be required to fix the problem and part of their payment would be retained as a guarantee. If the achieved savings are too low, the participating SME can request execution of a performance bond to recover its investment costs. Conversely, when savings exceed the agreed amount, the additional benefits are shared by the suppliers and SMEs. In addition to these risk management mechanisms, this program would verify the competence of technology

[75] FIDE has a mandate to work with municipalities. However, it is currently not working with them because several municipalities did not pay back the loans.

vendors and the quality of technical proposals through third-party certifiers accredited by the National Certification Association. The program is expected to be operational by the end of 2015 (Oliver, 2014).

Other commercial banks, such as CI Banco and BANAMEX, have established energy efficiency programs aimed at SMEs. The terms of these loans are similar to those of the Eco-Credit, but SMEs would not be able to repay the loans through their utility bills. Commercial banks can offer a much shorter turnaround time for SME loan applications, more flexible energy audit requirements, a wider network of branches, and better marketing to reach potential customers. In addition, loans have higher ceilings of up to MXP 12 million (US$ 800,00). Firms that spend at least MXP 300,000 per year on electricity would be targeted so that transaction costs would not be excessive (BANAMEX, 2014).

GIZ worked with the National Association of Self-Service and Departmental Stores to develop a NAMA to increase energy efficiency from refrigeration and air conditioning. This NAMA would facilitate the substitution of current technologies, which mostly use fluorinated gases with a high global warming potential (HCFC, CFC, PFC, HFE, and HFC), with alternatives such as carbon dioxide and ammonia (GIZ, 2014). GIZ would provide technical advice, support the identification of technologies and develop capacities, but not supply any financing.

Opportunities to Increase Energy Efficiency

USAID could support the following activities, focusing on medium enterprises, especially in areas with a high density of industrial complexes, such as the Bajío, Mexico City and nearby states, including border states.

- **Promotion of energy management systems (EMS).** An EMS can boost economic savings from investments on energy-efficient equipment and strengthen managerial skills for increased competitiveness. GIZ recently initiated efforts to promote adoption of best energy management practices in Mexico via energy management standards like ISO 50001, EVO, and ASHRAE.[76] USAID could build on these activities by helping key energy efficiency stakeholders assess the pros and cons of different energy efficiency standards. Part of this discussion should include whether it makes sense to develop new standards for Mexico or use existing ones. The USAID MLED program has provided training to the development bank NAFIN and commercial bank BANAMEX on energy audit based loans for SMEs. USAID could support the linking of credit to an EMS so that continuous improvements can be achieved over time and results can be monitored. Existing energy management services are available.
- **Expansion of energy efficiency insurance**. Mexico's agricultural development bank FIRA and the IDB were pioneering energy efficiency insurance for agro-industrial SMEs.[77] USAID could replicate this approach in other sectors. For example, USAID could help develop easily understandable standardized contracts between energy efficiency technology providers and SMEs. It could help expand the system of verified vendors and the range of technologies included and encourage commercial banks to participate through DCA loan guarantees. USAID could publicize the availability of accelerated tax depreciation for capital investments, and target women-owned businesses and businesses that mainly serve women, in collaboration with GIZ and the "Mujeres in Movimiento" initiative. This initiative provides resources,

[76] ISO 50001 is the standard from the International Standards Organization that supports organizations in all sectors to use energy more efficiently through the development of an energy management system. EVO (Efficiency Valuation Organization) is a non-profit organization whose products and services help people engineer and invest in energy efficiency projects worldwide. ASHRAE (American Society of Heating, Refrigerating, and Air Conditioning Engineers) focuses on building HVAC systems, energy efficiency, indoor air quality, and industrial refrigeration and sustainability.

[77] FIRA's Program is inspired on a similar program implemented by Bancolombia and IDB in 2011. Bancolombia's program was still operational as of 2014 and a particular line of credit was provided for SMEs.

information, and advisory services to women entrepreneurs and includes representatives from the public and private sectors in several Mexican states.[78]

- **Energy efficiency in value chains**. USAID could work with SMEs that sell to large firms interested in improving the energy and environmental performance of their suppliers and distributors (value chain). A private think tank, CESPEDES, has recommended that suppliers for large companies voluntarily report their GHG emissions to the private sector GHG registry Programa GEI and seek opportunities to reduce their own GHG emissions. Large firms could establish required or voluntary environmental and energy performance criteria for their suppliers with clear deadlines. USAID could help suppliers identify emission reductions opportunities through streamlined audits, development of benchmarks, and information sharing on proven practices. Large firm commitments to establish performance criteria could increase the likelihood that energy-saving measures will be adopted. In addition, USAID could facilitate the development of a model similar to Property Assessed Clean Energy (PACE) that pays 100 percent of a project's costs and is repaid for up to 20 years with an assessment added to the property's tax bill.[79] PACE might work well with suppliers of large firms because they are generally part of the formal economy.
- **Promote energy audits and improved management**. China, Japan, and Italy require periodic energy audits of industrial facilities and a dedicated, on-site energy manager who can improve processes and identify areas to reduce inefficient energy use (ACEEE, 2014). Although establishing a new legal requirement for industrial energy efficiency might be politically and administratively difficult in Mexico, USAID could work with government agencies and firms to assess the effects of mandates and incentives for improving energy efficiency.
- **Increase access to financing for energy efficiency projects**. USAID could help the GOM and state governments set up financing windows within a public-private trust fund for priority industries to accelerate introduction of low-carbon technologies and increase industrial competitiveness. The USAID DCA could provide loan guarantees for private financing. Another option is to encourage NAFIN or Mexico's Agricultural Shared Risk Trust Fund to offer the loan guarantees. The volume of financing could be expanded by issuing bonds or direct equity participation in private equity funds, such as those already in place through the Ministry of Economy. One advantage of a public-private trust fund is that public money could be deposited in a trust fund, REIT, or MLP from the proceeds of green bonds issued by the government or firms. The mobilized funds could finance energy efficiency investments or seed capital or guarantee programs. This could reduce the cost of capital and perceived risk of the investments.

3.3. MUNICIPAL SERVICES

Municipal GHG emissions are mainly from street lighting, water supply, solid waste and wastewater management, and public buildings. Wastes are the largest municipal source, comprising 5.9 percent of national GHG emissions. In 2010, solid waste accounted for 53.5 percent of GHG emissions from waste, followed by municipal wastewater treatment at 23 percent and industrial wastewater treatment at 21.6 percent. Waste burning generated 1.2 percent of the total, and biological treatment of waste was 0.6 percent (SEMARNAT, 2013). Between 2000 and 2010, GHG emissions grew 178 percent from solid waste management and 126.6 percent from wastewater management. Both sources will continue to grow with increasing urbanization (SEMARNAT, 2012a). Municipal emissions from energy consumption were significantly lower. In 2013, public

[78] Mujeres en Movimiento is currently working with federal agencies and the state governments of Aguascalientes, Mexico City, the State of Mexico, Guanajuato, and Queretaro. https://www.inadem.gob.mx/templates/protostar/mujeres_moviendo_a_mexico.php
[79] http://www.pacenow.org/. PACE is a US association of people and organizations seeking financing for energy and resource efficient communities.

services provided by states and municipalities consumed 33 PJ of energy (0.68 percent of Mexico's total consumption). The amount and sources of municipal energy varied with the type of services, location and degree of urbanization, and local climate (SENER, 2013b). GHG emissions from state and municipal government vehicles were classified under the transport sector.

Energy Efficiency Potential

The potential for GHG emission reductions from municipal services has been assessed for many states and municipalities in Mexico, generating a long list of possible mitigation actions. The NGO ICLEI helped 250 municipalities develop their PACMUNs. However, some energy policy experts criticized the quality of ICLEI's assessments and recommendations for Mexican cities. There was no national database on the implementation of GHG emission reductions or energy efficiency projects from municipal services. USAID could support the aggregation of municipal energy consumption data from existing sources.

