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Update of Mexico's Emissions Baselines and Mitigation Portfolio 2009-2030

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Update of Mexico's Emissions Baselines and Mitigation Portfolio

This study was prepared by the Stockholm Environment Institute (SEI). The main authors are Victoria Clark and Charles Heaps of SEI, under the supervision of Antonio Mediavilla and Ricardo Troncoso of WWF Mexico, within the framework of the Mexico Low Emissions Development Program (MLED), sponsored by the United States Agency for International Development (USAID), under the contract "AID-523-C-11-00001" implemented by TETRA TECH ES INC.

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Table of Acronyms and Abbreviations

BAU	Business as Usual scenario, or baseline
BIE	Banco de Información Económica
CCS	Carbon Capture and storage
CMM	Centro Mario Molina
CONAFOR	Comisión Nacional Forestal
CONAPO	Consejo Nacional de Población
CONUEE	Comisión Nacional para el Uso Eficiente de la Energía
COP	Conference of the Parties
CFE	Comisión Federal de Electricidad
CH_4	Methane
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CTS	Centro de Transporte Sustentable
ENIGH	Encuesta Nacional de Ingresos y Gastos de Hogares
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GW	Gigawatt
GWh	Gigawatt-hour
GWP	Global Warming Potential
Ha	Hectares
HDV	Heavy Duty Vehicles
HFCs	Hydrofluorocarbons
INECC	Instituto Nacional de Ecología y Cambio Climático
INEGEI	Inventario Nacional de Emisiones de Gases de Efecto Invernadero
INEGI	Instituto Nacional de Estadística y Geografía
IPCC	Intergovernmental Panel on Climate Change
IMP	Instituto Mexicano del Petróleo
LAERFTE	Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética
LEAP	Long-range Energy Alternatives Planning system
Lm	Lumen
MEDEC	México: Estudio de la Disminuación de Emisiones de Carbono
N_2O	Nitrous Oxide
PECC	Programa Especial de Cambio Climático
PEMEX	Pétroleo Mexicano
PV	Solar Photovoltaic
SEI	Stockholm Environment Institute
SEMARNAT	Secretaría de Medio Ambiente u Recursos Naturales

SENER	Secretaría de Energía
SF_6	Sulfur Hexafluoride
SIACON	Sistema de Información Agroalimentaria de CONsulta
SIAP	Servicio de Información Agroalimentaria y Pesquera
SIE	Sistema de Información Energética
SLCPs	Short-Lived Climate Pollutants
UNAM	Universidad Nacional Autonoma de México

Abstract

As a part of the Mexico Low Emission Development Program, the Stockholm Environment Institute (SEI) with assistance from the Universidad Nacional Autónoma de México (UNAM) was commissioned by the National Institute of Ecology and Climate Change (INECC) to develop an updated national emissions baseline from 2009 to 2030 together with a set of mitigation scenarios for the same period. The focus of this project was to provide a transparent and understandable model though scenario modeling, documentation, and training courses.

SEI created three baseline scenarios and modeled 51 mitigation options across nine sectors: transport, commerce, electricity generation, industry, oil and gas, households, forestry, agriculture and waste. Where feasible, SEI and UNAM used the 2009 marginal abatement costs (MAC) curves developed by INECC and McKinsey and Company as a basis for this work, but updated this with new analysis and official national data sources in order to create a final product that emphasized transparency.

Though we expect that the model produced by SEI and UNAM can be further improved with additional input from INECC and local experts, the current results show that significant potential exists for reducing GHG emissions and mitigating climate change across energy and non-energy sectors in Mexico. The total mitigation potential of the combined measures comes to 180 MtCO2e in 2020 and 449 MtCO2e in 2030, amounting to 19% and 38% reductions compared to the baseline, respectively.

Executive Summary

In recent years, the Mexican government – through the Ministry of Environment and Natural Resources (SEMARNAT) and the National Institute for Ecology and Climate Change (INECC) – has taken numerous initiatives related to climate change mitigation planning, including the development of national emissions baselines, identification of emission reduction opportunities, construction of abatement cost curves and developing alternative emissions scenarios, all with the broader intent of developing a national emissions reduction strategy.

These efforts have been driven by national policies such as the target of 30% emission reductions compared to a baseline by the year 2020, set by President Felipe Calderón in 2009 at COP 15 in Copenhagen, Denmark.

This project sought to revise, update and strengthen the information used in these types of efforts and to generate key elements for the formulation and implementation of a long-term national Low Emissions Development Strategy.

The Stockholm Environment Institute (SEI), in collaboration with the Universidad Nacional Autónoma de México (UNAM), were asked to assist with these efforts in two key areas: 1) revising and updating the national greenhouse gas emissions baseline; and 2) updating opportunities and actions for emissions reductions in a mitigation scenario.

The project focused on creating an open, transparent and accessible model that can be continuously updated and maintained by INECC staff as new data becomes available and as changes are made to scenarios and goals. To help achieve this goal, the modeling conducted for this project has been implemented within the Long-range Energy Alternatives Planning (LEAP) system, a widely-used software tool developed at SEI that is notable for its transparency, flexibility and ease-of-use, and which is freely available to developing country organizations.

The approach to building baseline and mitigation scenarios involved numerous consultations with stakeholders and INECC staff to discuss gaps in previous work, to help INECC staff learn to use the LEAP tool, and to review the methodologies, assumptions, and data.

Results

Before building a complete mitigation scenario, SEI and UNAM first reviewed previous work, defined the scope and methodology, collected new data, developed baseline scenarios and screened mitigation options.

The baseline scenario for the INECC 2013 analysis included data and projections for the agriculture, waste, electricity generation, industry, oil and gas, residential, services, forestry and transport sectors. Three different baseline scenarios were created with low (baja), medium and high (alta) estimates of GDP growth, which resulted in total emission of 1025, 1175, and 1335 million tonnes of carbon dioxide equivalent, respectively, in 2030.