Street Lighting

More energy-efficiency street lighting is a cost-effective GHG mitigation measure (MLED, 2013). However, even if energy-efficient lighting is adopted, expansion of the lighted area may increase total fuel use even though it may improve public safety, especially for women and girls. Through the end of 2014, the Energy Transition and the Sustainable Use of Energy Fund provided grants for pilot projects in municipalities of Michoacán, Guerrero, Sonora, and Chihuahua with more than 100,000 inhabitants (SENER, 2014a). In 2014, the National Project on Efficient Municipal Lighting, the Public Spaces Recovery Program, and the Program for the Development of Regional and Sustainable Tourism supported the retrofitting of street lights with more energy-efficient alternatives (SEGOB, 2014). CONUEE reported 15 successful projects, including those in Aguascalientes, Chihuahua, Durango, Estado de México, Jalisco, Morelos, Nuevo León, Oaxaca, and Sonora. The City of Xalapa switched 9,000 street lights to LEDs—one-third of its total public lighting (Rodríguez, 2015). These projects substituted existing high-pressure sodium lamps with LEDS, although other technologies were available. The costs of these technologies varied widely. Energy-efficient lamps can cost between MXP 162-700; ballasts MXP 1,000-1,200, and luminaries MXP 1,200-1,500. These technologies have reduced electricity bills for municipalities by 20-51 percent, cutting GHG emissions by up to 5,500 tCO_2e per year. Despite these potential gains, data from 2013 and 2014 indicate that municipal governments underspent their budget allocations. In 2014, the budget for the National Project on Efficient Municipal Lighting was about MXP 120 million (US$ 8 million). There was no aggregated information about the activities and impact of energy-efficient street lighting projects already undertaken.

Municipal Solid Waste (MSW)

Although the design and management of landfills to reduce non-climate environmental impacts has improved, relatively little investment has been made to incorporate good practices to reduce GHG emissions. Most landfills did not collect biogas or use it to generate electricity. In 2014, Xalapa produced 460 tons per day of MSW in 2014 at a marginal cost of MXP 180-200 per ton (MXP 2.7 million per month). Although its landfill complied with NOM-084-ECO-1994, it lacked the potential for viable biogas production because the design did not include pipelines within the landfill. The concession for management of this landfill ends in 2017, and the municipality is exploring options, including expansion of the landfill and waste-to-energy solutions (Rodríguez, 2015).

In 2014, Leon, Guanajuato generated 1,260 tons of MSW daily and the recycling rate was less than 2 percent. No information was available on the disposal costs per ton. Since the city did not have any transfer plants, the transportation costs were around MXP 1.95 million in 2014. The La Verde landfill complied with NOM-084-ECO-1994 and operated under a private concession agreement. It had potential for biogas collection and

electricity production, but the municipality had not yet agreed with the landfill operator on the project's financial aspects and the electricity off-taker (ESMAP, 2014a).

Municipal and State-owned Buildings

Although municipal and state buildings constituted a very small share of the total built area in cities, their energy costs can be important for budget-constrained governments. The GOM asked state and local governments to set a good example in energy conservation. CONUEE supervised energy efficiency programs in more than 7,000 buildings owned by federal agencies and provided training to state and municipal governments for similar programs (CONUEE, 2015a).

FIDE provided support to assess the energy consumption of government buildings in Yucatan. Public hospitals and educational institutions can have significant potential for energy efficiency savings, but generally need external technical expertise in assessing the opportunities and their costs and benefits. Energy efficiency investments could be supported by the Environmental Fund of the State of Yucatan. The State Ministry of Finance managed the trust fund, and SEDUMA chaired the board, which had representatives from the public and private sectors. This fund will issue its first request for applications in 2016 (Vallejo, 2015). Other states have similar funds, for example, Veracruz. These funds receive resources from environmental fines and fees from services (such as mandatory vehicle inspections). They provide grants to implement environmental projects or conduct research.

The City of Puebla had 134 health centers, schools, markets, and public office buildings with an average age of 60 years. The total annual electric bill for these facilities was US$ 1.46 million—over 0.5 percent of the local budget (ESMAP, 2014b).

Water Management

There is potential for reducing electricity consumption and corresponding carbon emissions for water pumping and methane abatement in wastewater treatment. Puebla City consumed 900 liters of freshwater per second and this was projected to increase to 1,100 liters per second in less than a decade.[80] Production, treatment, and distribution of water in Puebla used 0.56 kWh of electricity per cubic meter.[81] In 2012, the Puebla water authority, SOAPAP, consumed 66 million kWh at a cost of US$ 12 million. Wastewater treatment comprised 12 percent of these costs (ESMAP, 2014b).

The municipality of Veracruz grew without a wastewater management system for many decades. It required MXP 1.2 billion to install sewage treatment systems for the whole population. In 2012, Veracruz created a public-private partnership with Aguas de Barcelona and the water and sanitation utility to manage the system. So far, it has raised MXP 300 million for sewers, rainwater catchment systems, and two wastewater treatment plants (Murrieta, 2015).

Xalapa received MXP 13 million (US$ 866,000) in 2015 from the Global Environmental Facility (GEF) to co-finance a rainwater catchment system for suburb Fernando Gutierrez Barrios. GEF plans to provide an additional MXP 28 million in 2016 and 2017 for infiltration trenches, reforestation of watersheds, and rainwater catchment and filtration (Rodríguez, 2015).

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[80] This data are provided by ESMAP (2014). However, other sources indicate that water consumption in Puebla is much higher. An interview published in August 2014, a representative from the water utility reported a consumption of 3,650 liters per second. http://intoleranciadiario.com/detalle_noticia/123350/ciudad/en-puebla-hay-un-desperdicio-brutal-de-agua

[81] One cubic meter is equivalent to 1,000 liters.

Implementation Barriers for Energy Efficiency in Municipal Services

Barriers to increasing energy efficiency in municipal services include (1) weak capacity to structure projects with solid technical and economic underpinnings; (2) low ability to obtain loan or bond financing; (3) lack of incentives for agencies not entitled to keep any of the resulting savings; and (4) absence of a municipal energy department with a clear mandate to promote energy savings.

Feasibility studies for municipal energy efficiency projects typically cost 5-7 percent of the total investment costs, and are often hard to finance (Gama, 2015). Until 2015, municipal terms of office were limited to one three-year term. With this constraint, few municipalities devoted substantial efforts to conduct energy audits, estimate the energy savings potential, or apply for available federal and state funds for energy efficiency projects extending beyond their terms of office (Gama, 2015).

Inadequate financial and technical skills can lead municipal decision makers to accept biased technical advice of suppliers offering low-quality goods and services that may need to be replaced prematurely. Corruption is also a serious problem in municipal procurement. As a result, replacement or rehabilitation investments may be needed after or even before a new administration is elected.

CONUEE found that more than 33 brands of LED street lighting systems being sold in Mexico were out of compliance with the NOM-031-ENER-2012 standards (Energia en Mexico, 2015). CONUEE only supports street lighting projects that use equipment and suppliers recommended for its Energy Efficiency in Municipal Street Lighting Project. The energy code required 6,000 hours of testing for recommended lighting products—about three years of typical operation. Although many efforts have been made to save energy consumed by municipal services, including street lighting, only a few municipalities implemented energy efficiency projects. Although federal programs increased municipal investments in energy efficiency, these grants only covered a fraction of the optimal level of investment, forcing municipalities to look for cost sharing and payment guarantees through income from federal contributions (Ramo, 33) and "participations" or shares of revenues collected by the federal government (Ramo, 28).[82] For example, the National Project on Efficient Municipal Lighting provided up to 10 million MXP or 15 percent of the cost of the lighting project to municipalities, whichever was less. Municipalities financing investments with federal contributions were required to get approval from the state congress. About 1,800 municipalities (73 percent of the total in the country) have insufficient revenue to provide guarantees for any borrowing. As a result, municipalities in Mexico need innovative financing schemes (Garcia, 2015).

Municipalities that outsource technical feasibility studies or financial project structuring also face corruption at all levels. Due to corruption, municipal, state or federal entities also have to pay above market prices for project financing or debt structuring fees (Gama, 2015). In many municipalities, government payments for electricity are made by the local department of finance. Most local government agencies do not know how much they pay for energy and would not benefit directly from energy savings if the cost savings is deducted from future budget allocations. In addition, most agencies have no budget for capital investment, even for items with short payback periods, such as motion-based sensors for lights.

[82] Ramo 28 is the budget line through which the Mexican Federal Government transfers a share of its revenues to states and municipalities. Resources allocated to Ramo 28 are collected from several sources, including taxes on alcoholic beverages and tobacco, diesel and gasoline, and hydrocarbon extraction and exports, among others.
http://hacienda.gob.mx/ApartadosHaciendaParaTodos/aportaciones/28/pdf/2.1.pdf. Ramo 33 consists of transfers from the federal government to states and municipalities that are earmarked to be spent on education services and infrastructure, health, basic infrastructure, public security and financial strengthening, and social programs.
http://hacienda.gob.mx/ApartadosHaciendaParaTodos/aportaciones/33/pdf/1.1.pdf

Other Stakeholder Activities in the Sector

The IDB's Emerging and Sustainable Cities Initiative carried out assessments for the municipalities of La Paz, Toluca, Xalapa, Puebla, and Campeche. The World Bank's Energy Sector Management Assistance Program (ESMAP) conducted an assessment using the Tool for Rapid Assessment of City Energy (TRACE) for 32 cities, one per state.[83]

TRACE is "a simple, practical tool for making rapid assessments of municipal energy use. It helps prioritize sectors that have the potential to save significant amounts of energy and identifies appropriate energy efficiency measures in six sectors—transport, municipal buildings, wastewater, streetlights, solid waste, and power/heat" (Cárdenas Valero, 2015, p. 2).

In Leon, the TRACE model identified priority projects that (1) conduct audits and upgrade streetlights; (2) install streetlight timers; (3) substitute vehicles involved in solid waste management with more fuel efficient units; (4) establish a benchmarking program of municipal buildings; and (5) conduct audits and upgrades in those buildings. In Puebla, the identified priority projects were to (1) conduct audits and upgrade streetlights; (2) develop a procurement guide for streetlights; (3) establish a benchmarking program of municipal buildings; (4) conduct audits and upgrades in those buildings; and (5) adopt mandatory energy efficiency codes for new buildings (Cárdenas Valero, 2015).

Since 2010, CONUEE has led the implementation of the Energy Efficiency on Municipal Street Lighting Project in collaboration with SENER, CFE, and BANOBRAS. This project supported replacement of inefficient street lighting for municipalities with new equipment that met CONUEE standards.[84] It also provides assistance to help municipalities ensure that street lighting products complied with norms NOM-031-ENER-2012 and NOM-013-ENER-2013 (CONUEE, 2015b).

The Carbon Trust recently concluded its Low Carbon States Program in Mexico, which provided technical support to the states of Jalisco and Tabasco, in collaboration with CONUEE. This program supported development of low-carbon plans, based on the Carbon Trust's Enplanner approach (Gray, 2015). The Environmental Law Institute is preparing a manual for municipal lightning and energy efficiency projects through a grant from the USAID MLED project. The manual aims to respond to a priority identified by CONUEE.

Opportunities to Increase Energy Efficiency in Municipal Services

USAID could support opportunities to reduce GHG emissions from municipal services through electricity generation from solid waste and greater energy efficiency in public lighting water pumping, and operation of municipal buildings.

- **Electricity generation from solid waste**. Mexico has the potential to obtain 652-912 MW of electricity capacity from solid waste biogas, which has a lower GHG emission factor than electricity from fossil fuels (SENER, 2012a). At the end of 2014, the electricity capacity from solid waste biogas was only 33 MW (SENER, 2014b).[85] Technologies for waste-to-energy projects are widely available, although there are questions about the economic viability. Pilot projects have been implemented in Mexico. For

[83] These cities are: Aguascalientes, Aguascalientes; Tijuana, Baja California; Los Cabos, Baja California Sur; Campeche, Campeche; Monclova, Coahuila; Colima, Colima; Tuxtla Gutiérrez, Chiapas; Ciudad Juárez, Chihuahua; Delegación Miguel Hidalgo, Distrito Federal; Durango, Durango; León, Guanajuato; Acapulco de Juárez, Guerrero; Pachuca de Soto, Hidalgo; Guadalajara, Jalisco; Ecatepec de Morelos, Estado de México; Morelia, Michoacán; Cuernavaca, Morelos; Tepic, Nayarit; Monterrey, Nuevo León; Oaxaca de Juárez, Oaxaca; Puebla, Puebla; Querétaro, Querétaro; Cozumel, Quintana Roo; San Luis Potosí, San Luis Potosí; Culiacán, Sinaloa; Hermosillo, Sonora; Centro, Tabasco; Reynosa, Tamaulipas; Huamantla, Tlaxcala; Veracruz, Veracruz; Mérida, Yucatán; and Fresnillo, Zacatecas.

[84] In 2013, CONUEE developed energy standards for street lighting (NOM-013-ENER-2013) and municipal buildings (NOM-007-ENER-2014). CFE or any other energy supplier must comply with these norms.

[85] http://www.cne.es/cgi-bin/BRSCGI.exe?CMD=VEROBJ&MLKOB=637296210404

example, the Monterrey landfill produced electricity for 45 percent of the metropolitan area's public lighting.[86]

One barrier to scaling up waste-to-energy projects is the single three-year term of municipal administrations, a constraint that was removed in 2015. USAID has already supported development of public-private partnerships in Mexico to develop waste-to-energy projects under its global development alliance with Evensen Dodge. To further support this GDA, USAID could provide municipal officials with support on the costs and benefits of technology options, alternative financial and market mechanisms for waste to energy projects, and due diligence on technology and financial service providers.

- **Replication of best practices for energy efficiency improvements in public lighting and water pumping**. The National Project on Efficient Municipal Lighting, the Public Spaces Recovery Program, and the Program for the Development of Regional and Sustainable Tourism were already funding efficient public lighting projects. Several municipalities have developed these projects through PPPs.[87] However, many municipal officials lack sufficient financial and technical skills to weed out inefficient technology providers that do not comply with existing standards. USAID could support municipal officials with increased access to technical and financial resources. A next step after the MLED-funded manual could be to help establish networks that provide technical and financial assistance. Networks could operate publicly funded hotlines and information hubs or work with fee-based brokers that collect a fee for structuring the projects.
- **Rapid energy assessments for municipal buildings**. Building on the work of CONUEE to improve energy efficiency in federal buildings, USAID could support rapid assessment of energy efficiency potential in municipal buildings. USAID could scale up support from CONUEE and other initiatives such as the Sustainable Energy for All's Building Efficiency Accelerator in Mexico City. To ensure that the assessments lead to actual GHG mitigation, they could be linked to grants (similar to CONUEE's Energy Efficiency on Municipal Street Lighting Project) or financial instruments and market mechanisms. USAID could support the training of both men and women to develop rapid energy assessments and oversee implementation of their recommendations. One of Mexico City's administrative subdivisions (Tlalpan) has trained and hired a group of women plumbers to provide plumbing services to the jurisdiction.

The World Bank identified potential energy efficiency projects in one city in each of the 32 Mexican states, using the TRACE model. The IDB prepared sustainability assessments in five Mexican cities under its Emerging and Sustainable Cities Initiative.[88] USAID could provide financial and technical support for feasibility studies of projects identified by these projects, including analysis of the GHG mitigation potential and co-benefits. In addition, USAID could help identify market mechanisms, leverage financing, and reduce risks and transaction costs. It could set up incentive-based contracts with firms to develop studies based on a flat fee for the service plus an additional payment based on the amount of energy saved. USAID already implemented incentive-based contracts in other areas of financial services; for example, in the West Africa Trade and Investment Hub Project.

[86] http://www.informador.com.mx/mexico/2010/166967/6/relleno-sanitario-genera-alumbrado-publico-en-monterrey.htm
[87] In 2014, the National Project on Efficient Municipal Lighting had an allocated budget of about MXP 120 million (US$ 8 million). There is no aggregated information about the activities and impact of energy-efficient street lighting projects already undertaken.
[88] La Paz, Campeche, Xalapa, Toluca, and Puebla.

3.4. BUILDINGS

Residential, commercial, and public buildings used 31 percent of Mexico's electricity consumption in 2014, making them the second largest consumer after industry at58 percent of the total.[89] Residential and commercial buildings also used fossil fuels, particularly liquefied petroleum gas (LPG), which constituted nearly 47 percent of fossil fuel use in this sector. Buildings emitted over 9 percent of Mexico's GHG emissions in 2010. Approximately 6.9 percent of GHG emissions were from residential buildings and 2.4 percent from commercial and public buildings (SEMARNAT, 2013). The 2014 Special Climate Change Program (PECC) identified a potential reduction of 34 million tCO_2e from greater energy efficiency in housing.