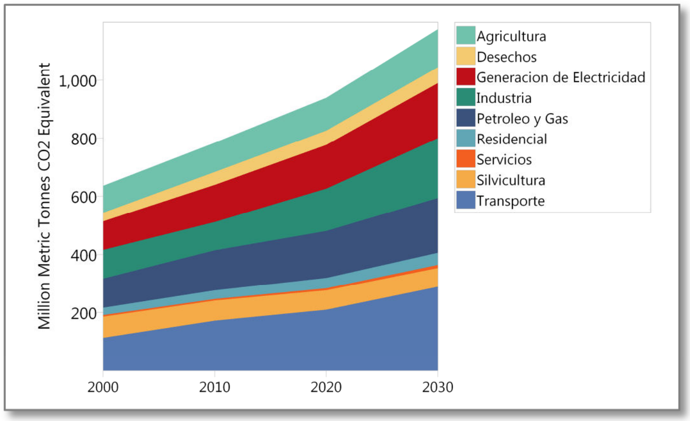

Figure 1: Total GHG emissions in the INECC 2013 BAU scenario by sector

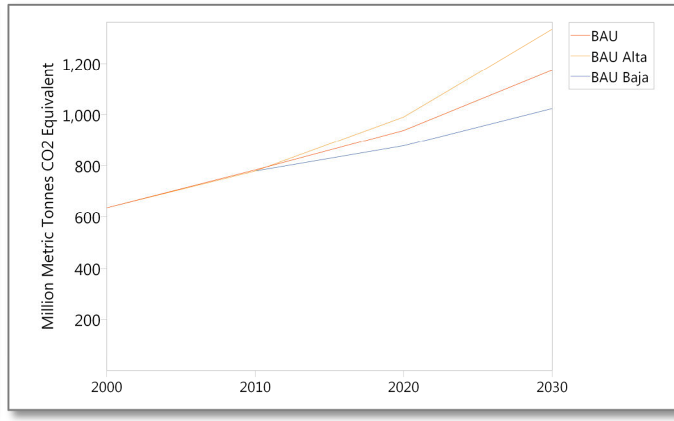

Figure 2: Total GHG emissions in the INECC 2013 analysis by baseline scenario

The mitigation scenario incorporated 51 measures to reduce greenhouse gas emissions, screened from the McKinsey 2009 analysis and other recent mitigation studies in Mexico.

The results of the mitigation scenario indicated that significant potential exists for reducing GHG emissions and mitigating climate change across energy and non-energy sectors in Mexico. The total mitigation potential of the combined measures was calculated to be 180 $MtCO_2e$ in 2020 and 449 $MtCO_2e$ in 2030, equivalent to 19% and 38% reductions compared to the baseline, respectively. We expect that this model will be improved by INECC with input from local stakeholders and experts.

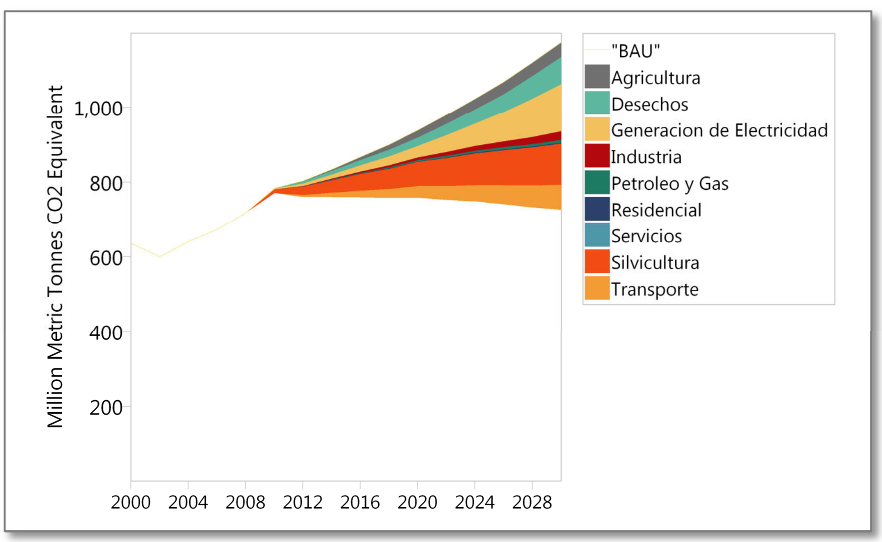

Figure 3: Total GHG emission reductions by sector in the INECC 2013 Mitigation scenario compared to the BAU

SEI recommends that INECC take next steps to include cost assumptions for cost curves and scenario cost benefit analysis and to refine assumptions and add complexity with help of local experts in Mexico.

Introduction

In recent years, the Mexican government – through the Ministry of Environment and Natural Resources (SEMARNAT) and the National Institute for Ecology and Climate Change (INECC in Spanish, previously INE) – has undertaken numerous initiatives related to climate change mitigation planning, including the development of national emissions baselines, identification of emission reduction opportunities, construction of abatement cost curves and developing alternative emissions scenarios, all with the broader intent of developing a national emissions reduction strategy.

These past studies needed to be updated to align with current data and revised energy plans. As a part of the climate change cooperation between the governments of the United States and Mexico, this project within the Mexico Low Emission Development (MLED) program aimed to create a national energy model that can be used to inform energy policy in Mexico that reduces emissions without affecting economic growth.

INECC asked The Stockholm Environment Institute (SEI) to prepare a new national greenhouse gas (GHG) emissions baseline as well as comparative mitigation scenarios. SEI is an international research organization that engages in environment and development issues at local, national, regional and global policy levels. SEI partnered with the Center for Energy Research (CIE in Spanish) at the Universidad Nacional Autonoma de México (UNAM), known for their expertise in the Mexican electricity sector.

SEI and UNAM were asked to assist with these efforts in two key areas: 1) revising and updating the national greenhouse gas emissions baseline; and 2) updating opportunities and actions for emissions reductions in a mitigation scenario.

The objective was to create a model that built upon the existing baseline, in a way that would be transparent and well documented so as to facilitate the transfer of a tool to INECC staff for further development.

This report includes an overview of the approach, methodology and assumptions behind the analysis as well as a summary of the policy implications. Detailed documentation of the inputs to the analysis is included as appendices to this report.

Background

In developing this analysis, SEI followed the basic approach recommended in the UNFCCC Guidelines for Preparing Mitigation Assessments (2012). This involved the following steps: reviewing previous work, defining the scope and methodology, collecting data, developing baseline scenarios, screening mitigation options and finally developing mitigation scenarios. The methods section outlines these steps in detail and describes how they were applied specifically for this analysis.

Step 1: Review previous baseline and mitigation efforts

Step 2: Define the Scope

Step 3: Define the Methodology

Step 4: Collect and Calibrate Data and Assumptions

Step 5: Develop Baseline Scenarios

Step 6: Identify and screen mitigation options

Step 7: Develop Mitigation Scenarios

Methods

Step 1: Review Previous Baseline and Mitigation Efforts

The SEI and UNAM teams started by assessing available national GHG baseline and mitigation studies to review data availability and existing approaches and to identify strengths and weaknesses. SEI and UNAM wrote a short report detailing the gaps in previous studies and proposed methods to meet them.

The primary work reviewed was the emissions baseline and cost curves developed by McKinsey & Company and INECC (2009). This study had a timeframe of 2006-2030 and included agriculture, waste, forestry, energy, buildings, oil and gas, transport and industry sectors.

Other studies reviewed were:

- MEDEC - The World Bank-funded *Low-Carbon Development for Mexico* study (Alatorre et al., 2009),
- Mario Molina - The ESMAP-funded *Low-Carbon Growth: A Potential Path for Mexico* work (McKinsey and Company, 2008),
- PECC - The Special Program on Climate Change (PECC in Spanish) project (SEMARNAT, 2009), and

- Quadri - The SEMARNAT report *Climate Change in Mexico and the Potential to Reduce Emissions by Sector* (Gabriel Quadri de la Torre, 2008).