Main Sources of Energy Consumption in Residential Buildings

In 2013, residential housing consumed close to 750 PJ of energy, 15 percent of the total energy consumption in Mexico. Household energy use depends on socio-economic characteristics, such as size and composition of the household, location (urban, peri-urban or rural), and local climatic conditions. However, most of the energy consumed in this sector was used for heating, cooking, and water heating. LPG comprises almost 35 percent of residential energy consumption, followed by wood fuels at 34 percent, and electricity at 25 percent. Natural gas only constituted 4.5 percent of total energy consumption and solar thermal provided 0.5 percent, but both have potential for rapid growth in Mexico (SENER, 2013b). Emissions from the transport sector are characterized as a separate sector by IPCC standards (see section 3.1).

Based on current trends for urbanization and energy use in Mexican households, fossil fuels' share of household energy consumption is likely to continue to increase. Most of the residential consumption is LPG and natural gas for water heating (35 percent of total household energy use) and cooking. Electricity is expected to continue providing one-third of household energy consumption over the next 20 years. Total household energy use is increasing at an average annual rate of 1.4 percent while per capita residential energy consumption sector is increasing at 0.5 percent per year (SENER, 2011a).

The demand for housing is expected to expand with income and population growth and urbanization. Population growth was projected at around 1 percent per year between 2015 and 2025. The urban share of Mexico's population was 77.8 percent in 2010, up from 74.6 percent in 2000, and 71.3 percent in 1990 (CONAPO, 2010; INEGI, 2010a). The demand for housing has grown faster than population due to income growth. It is projected to be 5.3 percent in 2015 (SHF, 2015). The increasing demand for housing and the prospects for a more competitive electricity market (following the structural and policy reforms) could provide good opportunities for increasing energy and water efficiency in the development of new housing and renovation of existing units.

Energy Efficiency Potential

There is substantial potential for increasing energy efficiency, consequently reducing GHG emissions from residential use of thermal energy and electricity. USAID could support fuel switching from LPG to solar water heating (SWH) to achieve higher thermal efficiency standards through insulation.

By 2004, only 650,000 m^2 of solar panels had been installed in Mexico (Buen, 2009). In 2008, the GOM established the *Programa para la Promoción de Calentadores Solares de Agua en México (*PROCASOL) which continued through 2012. PROCASOL's goal was to install 1.8 million m^2 of solar water heaters in Mexico. Through 2009, this program had installed around 816,000 m^2 of solar water heaters and the area increased to 1.4 million m^2 of solar water heaters in 2012. CONUEE highlighted PROCASOL's quantitative achievements, as well the development of professional standards for installation of solar water heaters and a voluntary standard for solar water heaters. Nevertheless, solar water heaters had only provided 0.5 percent of total residential

[89] Data from query in sie.energia.gob.mx, July 31, 2015.

energy consumption in 2013. Since Mexico has good solar resources, solar water heating still represents a relatively renewable energy resource for the country. CONUEE is considering the development of a mandatory standard for solar water heaters and is promoting this technology together with Mexico's Solar Water Heating Council.

There is also an opportunity to increase energy efficiency through more efficient electric appliances and demand management at the household level. Between 3.2 and 5.7 million tCO_2e could be reduced by installing more efficient air conditioning units, refrigerators, and lights in homes (MGM Innova, 2012).

Implementation Barriers for Residential Energy Efficiency

The level of environmental concern in Mexico's population has increased substantially over the last few decades. A 2012 survey found that more than 75 percent of respondents described themselves as interested or highly interested in environmental issues. Respondents identified climate change as the second most pressing environmental problem in Mexico after waste management (IIJ, 2012). Despite this increasing awareness, energy efficiency measures still face substantial implementation barriers in all economic sectors, especially for households who receive subsidized electricity prices that reduce incentives for energy saving-investments. Furthermore, households that pay unsubsidized prices for electricity due to higher consumption levels often find it difficult to assess the financial advisability and risks of energy efficiency investments. In addition, people's decisions on energy use are not often driven by rational financial decisions, but made through mental shortcuts that reduce the need for more effortful information processing, resulting in speedier decision making (Gillingham I, 2009; Ek and Söderholm, 2010; Frederiks et al., 2015).

People tend to make decisions that maintain the status quo, avoid risk, and stick to default or pre-set options, trying to achieve only satisfactory rather than optimal results. In addition, household decision making is often focused on avoiding losses instead of producing gains. Furthermore, long-term benefits are perceived as less valuable due to capital scarcity. Only the existence of incentives (both positive and negative) seems to shift behavior. This research is consistent with market research carried out by financial institutions in Mexico that are developing energy efficiency programs (BANAMEX, 2014).

The behavioral drivers for household decision making shed light on why existing financial schemes that promote energy efficiency through house retrofits and energy efficient appliances have not reached their full potential, for example, the "*Programa de Sustitución de Equipos Electrodomésticos para el Ahorro de la Energía*". SENER and NAFIN implemented this program between 2009 and 2012, which only reached 400,000 families.

Lack of financing was still an important barrier for the adoption of energy efficiency solutions in the residential sector. Even though retrofitting and substituting appliances with energy-efficient alternatives makes economic sense, many household face high upfront costs they cannot afford. The combination of limited financing tailored to client needs and a short-term time horizon for decision making results in low uptake of new and more efficient technology. Lack of detailed information on household energy use and climate conditions poses a barrier for the successful design and implementation of energy efficiency programs. Since the national census does not collect data on residential energy consumption, there was also inadequate data disaggregating energy trends between urban and rural households (SENER, 2011b).

Other Stakeholder Activities in Energy Efficiency

Since 2008, the GOM has promoted the reduction of residential GHG emissions through the (1) Green Mortgage Program, which financed new sustainable housing of the National Housing Commission (CONAVI); (2) *Programa de Cooperación Financiera para la Oferta de Vivienda Sustentable en México* (ECOCASA), which was supported by GIZ, KfW and the IDB; and (3) international carbon markets, in particular CDM programs.

The Green Mortgage Program provided credit for the installation of equipment and technologies that contribute directly and indirectly to reducing GHG emissions in homes eligible to receive federal housing subsidies. INFONAVIT developed the Evaluation System for Green Housing to estimate GHG emissions and energy and water consumption of a house based on its architectural design, materials, and technologies. The Evaluation System for Green Housing helped assess whether households qualify for a green mortgage. This program helped meet voluntary national targets, but lacked a good monitoring and evaluation system to assess impact. To improve the sustainability of the Green Mortgage Program, GIZ helped prepare tools to manage energy demand, water demand, and urban development. The energy and water demand components were based on tools developed by the German Ministry of Housing. The urban development tool was created by the Centro Mario Molina following a request from the GOM. Other barriers faced by this program include limited availability and high cost of energy-efficient building materials and equipment and developers' preference to build housing based on existing models to minimize costs and construction time (Loeprick and Gruner, 2015).

ECOCASA's energy efficiency measures were financed through mortgages and increased the sale price of housing by 1 percent. The ECOCASA measures typically cost MXP 5,000-12,000 for homes, with a ceiling price of MXP 900,000. At this cost level, only low-cost options can be selected. Rooftop solar photovoltaics were too costly for this program. Low-income housing developers use standardized construction processes that are difficult to further economize. ECOCASA expects to support construction of 27,000 energy-efficient houses between 2013 and 2020, mainstreaming higher environmental standards among developers and increasing the demand for environmentally-sound technologies in households (SHF, 2014).

Following the ECOCASA model, CONAVI and SHF implement the Sustainable Housing NAMA with technical and financial support from GIZ and KfW. This project provides financing and technical assistance to regional housing organizations ("Organizaciones Regionales de Vivienda") and housing developers to promote more environmentally sustainable technologies and increase adoption of better design and building practices and standards. The NAMA facility, supported by the GIZ and the British Embassy, is also developing an MRV system (GIZ, 2012b).

GIZ's technical support was accompanied by loan guarantees from SHF and KfW to financial intermediaries for bridge loans to small-scale and medium-scale housing developers. Additionally, KfW will provide grants to developers using specific environmentally sustainable and energy-efficient technologies, which will be defined by the program managers when the program starts in late 2015. The program expects to leverage up to EUR 200 million from private and public sources over the next seven years, improving the quality of life and reducing energy bills for 43,000 households (KfW, 2012).