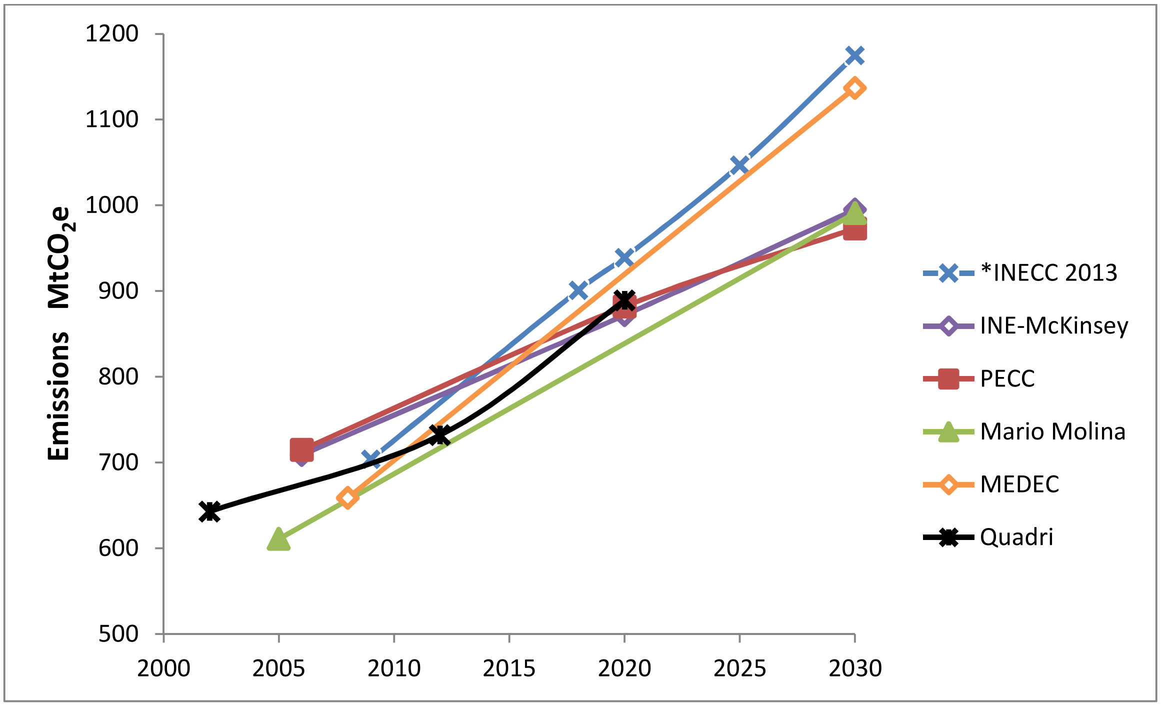

Figure 1: Emissions Baselines Compared[1]

Key Gaps and Updates to the 2009 Emissions Baseline and Mitigation Analysis

Transparency and documentation

The previously created 2009 baseline included documentation of the methodology and assumptions associated with each sector, but did not detail all variables and assumptions, meaning that the exercise could not be replicated or easily updated.

A goal in creating this 2013 baseline was to provide increased transparency and documentation of inputs and assumptions including:

- This report on assumptions, methods and data sources
- A usable LEAP data set which includes notes on assumptions, methods and data sources
- Documentation of each mitigation option and quantitative parameters used in LEAP modeling
- Training for INECC staff in how to use LEAP and the specific Mexico LEAP Model

Historical Data

The 2009 baseline did not include data before 2006. Historical data, though not necessary, gives context for future growth and makes it easier to make projections based on past trends. The

[1] The INECC 2013 baseline scenario plotted is the middle BAU scenario

updated baseline for 2013 included integrated historical data from 2000-2009 for demand and supply sectors. Supply side data (e.g. electricity generation) was not available before 2000, but energy demand and non-energy sectors included additional data back to 1990 for comparison to historical energy statistics and non-energy inventories.

Disaggregation of data

The 2009 McKinsey baseline included disaggregated data structures in some sectors (such as transport and electricity generation), but not in others. With help from INECC staff, the 2013 analysis added further disaggregation in the residential, transport, industry and electricity generation sectors, providing a fundamental understanding of how energy is being used in Mexico, which helped to best model long-run changes in the energy system.

Step 2: Define the Scope

The scope of the INECC 2013 analysis was decided through discussions with INECC staff. The resulting integrated analysis included historical data for the years 2000-2009 and scenario projections from 2010-2030. It included the agriculture, waste, forestry, electricity generation, residential, services, oil and gas, transport and industry sectors.

Step 3: Methodology

Step three details the high-level approach and methodology used in this analysis, and steps five and seven explain the assumptions in each sector for the baseline and mitigation scenarios, respectively.

We focused on disaggregation, usability and transparency while selecting a methodology for the 2013 analysis. For example, in the 2013 baseline we have disaggregated the residential sector into end uses and have further broken down the industry sector. The transport and electricity generation sector also include end uses by type of technology and fuel.

Additionally, we built in key drivers and variables in each sector, which give a more complete picture of emissions sources within an economy. This means that the transport sector included the vehicle-km traveled by each type of vehicle and the power sector not only included emissions but also capacity of power plants and thermal efficiency by type of power plant.

The 2013 INECC analysis also included the ability to continually update, change and improve the model in LEAP. INECC staff have been trained in how to use LEAP and this specific model. Specific inputs can be modified, new scenarios can be added, and new results can be calculated easily.

The LEAP Tool

All scenarios described in this study have been developed using SEI's LEAP energy modeling system (Heaps 2013). LEAP provides a convenient and sophisticated tool for integrating all the sectors and for running various policy scenarios. LEAP is a widely-used software tool for energy policy analysis and climate change mitigation assessment SEI. LEAP is an integrated modeling tool that can be used to track energy consumption, production and resource extraction in all sectors of an economy. It can be used to account for both energy sector and non-energy sector greenhouse gas (GHG) emission sources and sinks.

LEAP has developed a reputation among its users for presenting complex energy analysis concepts in a transparent and intuitive way. Below is a brief introduction to LEAP's calculation methodology. Note that specific sectoral assumptions are documented in steps four and six.

Energy Demand Methodology

In all energy demand sectors, LEAP calculates energy consumption as the product of an activity level and a final energy intensity. An activity level can be any indicator of economic or physical activity (e.g. households for the residential sector, commercial GDP for the commercial sector or annual cement production in the cement industry). Final energy intensity is the amount of energy used per unit of activity level (e.g. kWh of electricity used per household). LEAP then calculates the total emissions by multiplying the total energy consumption (activity level * final energy intensity) by an IPCC tier one emission factor.

In historical years, SEI used National Energy Balance data directly to represent historical energy use. In future years, each sector has a different methodology, which is described further in step five.

Energy Supply Methodology

Electricity: In historical years we used an accounting methodology where historical generation data is input directly from SENER data.