Moreover, GIZ actively promotes both SWH and solar-distributed power by developing the capacity of installers; standardizing products and services through sector-specific norms; and promoting and marketing technologies to consumers along with UNEP (CONUEE, GIZ, ANES, 2011).

Commercial Buildings

Main Sources of Energy Consumption in Commercial Buildings

In 2013, commercial buildings consumed close to 133 PJ of energy—2.7 percent of the total energy consumption in Mexico. Energy sources for commercial buildings vary with the local climate. Most of the energy is used for heating and cooling, electrical appliances and equipment, and water and food heating. LPG for water heating and cooking represented 49 percent of the energy consumption of commercial buildings, followed by electricity at 37 percent. Natural gas accounted for only 8.3 percent, while solar energy provided 2 percent (SENER, 2013b).

Electricity consumption in commercial buildings has fallen at an average annual rate of 3 percent since 2011. Over the same period, the use of fossil fuels has increased 0.1 percent per year, with increasing substitution of natural gas for LPG (SENER, 2013b). This trend is likely to continue, driven by the slow but steady

implementation of energy efficiency standards in building codes. These include retrofitting or replacement of HVAC systems, electric motors, and office appliances with more energy-efficient choices.

These trends are likely to continue in the context of Mexico's ongoing energy reform. PEMEX estimated that the demand for natural gas will grow at an annual rate of 3.6 percent from 2012 until 2018. Domestic production of natural gas was only projected to grow at 1.6 percent per year until 2020. PEMEX has already initiated major investments in natural gas production, transport, and distribution networks (PEMEX, ND).[90] LPG and natural gas are likely to continue to be the main sources of energy consumption in commercial buildings. However, natural gas is poised to become the main energy source because of substantially lower prices per unit of usable energy. This trend could reduce GHG emissions, although the use of natural gas as a bridge fuel during transition to a low-carbon economy has been questioned recently (Brandt et al., 2014).

Energy Efficiency Potential in the Commercial Buildings Sector

There is good potential for increasing energy efficiency and reducing GHG emissions by switching from LPG to natural gas and solar for thermal energy in commercial buildings. Natural gas-based cogeneration can also reduce carbon emissions; the GOM and the private sector have identified opportunities for use by hotels, hospitals, universities, and shopping malls that consume substantial amounts of thermal energy and electricity during the day and night (GIZ, 2013a). USAID could support adoption, implementation, and enforcement of higher energy efficiency standards through commercial building codes.

Solar water heaters can reduce fossil fuel consumption in specific commercial and service sectors, including hotels, sporting clubs, and hospitals. The most recent available data from 2008 showed that commercial and service sectors installed approximately 9 percent of the total area of SWH in Mexico, compared to 20 percent in industry SENER, 2012b). The hotel industry could install an additional 560,000 m^2 of solar panels, saving up to US$ 45 million per year at a capital cost of approximately US$ 123 million (CONUEE, BASE, 2011). USAID's MLED project supported the installation of a SWH system in the La Villa Children's Hospital, which was designed to meet 35 percent of the hospital's water heating needs and reduce carbon emissions by 16.5 tCO_2e/year.

Some thermal energy demand cannot be met with SWH because of physical restrictions on rooftops. In these cases, micro-cogeneration would be the second best option to reduce the carbon footprint of commercial buildings. More than 3,800 private and public hospitals, 16,600 hotels, and 122 shopping malls in Mexico could implement distributed cogeneration projects with potential savings of 13-30 percent (GIZ, 2013a).

Relatively little has been done in Mexico to increase energy efficiency through the development and implementation of building codes and smart demand management (Young et al., 2014). Most municipalities in Mexico have not yet included energy efficiency standards in their building codes and many have weak building code enforcement capacity. Of the 16 largest economies, Mexico ranked 12th in building energy efficiency (Young et al., 2014). Developed by the American Council for an Energy Efficiency Economy (ACEEE), this ranking included energy intensity, building codes, appliances labelling, and building retrofit policies in residential and commercial buildings. Mexico had one of the worst ratings for commercial building codes, appliance and equipment labelling, and retrofit policy within the OECD. However, the energy intensity of commercial buildings in Mexico was lower than in most developed countries because of lower requirements for heating and less use of air conditioning. Nevertheless, Mexico could improve building energy efficiency by developing standard energy efficiency components for building codes in different climatic zones, strengthening enforcement of building codes, creating policy incentives for building retrofitting, and expanding green certification.

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[90] For example, PEMEX and private firms were building the Los Ramones pipeline to transport natural gas from Eagle Pass, Texas to Los Ramones in Nuevo Leon. This pipeline is the second largest to be built in Mexico since 1980. The pipeline's second and final phase is slated to start operations in mid-2016. http://noticieros.televisa.com/mexico/1506/avanza-segunda-fase-gasoducto-ramones/. Once completed, the entire pipeline will transport about 3.5 billion cubic feet of natural gas per day (PEMEX, undated).

Implementation Barriers of EE in the Commercial Buildings Sector

Although the GOM and other entities are working to improve energy efficiency in building codes, there are substantial barriers to successful implementation. Compliance with building codes and demand management on commercial buildings are complex due to the number of stakeholders involved in the design, construction, and operation of buildings. Multiple types of expertise are needed to coordinate efforts to achieve high energy efficiency standards in design and construction. Coordination problems and diverging financial incentives of architects, engineers, equipment providers, developers, and investors are common, resulting in a lack of agreement on energy efficiency measures. The different interests of developers, building owners, tenants, and building managers also deter energy efficiency in commercial and residential buildings (WBCSD, 2007).

Although some building developers have shown interest in implementing energy efficiency measures in construction, there is inadequate financing that recognizes the requirements for financing energy efficiency in new buildings and retrofitting of old buildings. Different loan products may be required for financing buildings that will be sold to investors for leasing versus owner/occupiers. The nature and size of the required financing also differs for retrofits.

If suitable financing is available, the willingness of developers to invest in clean energy depends on the net present value of the higher purchase price or rent that can be obtained if buyers and tenants are willing to pay more for the energy savings. The net present value also depends on their expected length of ownership, ability to sell the building at a premium price, and discount rate (time preference). The willingness of tenants to pay more may be limited by their lower ability to pay and shorter time horizon. If multiple occupancy buildings are not individually metered or lessors pay the utility costs, tenants may have little or no incentive to conserve energy. Market research is required to assess the willingness of investors, owner/occupiers, and tenants to pay for various renewable energy and energy efficiency measures. The barriers to increasing energy efficiency in buildings could be reduced by increasing the availability of financing on appropriate terms, development and implementation of energy building codes, incentives for retrofitting, and activities of ESCOs (WRI, 2015).

Other Stakeholder Activities in Energy Efficiency in the Commercial Buildings Sector

Since 1989, CONUEE has been leading efforts to increase energy efficiency in buildings with donor support, particularly from GIZ. CONUEE promotes energy-efficient lighting and HVAC systems and has developed energy-efficient construction codes for the envelope of new buildings (NOM-020-ENER-2011 for residential buildings and NOM-008-ENER-2001 for nonresidential buildings) and thermal insulation (NOM-018-ENER-1997).[91] However, decisions on adopting the model codes are ultimately up to states and municipalities.

DANIDA has supported efforts of states and municipalities to incorporate these energy efficiency standards in their mandatory codes for new buildings, particularly in Morelos, Baja California, and Tabasco. This support also included the development of manuals to help builders understand the standards.

Sustainable Energy for All (SE4ALL) is a UN initiative led by the World Bank.[92] In early 2015, SE4ALL supported establishment of an Energy Efficiency Accelerator to increase use of clean energy for buildings in selected cities in the country (WRI, 2015).

Some cities have incorporated energy efficiency into building codes. For instance, Veracruz developed Building Energy Efficiency Standards based on the CONUEE standards and also including renewable energy. However,

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[91] The building envelope is the physical separator between the conditioned and unconditioned environment of a building including the resistance to air, water, heat, light, and noise transfer. The three basic elements of a building envelope are a weather barrier, air barrier, and thermal barrier.