We chose to use a simulation methodology for future years, where electricity generation is projected based on electric capacity expansion and dispatching power plant processes along a system load curve. In each year, LEAP calculates the total electricity demands as the sum of the user-specified electricity consumption defined by the user as demands. Then LEAP calculates the requirements for electricity generation after transmission and distribution losses. We defined a future capacity expansion plan (in MW), thermal efficiency, and availability by type of power plant. To simulate the dispatch of processes, LEAP makes a list of processes sorted by their merit order (which defines whether a process will meet base or peak loads) and dispatches available capacity along a system load duration curve, which maps out variations in electrical demand over the course of a year. This total generation by fuel is divided by a thermal efficiency to calculate the fuel needs, which is multiplied by an IPCC tier one emission factor to calculate total emissions.

Oil and Natural Gas: The oil and gas sector included extraction, refining and processing. In LEAP these sectors did not have associated emissions, they simply tracked the flow of energy conversion. Combustion of fuels in oil and gas activities was modeled as a demand sector.

Non Energy Methodology

LEAP was also used to model non-energy sector sources and sinks of greenhouse gases in the agriculture, waste and forestry sectors in Mexico, as well as fugitive emissions from the oil and gas sector and from industrial processes.

Step 4: Collect and Calibrate Data and Assumptions

Based on the scope and methodology chosen, we investigated available historical data and future projections to assess if additional data needed to be collected to ensure a sufficient level of disaggregation to meet the objectives of the study. A goal of this project was to use official national data sources, and to fill in with international data sources or team assumptions only when necessary. Below is a list of key data sources in the INECC 2013 analysis.

- System of Energy Information (SIE) and the Secretary of Energy (SENER) National Energy Balances (2011): Used for all historical (1990-2009) energy demand (in residential, services, industrial, transport, oil and gas, and agriculture sectors) (SENER, 2013).
- SENER Prospective 2012-2026 and the Federal Commission of Electricity (CFE) for historical electricity production and capacity from 2000-2009 and capacity projections from 2012-2026 (SENER, 2012).
- National Commission for the Efficient Use of Energy (CONUEE) and National Survey of Income and Expenditures of Households (ENIGH) data for residential end use projections (CONUEE, 2009; INEGI, 2009).
- Center for Sustainable Transport transportation data for projections of road transport fleet, vehicle miles traveled and energy intensity (CTS, 2012).
- Bank of Economic Information (BIE) GDP data (BIE, 2012).
- National Institute of Statistics and Geography (INEGI) censuses and the National Population Council (CONAPO) for population and household data (INEGI, 2010; INEGI, 2011)
- Intergovernmental Panel on Climate Change (IPCC) Tier 1 Emission Factors
- INECC's national GHG inventory (INEGEI): Used for non-energy emissions account in years 1990-2009 (SEMARNAT, 2012).
- Cost curve mitigation lever assumptions (McKinsey and Company, 2009)
- New mitigation measures from MEDEC study (Alatorre et al., 2009)
- SEI expert team assumptions

Step 5: Develop Baseline Scenarios

A baseline scenario provides a plausible and consistent description of future developments in the absence of explicit new GHG mitigation policies. A set of baselines, or business as usual (BAU) scenarios, were created by SEI and discussed at length with INECC staff in multiple trainings to workshop methodologies, data sources and assumptions.

The baseline scenarios were developed using general accounting principles. Historical energy data was taken from National Energy Balances, while historical non-energy emissions were contributed by the INEGEI. Energy-related demand emissions were projected based on an activity level approach – emissions being calculated as the product of an activity level (dependent on sector), energy intensity and emission factor. Electric sector supply emissions were projected based on power plant capacity plans and assumptions about dispatch merit order. Non-energy-related emissions were projected primarily based on IPCC methodologies and emissions factors. Specific assumptions are documented below by sector. For more detail about calculations and assumptions within the 2013 INECC baseline, see the attached Appendix One.

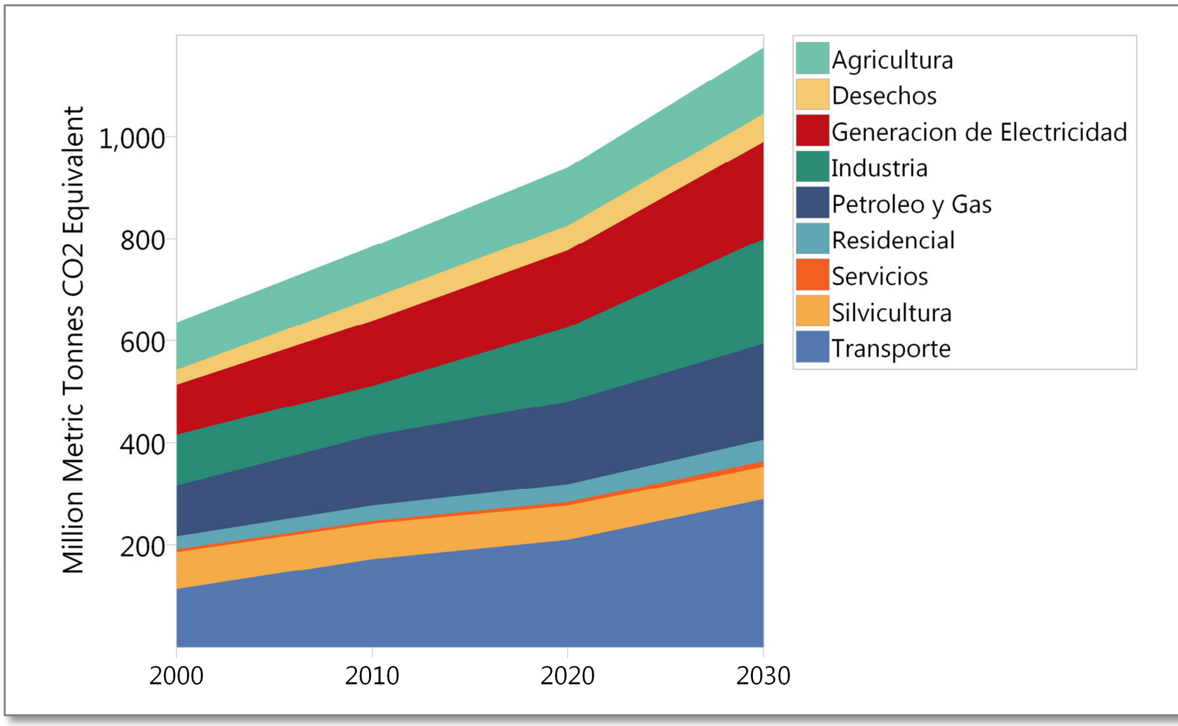

Figure 2: Total GHG Emissions by Sector in the INECC 2013 BAU Scenario

Our analysis included 3 baseline scenarios, each with different GDP growth rates intended to highlight the variability of emissions pathways when projected with different GDP projections. The three scenarios were calculated with a 2.2% (low BAU, Baja in Spanish), 3.2% (BAU) and 4.2% (high BAU or Alta in Spanish) growth rate for total GDP. These growth rates were selected after a careful review of official data sources in Mexico by the INECC team.

No official emissions projections were available in Mexico, but SENER produces annual projections of energy consumption in Mexico (2012), which we compared alongside the energy demand projections in the three INECC baseline scenarios.[2]

[2] Note that SENER Prospective only contains projections until 2026, while the INECC baselines project until 2030.