[92] The Initiative brings all sectors of society to the table: business, governments, investors, community groups and academia. The United Nations is the ideal institution to convene this broad swathe of actors and forge common cause in support of three inter-linked objectives: (1) ensure universal access to modern energy services; (2) double the rate of improvement in energy efficiency; (3) double the share of renewable energy in the global energy mix. These objectives are complementary to be achieved by 2030. http://www.se4all.org/

Veracuz experienced issues due to noncompliance, corruption, and shoddy construction work. Despite the building code, some houses have been turned over to buyers without paved streets, sewage, or water supply systems (Murrieta, 2015). In 2012, the municipality adopted a new construction norm for housing for all income levels as well as commercial and governmental buildings to improve sustainability standards and urban planning within the municipality (Murrieta, 2015).

Xalapa used its climate planning mechanism PACMUN and its participation on the Sustainable and Emergent Cities Initiatives of the IDB to foster regulatory changes. GIZ helped Xalapa comply with NOM-020-ENER-2012 and NOM-08-ENER-2001, which have been included in new building codes for commercial, governmental, and residential buildings. From 2016 onward, all housing and commercial buildings will be required to comply with the standards for adoption of solar water heaters and rainwater capture and management. The goal is to have 55 percent coverage of rooftops with solar water heaters. Xalapa's government estimated a payback period of 4.5 years for rainwater capture and 2.5 years for solar water heating. The municipal government is planning to strengthen the audit and verification capabilities of the Urban Development Department inspectors (Rodríguez, 2015).

In 2015, the Mexico City Government initiated a certification system based on building performance in energy and water management, quality of life and social responsibility, solid wastes, and other environmental impacts. This certification is issued by the local Ministry of Environment, following an audit by a certified third party. Certified buildings can benefit from a reduction of up to 20 percent on local property taxes or 40 percent of local labor taxes.[93]A total of 39 buildings received this certification between January and July 2015, and the process has begun for 540 more buildings.

Opportunities for Energy Efficiency in Buildings

USAID could support the following actions to reduce GHG emissions from buildings:

- **Deployment of solar water heating (SWH).** Hospitals, sporting clubs, and shopping malls have a good potential for solar water heating. GIZ actively promotes SWH by developing the capacity of installers, standardizing products and services through sector-specific norms, and marketing technologies to end users. In addition, some municipal governments, such as Mexico City and Xalapa, have established SWH goals.[94] The NGO Fabricantes Mexicanas de Energías Renovables A.C. (FAMERAC) has a capacity development program for the sales staff of SWH installers.

  USAID could build on these efforts by bringing local governments and installers together to promote SWH in residential and commercial buildings. It could also support organizations certifying men and women as technicians, particularly GIZ and SENER. USAID could help develop new financial and market mechanisms to make SWH more attractive, such as financing the cost of an assessment and installation of the SWH through property tax bills. USAID could support local governments in assessing policies and facilitating the certification of service providers. USAID could support tailored communications on the advantages of SWH for women-headed households, which represent 28 percent of the total households in the country. It could also facilitate gender-specific financing, incorporating the lessons of Mexico's anti-poverty programs, which show that women can be more adept at managing household financial resources than men.[95] Certified female SWH technicians could help implement this activity and women-headed households might feel more comfortable receiving them in their homes.

- **Development and enforcement of building codes**. Although the GOM developed energy standards for buildings, most municipalities in Mexico have not incorporated these standards into their

[93] http://www.sedema.df.gob.mx/sedema/index.php/tramites/programa-de-auditoria-y-autoregulacion-ambiental/edificaciones-sustentables
[94] Xalapa's goal is to have 55 percent coverage of rooftops with solar water heaters starting from 2016. In Mexico City, a standard requires certain businesses with more than 51 employees to heat at least 30 percent of their used water with solar heaters.
[95] http://wwwprof.uniandes.edu.co/~ijaramil/progresa.pdf

building codes. As a result, the energy efficiency norms have not been widely implemented. Even where building codes with energy efficiency standards have been adopted, lack of consistent enforcement is a major barrier to their effectiveness.

USAID could support the adoption and enforcement of energy-efficient building codes and strengthen the capacity of public officials, engineers, and architects to apply better construction techniques and energy-efficient equipment. GIZ and the Danish-Mexico Energy Program have begun training programs on energy efficiency for residential buildings in a few states and municipalities.[96] USAID could conduct similar efforts in other locations and expand this to include commercial and public buildings. The Green Mortgage and ECOCASA programs have encouraged better practices for housing construction, but there were no specific programs for commercial buildings. USAID could also provide support to replicate the American Council for an Energy-Efficient Economy's Building Codes Awareness Project in Mexico. In the US, this project identifies compliance gaps and best practices and helped develop strategic compliance plans. More than 30 U.S. states have completed these analyses and are in the process of implementing them.[97] USAID could also support financial analyses and market assessments for energy efficiency, similar to the US Department of Energy's Better Buildings Program in the United States (NREL, 2015).

- **Green certification**. Green certification provides developers, buyers, and tenants with standardized information on the energy consumption and environmental impacts of a property. USAID could support the Mexico City Government's efforts to strengthen green certification by introducing a monitoring system. In addition, USAID could support the replication of this program in other large cities. USAID could support the development of building energy labels that estimate energy consumption. The US, Brazil, and China have adopted building energy labeling on a mandatory or voluntary basis. Typically, the labeling only applies to new buildings, but it can also be triggered upon the sale, leasing, or retrofitting of existing buildings (ACEEE, 2014).
- **Opportunities to increase energy efficiency in middle- and high-income housing.** Most of the residential energy efficiency activities in Mexico have focused on low-income housing. USAID could fill a gap by extending energy efficiency activities to middle- and upper-income housing. These market segments may be better able to use innovative financial and business mechanism to overcome the barriers to adoption of energy efficiency and renewable energy. Higher income households have more disposable income and may be able to take more risks, allowing them to be early adopters of technologies, which can be scaled up later as market prices fall.
- **Rehabilitation of existing buildings**. USAID could support preparation of plans for the development and rehabilitation of industrial, commercial, and residential areas, including abandoned buildings. USAID could support policy dialogues to improve the regulatory environment and incentives for these investments and help identify financing sources. Implementation and financing support for rehabilitation or redevelopment could be contingent on the inclusion of energy efficiency considerations and increasing densities for efficient public service and infrastructure delivery. These efforts could be facilitated by supporting broader stakeholder engagement and coordinated development of public transport hubs by multiple jurisdictions. For example, Mexico City has awarded concessions for public transport hubs that used market mechanisms to capture value.[98]
- **Consolidation and structuring of financing for energy efficiency in buildings**. USAID could help domestic institutions structure debt and leverage financing for energy efficiency in new housing and

[96] The Danish program is working in the states of Morelos, Baja California and Tabasco. GIZ is working in the state of Veracruz.
[97] http://database.aceee.org/state/compliance
[98] E, Mendoza. "GDF Entrega Paraderos Del Transporte Público a La Iniciativa Privada." GDF Entrega Paraderos Del Transporte Público a La Iniciativa Privada. Contralínea, 7 Apr. 2015. Web. 7 Aug. 2015. http://contralinea.info/archivo-revista/index.php/2015/04/07/gdf-entrega-paraderos-del-transporte-publico-la-iniciativa-privada/

retrofits by bundling and standardizing interventions and scaling up financing mechanisms. USAID could work with federal, state, and local governments to consolidate existing or new market mechanisms into one or more dedicated trust funds. Existing mechanisms to consider include Mexico's carbon tax, property taxes, car registration fees, and cost recovery through electricity bills. Other innovative models tested in California, New York, and Texas include integrated rooftop solar systems for multiple buildings, behind-the-meter batteries, plug-in electric vehicles, and quick demand response systems into the grid. These states have developed rules to determine how distributed energy sources can be aggregated and dispatched to serve the grid.[99] USAID could provide technical assistance to the GOM, which has begun developing regulations for grid integration of intermittent distributed generation. USAID could promote use of green bonds at the federal, state, or local level to support energy efficiency investments in conjunction with private equity funds and publicly traded companies. USAID could also support loan guarantees and work with certified technology providers.