A workshop was held with the INECC team to discuss the differences between the bottom-up INECC scenarios and the SENER Prospectiva official projections. In each energy demand sector, the team scrutinized the assumptions the official SENER projections to ensure consistency and decide if improvements should be made to the INECC energy projections. Of the sectors that used GDP as an activity level, the teams calculated appropriate elasticities to allow the INECC 2013 energy projections to better reflect the SENER projections. The result of this process was an improved set of BAU scenarios which had energy projection trends more aligned with national SENER projections, but consistent with the goals of the integrated 2013 INECC analysis.

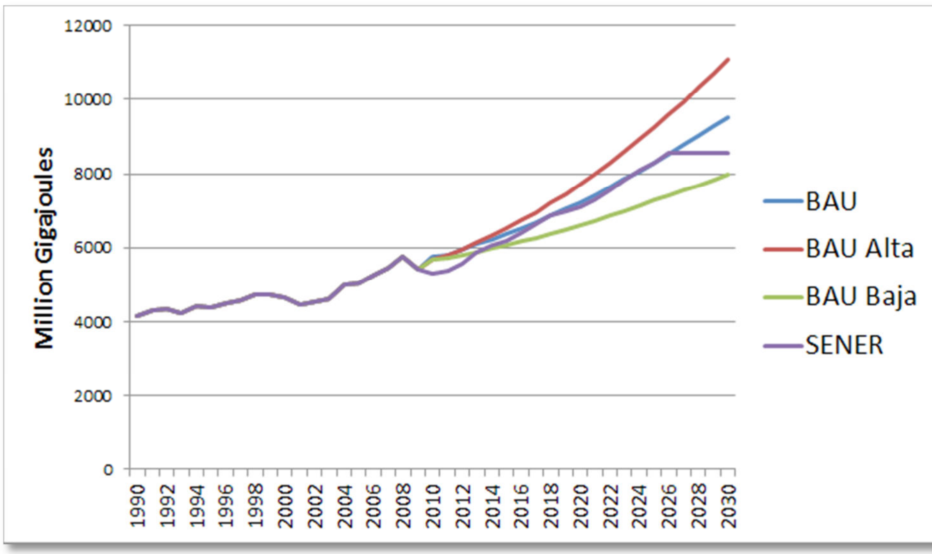

Figure 3: Total Energy Demand Compared Across Baseline Scenarios

Total GDP and value added are variables used as a measure of activity in the industry, services, agriculture and transport sectors (please see documentation of each sector below for more details on how GDP is incorporated into emissions projections). Not all sectors varied with GDP based on our modeling methodology. Waste, agriculture, forestry and residential sectors were projected independently of GDP variations. See each sector's description below for details on how GDP and value added were incorporated.

All results presented in this report are from the middle BAU scenario, which uses a 3.2% GDP growth rate.

Residential

The Residential sector was modeled using a top-down methodology for historical years and a bottom-up or end use methodology in future years. In historical years, National Energy Balance data was reported by fuel for the whole sector. In future years, energy was broken down by end use and technology, a bottom-up methodology chosen to facilitate transparency within the model and to make it easier to create mitigation scenarios. Energy consumption in this sector was driven by the activity level of the total number of households in Mexico. As two separate methodologies were used, SEI calculated a scaling factor for all end use energy intensities to ensure a logical transition from top-down historical data to bottom-up estimations.

The residential sector makes use of a disaggregated data structure in future years to give a more detailed representation of the uses of energy in Mexico. The included end uses were hot water heating, heating and cooling, refrigeration, cooking, lighting, entertainment and other uncategorized electricity use. Assumptions about the use of different technologies were based on the National Survey of Income and Expenditures of Households (ENIGH, 2012), while energy intensities were based on a report from the National Commission for the Efficient Use of Energy (CONUEE, 2009). The basic equation for the calculation of emissions in the residential sector can be seen below.

Emissions = Households * Share of Technology Use in Households * Final Energy Intensity *Emission Factor
= [HH]*[% of HH]*[GJ/HH]*[tCO_2e/GJ]

Residential emissions are dominated by LPG use in cooking and hot-water heating end uses, as can be seen in Figure 4.

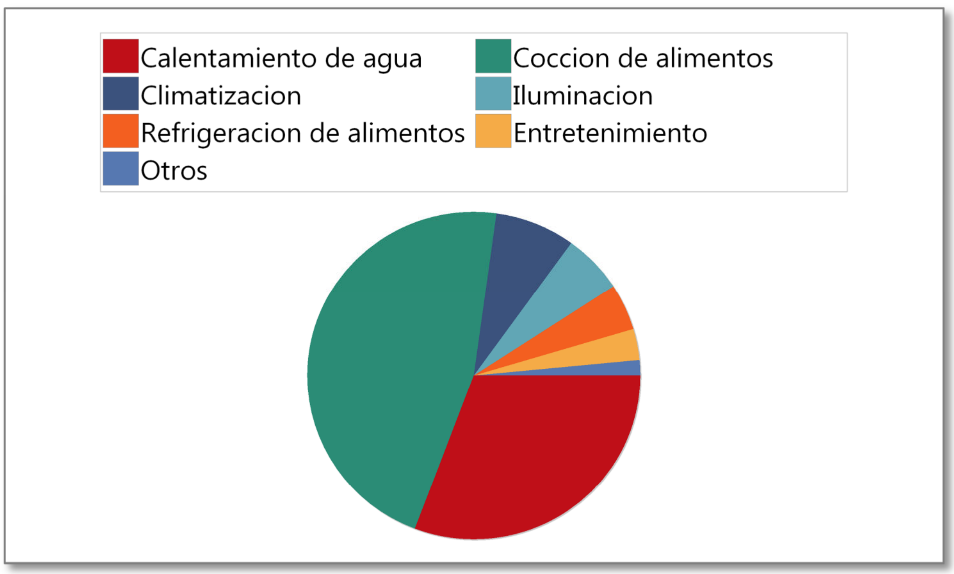

Figure 4: Total Energy Demand in the Residential Sector by End Use in 2009

Services

The Services sector was broken down into commerce (hotels, restaurants, etc.) and public services (electric water pumping and public lighting). Historical energy estimates were available from the National Energy Balances.

Future estimates of energy consumption were projected based on an activity level and energy intensity. Activity in the commerce sector was based on commercial value added, calculated as the total GDP multiplied by the share of value added by tertiary activities. The activity level for public services was based on total GDP and share of value added by public services. Historical GDP and value added data were available from the BIE (2012). Total GDP was projected with the global growth rates defined above (3.2% in the BAU) and share of value added was projected based on historical growth rates.

Energy intensities were calculated by dividing total historical energy consumption by value added in the services sector. In the commercial sector one additional variable was used – fuel share – that separates final energy intensity for the whole sector from the share of each fuel contributing to the energy intensity. In this analysis, energy intensities and fuel shares were held constant at the 2009 value. The equation for calculating emissions in the services sector is available below.

Emissions = Total GDP * Share of Value Added by Services * Final Energy Intensity * Fuel Share * Emission Factor

= [Mexican Peso]*[% of Mexican Peso]*[GJ/Peso]*[% of GJ by fuel]*[tCO_2e/GJ]

Industry

The industry sector included emissions from energy combustion as well as process emissions.

For calculations of energy emissions, the industry sector was broken down into 16 sub sectors and one category for other industries. These categories were taken from the National Energy Balances. Though the energy balances provide energy data at this level of disaggregation, we were not able to find official activity level data for all sectors. Ideally it would have been possible to make use of physical production data in each sub sector. Physical production is more closely correlated to energy consumption than value added GDP, but official production projections were only available for two sub sectors. The cement and iron and steel industries had official production projections in metric tonnes of product, provided by CANACEM and CANACERO, respectively, which were used as the activity level in those sectors. From these projections, SEI calculated a tonne per peso production and then multiplied by the INECC 2013 global value added GDP assumptions to ensure consistency with the GDP projections in other sectors. The equation used for calculating emissions in the cement and iron and steel industries is shown below.

Emissions = Total GDP * Share of Value Added by Industry * Product Production * Final Energy Intensity * Fuel Share * Emission Factor

= [Mexican Peso]*[% of Mexican Peso]*[t/Peso]*[GJ/t]*[% of GJ by fuel]*[tCO_2e/GJ]

For all other sub sectors, we used total industrial value added as an activity level, following the same approach as described in the services sector.

Process emissions were broken down by key industrial sectors: production of metals (iron and steel, aluminum, and other), consumption of HFCs and SF6, production of HFCs and SF6, Chemical industry, and mineral products (cement and other). Historical emissions were available from the INEGEI (SEMARNAT, 2012). They were assumed to grow at the same rate as total industrial energy demand. Cement, aluminum, and iron and steel process emissions were projected based on the energy consumption within their respective sub sector.

Oil and Gas

Emissions from the oil and gas sector come from fuels combusted directly for oil and gas sector processes as well as fugitive emissions. Direct combustion of fuels in the oil and gas sector is dominated by natural gas. Baseline emissions were driven by total GDP as an activity level with an elasticity of 0.5, a parameter agreed upon in a workshop by the INECC team to make energy projections more similar to the SENER Prospective (2012).

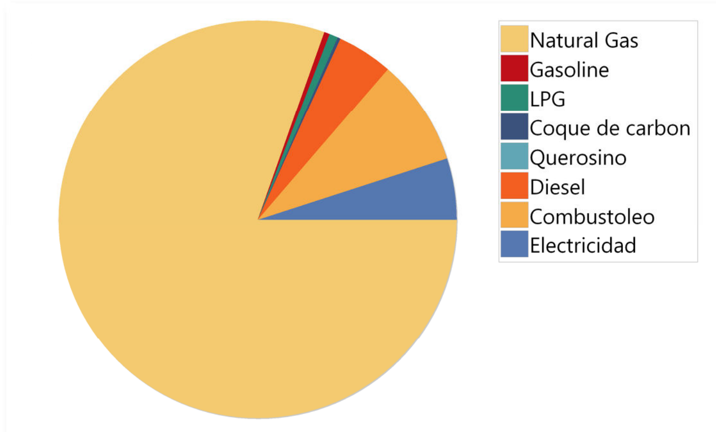

Figure 5: Breakdown of Fuel Consumption in the Oil and Gas Sector in 2009

Emissions were calculated using the equation below, following the same approach as was used in the services sector.

Emissions = Total GDP (elasticity 0.5)* Final Energy Intensity * Emission Factor
= [Mexican Peso]*[GJ/Peso]*[tCO_2e/GJ]

Fugitive emissions were documented from solid fuels, petroleum and natural gas in addition to gas flaring. These were assumed to grow at the same rate as total final energy consumption from the oil and gas sector.

Transport

The transport sector, like the residential sector, uses top down data from the National Energy Balances for historical years and a bottom-up end use analysis for future scenario projections. The baseline scenario breaks down end uses into two categories: road transport and "other", which includes rail, air, sea and metro.

Road transport is modeled in a detailed manner based on official projections of total number of vehicles, kilometers traveled, and energy efficiencies by transport mode from the Center for Sustainable Transport (CTS, 2012). The road fleet as defined by CTS includes buses, compact vehicles, light-duty passenger vehicles, heavy-duty vehicles, luxury and sports cars, subcompact vehicles and light-duty freight vehicles.

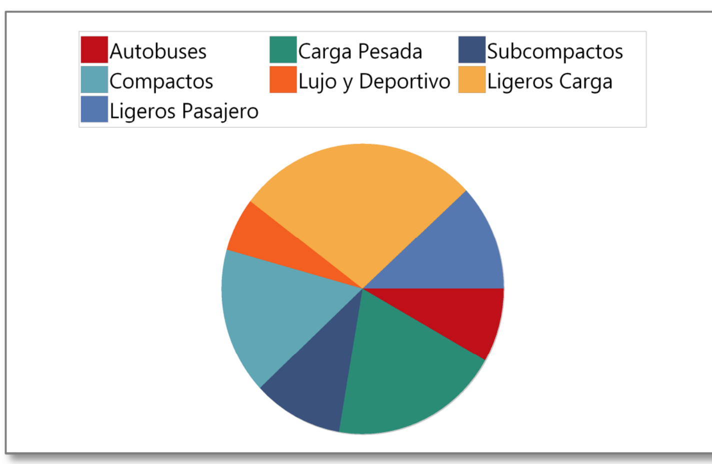

Figure 6: Total Energy Consumption in the Road Transport Sector by Mode in 2009

Baseline projections in the road transport sub-sectors were projected based on total GDP (with an elasticity of 1.3)[3], vehicle-km/peso (activity level) and efficiency improvements in energy consumption (final energy intensity). The transport sector was the only demand sector that included efficiency improvements (i.e. a decrease in energy intensity) in the baseline scenario. Gasoline and diesel fuels dominated total energy consumption in the baseline scenario. To ensure consistency between the two sources of data, SEI scaled the bottom-up energy intensities for gasoline and diesel use to the historical values in 2008.[4] Emissions were calculated using the formula below.

Emissions = Total GDP (elasticity 1.3) * Total Vehicle Kilometers Traveled * Share of Mode of Transport * Final Energy Intensity * Emission Factor
= [Mexican Peso]*[veh-km/peso]*[% of veh-km]*[GJ/veh-km]*[tCO_2e/GJ]

Other transport sectors were projected based on data and growth rates from the MEDEC study (Alatorre et al., 2009).

Agriculture

The agriculture sector was broken down into energy and non-energy emissions. Energy-related emissions were calculated using value added to GDP from the primary sector (agriculture and fishing activities) as the activity level and following the same methodology described in the services sector. Baseline fuel use is dominated by diesel and electricity use, and final energy intensities (GJ/peso) were assumed to remain constant over the period 2010-2030.