[99] http://www.greentechmedia.com/articles/read/californias-plan-to-turn-distributed-energy-resources-into-grid-market-play

4. CONCLUSIONS

Mexico has made significant progress in the adoption of institutional frameworks for climate change action. One key milestone was the 2012 General Law on Climate Change (LGCC), which distributed responsibilities among federal and subnational governments to tackle climate change mitigation and adaptation. This law also established non-binding climate change mitigation goals. The 2015 Intended Nationally Determined Contribution (INDC) furthered the LGCC's goals by committing the GOM would unconditionally reduce its GHG and short-lived climate pollutant (SLCP) emission by 25 percent below business as usual (BAU) by 2030 and up to 40 percent contingent on international support (GOM, 2015).

Since the adoption of the first Special Climate Change Program in 2009, Mexican federal and subnational agencies have strengthened their capacity to develop climate change policies and programs, supported by sound scientific and technical analysis. Two federal administrations have successfully adopted climate change programs that integrate the main elements of Mexico's Low Emission Development Strategy (LEDS), including (1) a well-defined process with clear institutional roles and responsibilities; (2) a sound assessment of the current situation, including increasingly rigorous GHG inventories; (3) analysis of BAU scenarios and LEDS pathways; (4) prioritization of actions; and (5) implementation and monitoring of the PECC. Subnational governments have also enhanced their capacity to develop LEDS, although more institutional development is clearly needed.

Despite this important progress, institutional capacities require further development at the federal, state, and municipal subnational levels if the country is to achieve its climate change goals. Reducing Mexico's GHG emissions from the energy sector is indispensable to meet the country's climate change mitigation goals. Mexico emitted 748 million tCO_2e of GHG in 2010. Energy production and use was the largest source of emissions, accounting for 67.3 percent of total emissions. Transport contributed 22.2 percent of total electricity generation, Electricity generation was responsible for 21.8 percent of total emissions followed by industry at 19 percent, electric power generation at 16 percent, and oil and gas at 11 percent (SEMARNAT, 2013).

Existing studies have identified the largest GHG mitigation potential from greater efficiency in Mexico's transport sector, followed by industry, waste, and buildings.[100] Except for waste, which includes the relatively costly improved treatment of wastewater, GHG reductions in the other sectors can underpin the transition to a low emission development, while yielding important economic benefits. The largest opportunities for energy savings are in the transport and industrial sectors, which contributed the largest share of Mexico's GHG emissions and are poised to contribute an even larger share in the future. While emissions reductions from municipal services (including waste management and buildings) seem relatively modest, they were identified as priority sectors by consulted stakeholders and because, in addition to contributing to achieve Mexico's mitigation goals, they would yield important co-benefits, including economic savings and improved local environmental conditions.

[100] Mitigation from industry and buildings include direct and process reductions, as well as indirect reductions from decreased power consumption. Waste is considered a renewable source of energy by Mexican legislation; however, it is discussed in this memo because it was not covered in the NREL assessment on renewable energy and it is a priority for Mexico, as stated in the General Law on Climate Change and the climate change laws of Veracruz and Mexico City.

This report has provided recommendations to achieve GHG emissions reductions and energy savings, identifying specific areas of opportunity in four key sectors, as summarized in Table 16. Summary of Recommendations to Improve Energy Efficiency in Key Sectors

Table 16. Summary of Recommendations to Improve Energy Efficiency in Key Sectors

Transport and urban development	Reducing the use of private vehicles and improving the efficiency of the vehicle stock through scrappage programs, school bus programs and other shared transportation initiatives, parking meters and other demand management interventions, and improvements in efficiency of government-owned vehicle fleet.
	Improving accessibility, security, and quality of public transport through public transport integration, introduction of peak-pricing strategies, and reduction of gender-based violence (GBV) in public transport.
	Promoting sustainable urban development to reduce the need for motorized vehicles through the development of financial mechanisms for denser urban development, facilitation of public-private partnerships (PPPs) for urban mobility, and mobilization of finance for public transportation and protected bicycle lanes.
Industry	Promoting energy management systems (EMS) by helping key energy efficiency stakeholders assess the pros and cons of different energy efficiency standards and working with financial institutions to link credit lines to EMS so that results are monitored and transaction costs reduced.
	Expanding energy efficiency insurance in other sectors and with other technologies, particularly by helping develop easily accessible and understandable standardized contracts that can be signed by medium enterprises and providers of energy efficiency technology.
	Expanding energy efficiency gains by working with SMEs that sell to large firms interested in improving the energy and environmental performance of the suppliers and distributors in their value chains.
	Promoting energy audits and improved management by reducing carbon taxes if a firm has made substantial energy efficiency improvements.
	Helping the federal and state governments set up financing windows for energy efficiency projects within a public-private trust fund for priority industries.
Municipal services	Expanding power generation from solid waste management by providing municipal officials with access to technical resources, including technical assistance on available technologies and alternative financial and market mechanisms that can be adopted to fund this type of projects.
	Replicating best practices for energy efficiency improvements in public lighting and water pumping, potentially through the establishment of networks that provide technical assistance and on-the-spot support. Networks could include publicly-funded hotlines and information hubs or brokers that collect a fee for structuring the projects by bringing together different financial and technical service providers.
	Conducting rapid energy assessments for municipal buildings, and linking financial instruments and market mechanisms to realize the investment on energy savings in buildings with highest return of investment.

	Facilitating implementation of pre-identified projects by providing financial and technical support for feasibility studies, and leveraging financial resources, and reducing risks and transaction costs.
Buildings	Deploying solar water heating (SWH) by bringing local governments together with installers to develop a program to install SWH in residential and commercial buildings; develop new financial and market mechanisms to make SWH more attractive (such as adding the cost of an assessment and installation to property's tax bills); and support program for female-headed households that would be more likely to accept advice and services from female technicians.
	Establishing and enforcing energy-efficient building codes and strengthen the capacity of public officials, engineers, and architects to apply better construction techniques and energy-efficient equipment; development of a program for energy-efficient buildings in commercial and public buildings; analyzing current compliance gaps and identifying good practices and developing a strategic compliance plan; and supporting financial analyses and market assessments for energy efficiency (as is done by the US Department of Energy's Better Buildings Program).
	Promoting green certification by replicating successful programs in large cities and developing a building labeling program.
	Preparing plans for the development and rehabilitation of industrial, commercial, and residential buildings, including abandoned buildings; and supporting a policy dialogue to improve the regulatory environment and incentives for these investments or help identify financing sources.
	Consolidating and structuring financing for energy efficiency in buildings, by helping domestic institutions structure debt and leverage financing for energy efficiency in new housing and retrofits by bundling and standardizing interventions and scaling up financing mechanisms.

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APPENDIX 1. MEETING AND ATTENDEES

Monday, June 15	
USAID Mexico Low Emission Development Program (MLED)	Ana Silvia Arrocha María Elena Zarco Rogelio Avendaño Adrián Paz Alejandro Lorea Ana María Contreras Ricardo Troncoso
GreenMomentum	Jonathan Pinzón Fernando Rangel
Tuesday, June 16	
Gender Unit, SENER	Yanci Gutiérrez
General Direction of Energy Efficiency, SENER	Santiago Creuheras Adrián Cordero
GIZ (Energy and Gender)	Sandra Caballero Ana Skwierinski
Local Governments for Sustainability (ICLEI)	Luciana Puebla
Wednesday, June 17	
General Direction of Energy, SEMARNAT	Galo Galeana Alma Escamilla
Trust Fund for Electricity Savings (FIDE)	José Antonio Urteaga
Thursday, June 18	
MLED	Mark Oven
Centro Mario Molina	Guillermo Velasco Andrés Flores
National Institute of Ecology and Climate Change (INECC)	Amparo Martínez Daniel Buira Miguel Breceda Alejandra López
Friday, June 19	
GIZ (Mexico-Germany Climate Change Alliance)	Yuriana González
EMBARQ / Center for Sustainable Transport	Adriana Lobo Julia Martínez Lorena Baca Saúl Alveano
IMCO (Mexican Institute of Competitiveness)	Rodrigo Gallegos
Monday, June 22	
WWF/Universidad Iberoamericana	Vanessa Pérez-Cirera
GIZ (Housing NAMA Team)	Arne Loeprick Andreas Gruner