Emissions = Total GDP * Share of Value Added by Agriculture * Final Energy Intensity * Fuel Share * Emission Factor
= [Mexican Peso]*[% of Mexican Peso]*[GJ/peso]*[% of GJ by fuel]*[tCO_2e/GJ]

Non-energy emissions were broken down into the following sub-sectors: enteric fermentation, rice cultivation, agricultural lands, planned burning of lands, manure management, and burning of waste. Historical non-energy emissions were taken from the INEGEI and were projected with variable growth rates by subsector based on the analysis done by McKinsey (2009).

Electricity Generation

The baseline projection of electricity generation in Mexico includes nine types of processes. SEI grouped power plants by fuel consumed, not by specific type of power plant. The processes included in the baseline were residual fuel oil, diesel, onshore wind, coal, natural gas, nuclear, hydroelectricity, geothermal, and imports.

Historical electricity generation was available from SENER Prospective from 2000 until 2009 (2012).

[3] This elasticity was a parameter provided by the INECC team as a result of a workshop comparing the INECC baselines to the SENER prospective.
[4] In a workshop with INECC, it was decided that projections should be calibrated to 2008 data, as the 2009 base year was an outlying year.

Future generation was calculated by simulating future available capacity for each process and the dispatch of processes along a system load curve. Baseline capacity expansion plans were available from SENER's annual "Prospectiva" projections until 2026, and SEI assumed that any additional capacity beyond this would be met with new natural gas generation. Processes were dispatched along a load duration curve provided by the MEDEC analysis (Alatorre et al., 2009) by merit order (i.e. or specifying which plants will meet peak and base loads). Performance parameters such as process availability and thermal efficiency were assumed by SEI. For more information on specific assumptions, please see Appendix One.

Emissions in the electricity generation sector were calculated using the formula below.

Emissions = Electricity Generation by Process * (1/Thermal Efficiency) * Emission Factor
= [GWh]*[GJ Input Fuel/GWh Electricity]*[tCO_2e/GJ]

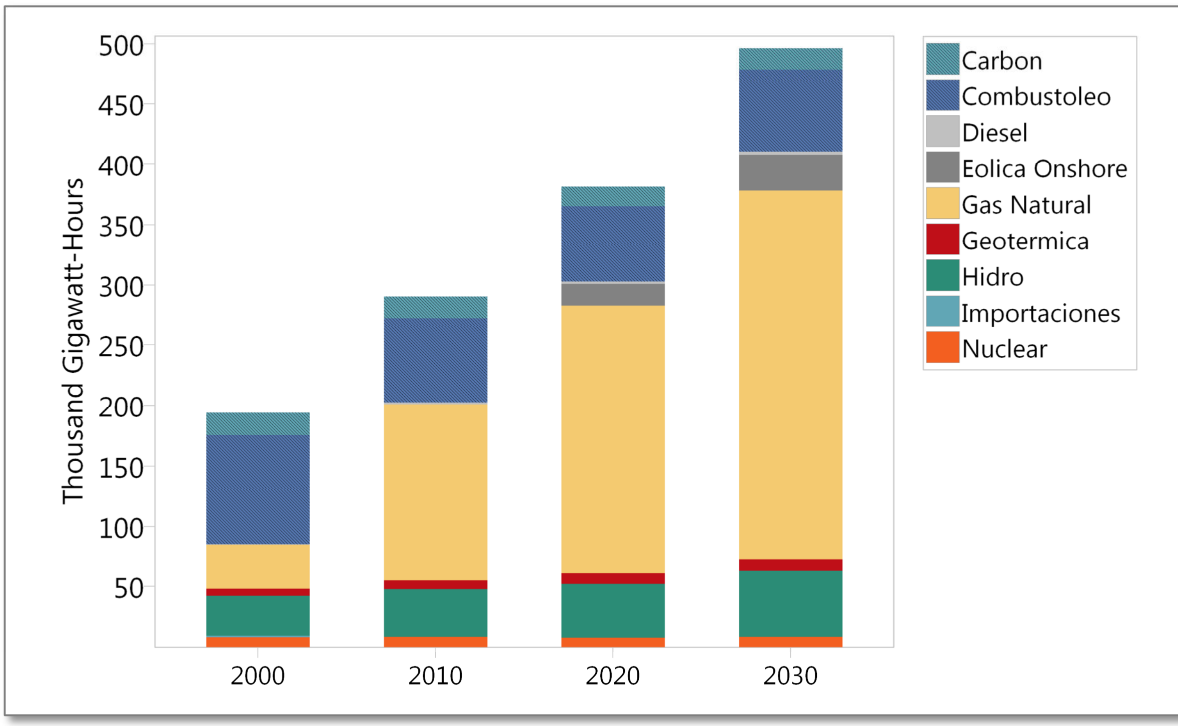

Figure 7: Total Electricity Generation in the BAU Scenario by Power Plant Process

Figure 7 shows that natural gas, residual fuel oil and hydroelectric power plants dominated the modeled electric generation mix, and a small amount of wind, coal and nuclear power plants make up the rest.

Forestry

Historical forestry emissions were available from the INEGEI. Future forestry emissions were calculated using the following formula:

Emissions = Carbon Stock * Total Forested Area * Deforestation Rate
= [CO_2/Ha]*[Ha]*[% deforested]

A constant deforestation rate of 0.4% was used based on estimates from the National Committee on Forestry (CONAFOR).

Waste

The waste sector in this model included four subcategories: solid waste, wastewater (industrial and municipal), incineration of waste, and human waste. The historical emissions in the first three categories were based on INEGEI data; projections were based on simple growth rates from McKinsey (2009). Human waste estimations in all years were calculated based on the McKinsey methodology from the 2009 McKinsey analysis.

Emissions = Population * Annual Per Capita Protein Consumption* Fraction of Nitrogen in Protein * Emission Factor

= [Persons]*[kg protein/person]*[kg N/kg protein]*[kg N_2O/kg N]

More detailed assumptions are available in Appendix One.

Step 6: Identify and Screen Mitigation Options

The INECC 2013 analysis included 51 mitigation options, the result of selection and screening by SEI and UNAM.

SEI and UNAM reviewed the portfolio of mitigation options from the McKinsey 2009 study, and included 46 options that were able to be replicated using the baseline structure defined in step five. Included mitigation options were consistent with the baseline and had documented assumptions about how they would affect energy demands, energy efficiencies or activity levels.

Five additional options were added after a review by UNAM of the other recent mitigation studies completed in Mexico. These options were selected because they were not already included in the initial list from the McKinsey study and because they had sufficient documentation to be incorporated within the context of the other mitigation options.

Step 7: Develop Mitigation Scenarios

In the final step, SEI built mitigation scenarios into LEAP that reflect a future where explicit policies and measures are adopted to reduce greenhouse gases. Each of the 51 mitigation options was modeled independently and then all options were grouped together as one integrated mitigation scenario.

Results

Though we expect that this model will be further improved with additional input from INECC and local experts, the current results show that significant potential exists for reducing GHG emissions and mitigating climate change across energy and non-energy sectors in Mexico. The total mitigation potential of the combined measures comes to 180 MtCO2e in 2020 and 449 MtCO2e in 2030, amounting to 19% and 38% reductions compared to the baseline, respectively. All mitigation options were compared to the middle baseline, BAU, scenario.