United Nations Environmental Programme (UNEP)/Latin American Regional Climate Initiative (LARCI)	Juan Carlos Arredondo-Brun, LARCI Jorge Villarreal-Padilla, LARCI Mercedes Garcia, UNEP
Tuesday, June 23	
Under-Ministry of Planning, SEMARNAT	Rodolfo Lacy Beatriz Bugeda Mónica Echegoyen
National Commission for the Efficient Use of Energy (CONUEE)	Odón de Buen Sergio Segura
Wednesday, June 24	
Inter-American Development Bank (IDB)	Ramón Guzmán Margarita Cabrera Alexander Varsa
Environmental Protection Agency (Global Methane Initiative)	Chris Godlove, EPA Miguel Franco, TetraTech
Nacional Financiera development bank (NAFIN)	Marianna Lara Adriana Reyes Iván Cornejo
Thursday, June 25	
BANAMEX	Miguel Vejar
World Bank	Guillermo Hernández
USAID Mexico Economic Policy Program (MEPP)	Narciso Suárez
Friday, June 26	
MLED	Adrián Paz
Danish Cooperation	Ulla Blatt
Evensen Dodge	Fernando Gama
Thursday, July 2	
AMEXCAP	Maria Ariza
Friday, July 3	
Mexico City's Ministry of Environment and Natural Resources	Oscar Vázquez
Thursday, July 9	
CESPEDES	Juan Manuel Diosdado Luisa Manzanares Isabel Moreno Adrián Vázquez
Sociedad Hipotecaria Federal	Ernesto Infante Carlos Eduardo Gaitán
Adobe Capital	Miguel Duhalt
Friday, July 10	
NAMA Facility	Miguel Angel Chavarria
Ministry of Agrarian, Territorial and Urban Development (SEDATU)	Alejandro Treviño Díaz Edith Rodríguez Martínez Adriana López Hernández
Mexico City's Ministry of Urban Services	Pablo Romero Jerónimo Osejo Michele Uriarte Oscar Vázquez Talia Martínez
Tuesday, July 14	
Ministry of Urban Development and Environment of the State of Yucatan	Roberto Vallejo
Fundación Valladolid	María José Cárdenas

	Jesús Miranda
Thursday, July 16	
Municipal Government of Veracruz	Josefina Murrieta
Municipal Government of Xalapa	Sergio Angón
Friday, July 17	
Ministry of Environment of the State of Veracruz	Victor Alvarado Carla Guadalupe Enríquez Beatriz del Valle
Wednesday, August 5	
National Council on Science and Technology (CONACYT)	Julia Tagueña Victor Carreón

APPENDIX II. AVERAGE PRICE OF ELECTRICITY TARIFFS IN MEXICO

Tariff	Average price, August 2015 (MXN cents/kWh)
Residential	110.756
1 Residential	110.744
1A Residential for locations with a minimum average temperature of 25°C in summer	106.732
1B Residential for locations with a minimum average temperature of 28°C in summer	107.365
1C Residential for locations with a minimum average temperature of 30°C in summer	107.034
1D Residential for locations with a minimum average temperature of 31°C in summer	105.14
1E Residential for locations with a minimum average temperature of 32°C in summer	88.412
1F Residential for locations with a minimum average temperature of 33°C in summer	83.352
DAC Residential High Consumption	330.338
Commercial	268.94
2 General up to a demand of 25 KW	273.988
3 General for a demand of more than 25 KW	225.439
7 Temporary	477.464
Services	253.745
5 Public lighting (Mexico City, Monterrey and Guadalajara)	340.725
5A Public lighting (rest of the country)	282.512
6 Water pumping (water supply or municipal wastewater)	191.226
Agricultural	52.468
9 Water pumping for irrigation	196.431
9-M Water pumping for irrigation, medium tension	1,573.56
9CU Water pumping for irrigation (subsidized tariff)	56.985
9N Water pumping for irrigation, medium tension (subsidized tariff)	47.144
Industrial	123.004
Medium enterprises	133.108
OM Ordinary, medium tension, with a demand under 1000 KW	168.425
OMF Ordinary, medium tension, with a demand under 1000 KW, fixed charge	0

HM Ordinary, medium tension, with a demand of 100 KW or more	125.243
HMF Ordinary, medium tension, with a demand of 100 KW or more, fixed charge	119.983
H-MC low use (medium tension with low load factors, applies only in Baja California, Sonora and Sinaloa)	150.176
H-MCF Low use, fixed charge	0
Large industry	101.58
HS General, high tension, sub transmission	112.559
HSF General, high tension, sub transmission, fixed charge	105.637
H-SL General, high tension, sub transmission, high use	106.046
H-SLF General, high tension, sub transmission, high use, fixed charge	140.29
HT General, high tension, transmission	92.178
HTF General, high tension, transmission, fixed charge	0
H-TL General, high tension, transmission, high use	81.398
H-TLF General, high tension, transmission, high use, fixed charge	0

Source: Secretaría de Energía, Sistema de Información Energética. http://sie.energia.gob.mx/movil.do?action=applyOptions. Query made on September 30, 2015.

APPENDIX III. DEFINITIONS

Building envelope: The physical separator between the conditioned and unconditioned environment of a building, including the resistance to air, water, heat, light, and noise transfer. The three basic elements of a building envelope are a weather barrier, air barrier, and thermal barrier. The term *building envelope* is sometimes used synonymously with *building enclosure*, but the latter term also includes the broader aspects of appearance, structure, safety from fire, and security. The act of creating a building envelope is sometimes called *weatherization*.

Co-benefits: The positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare. Co-benefits are often subject to uncertainty and depend on local circumstances and implementation practices, among other factors. Co-benefits are also referred to as *ancillary benefits*.

Cost-effectiveness: A policy is more cost-effective if it achieves a given policy goal at lower cost. Integrated models approximate cost-effective solutions, unless they are specifically constrained to behave otherwise. Cost-effective mitigation scenarios are those based on a stylized implementation approach in which a single price on carbon dioxide (CO_2) and other greenhouse gases (GHGs) is applied across the globe in every sector of every country and that rises over time in a way that achieves lowest global discounted costs.

CO_2-equivalent (CO_2.eq) concentration: The concentration of carbon dioxide (CO_2) that would cause the same radiative forcing as a given mixture of CO_2 and other forcing components. Those values may consider only greenhouse gases (GHGs), or a combination of GHGs, aerosols, and surface albedo change. CO_2-equivalent concentration is a metric for comparing radiative forcing of a mix of different forcing components at a particular time, but does not imply equivalence of the corresponding climate change responses nor future forcing. There is generally no connection between CO_2-equivalent emissions and resulting CO_2-equivalent concentrations.

CO_2-equivalent (CO_2-eq) emission: The amount of carbon dioxide (CO_2) emission that would cause the same integrated radiative forcing, over a given time horizon, as an emitted amount of a greenhouse gas (GHG) or a mixture of GHGs. The CO_2-equivalent emission is obtained by multiplying the emission of a GHG by its global warming potential (GWP) for the given time horizon (see WGI Chapter 8, Table 8.A.1 and WGIII Annex II.9.1 for GWP values of the different GHGs used here). For a mix of GHGs, it is obtained by summing the CO_2-equivalent emissions of each gas. CO_2-equivalent emission is a common scale for comparing emissions of different GHGs, but does not imply equivalence of the corresponding climate change responses. There is generally no connection between CO_2-equivalent emissions and resulting CO_2-equivalent concentrations.

Global warming potential (GWP): An index measuring the radiative forcing following an emission of a unit mass of a given substance, accumulated over a chosen time horizon, relative to that of the reference substance, carbon dioxide (CO_2). The GWP thus represents the combined effect of the differing times these substances remain in the atmosphere and their effectiveness in causing radiative forcing.

Measurement: Collecting information on the progress of implementation and impacts of a NAMA or other climate change action.

Nationally Appropriate Mitigation Action (NAMA): Actions taken by developing countries to reduce GHG emissions in the context of sustainable development supported by developed countries with finance, technology, and capacity-building, with the objective of achieving substantial deviation from BAU emissions.

REITs: Financial securities that invest in real estate directly, either through properties or mortgages, allowing small investors to participate in the real estate market, providing a special tax regime, and highly liquid positions, as they are publicly traded.

Reporting: Submitting the measured information in a defined and transparent manner to the appropriate authorities.

Short-Lived Climate Pollutants (SLCP): Substances with a relatively short lifetime in the atmosphere—a few days to a few decades—and a warming effect on near term climate. The main SLCPs are black carbon, methane, tropospheric ozone, and many hydrofluorocarbons.

Verification: Assessing the information that is reported for completeness, consistency, and reliability.