High-level results are reported in this section. For detailed information on the assumptions in each of the 51 mitigations options, please see Appendix Two.

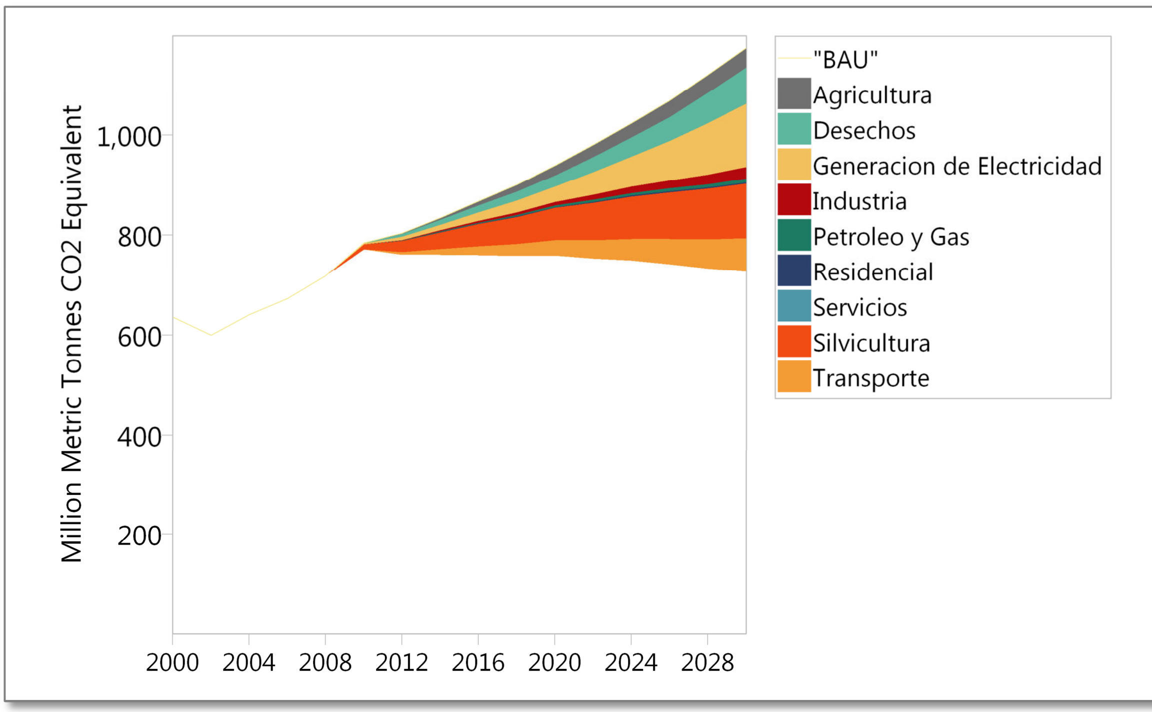

Figure 8: Mitigation Potential By Sector in the INECC 2013 integrated analysis compared to the BAU

Table 1: Reductions of GHG Emissions of the integrated INECC 2013 baseline in key study years by sector

	2009	2018	2020	2025	2030
"BAU"	**704.46**	**901.17**	**939.32**	**1047.45**	**1175.46**
Agriculture	0	13.78	19.51	31.45	39.41
Waste	0	18.25	22.47	42.08	72.79
Electricity Generation	0	23.7	30.82	67.61	126.92
Industry	0	5.45	7.44	14.48	22.88
Oil and Gas	0	2.51	3.24	5.25	7.57
Residential	0	0.91	1.18	1.94	2.82
Services[5]	0	0	0	0	0
Forestry	0	54.53	64.77	89.74	109.47
Transport	0	23.77	30.59	47.25	66.72
Total (Integrated)		**142.90**	**180.02**	**299.80**	**448.58**

Table 2: Reductions of GHG Emissions of INECC 2013 baseline in 2030 by individual measure

Sector	Mitigation Measure	GHG Emission Reductions in 2030 [$MtCO_2e$]
Agriculture	Tillage and residue management practices	3.41
	Agronomy practices	5.37
	Cropland nutrient management	4.90
	Rice management - Shallow flooding	0.17
	Rice management - nutrient management	0.05
	Grassland management	14.21
	Grassland nutrient management	0.70
	Degraded land restoration	1.17
	Livestock - Feed Supplements	2.78
	Livestock - Antimethanogen vaccine	6.65
Waste	Landfill gas flaring	6.50
	Landfill gas direct use	18.70
	Recycling new waste	31.47
	Composting new waste	6.80
	Wastewater treatment	9.33

[5] Any emissions reductions due to reduced electricity consumption (in this model, seen mainly in the commercial, residential and industrial sectors) are accounted for in the electricity generation module, where emissions occur.

Electricity Generation	A future electric grid that includes: Coal with CCS, Gas with CCS, Biomass co-firing, Biomass with CCS, On shore wind, Off shore wind, Solar PV, Concentrated solar, geothermal, Small hydro, Oil to gas shift, Coal to gas shift	87.00
	Smart grid	9.87
Industry	Efficiency in iron and steel industry	5.56
	Alternative fuels in cement industry	8.90
	Shifting to more natural gas use in the chemicals industry	0.24
	Cogeneration	28.79
	Increased charcoal use in iron and steel	7.27
Oil and Gas	Natural gas usage planning	7.57
Residential	Lighting - switches to CFLs and LEDs	7.60
	Efficiency in HVAC	2.95
	Efficient appliances	4.74
	Efficient consumer electronics	0.81
	Solar hot water heaters	3.26
	Efficient new stoves	0.52
Services	Lighting - switches to CFLs and LEDs	5.26
	Controls in lighting	7.74
	Efficiency in HVAC	1.97
	Efficient appliances	0.21
	Efficient office electronics	0.85
	Solar hot water heaters	1.90
Forestry	Reduced deforestation from slash & burn agriculture Conversion	16.95
	Reduced deforestation from pastureland conversion	21.65
	Reduced intensive agriculture conversion	29.52
	Pastureland afforestation	7.96
	Cropland afforestation	0.67
	Reforestation of degraded forests	14.55
	Degraded Forest Reforestation	4.38
	New Plantations	13.80
Transport	Sugarcane biofuels	5.10
	Switchgrass biofuels	7.47
	HDV Efficiency	4.95
	LDV Efficiency	1.99
	Metro and Bus	16.00
	Urban densification	13.04

	Bicycles	7.78
	Increased train freight	17.88
Total (independent)		**488.91**[6]

Agriculture

The agriculture sector included emissions from both energy and non-energy sources, but only non-energy mitigation measures were included in the INECC 2013 analysis. Baseline emissions in the agriculture sector were dominated by non-energy emissions from enteric fermentation, manure management and agricultural soils. The largest mitigation impacts in this sector were grassland management, livestock antimethnanogen vaccine and agronomy practices.

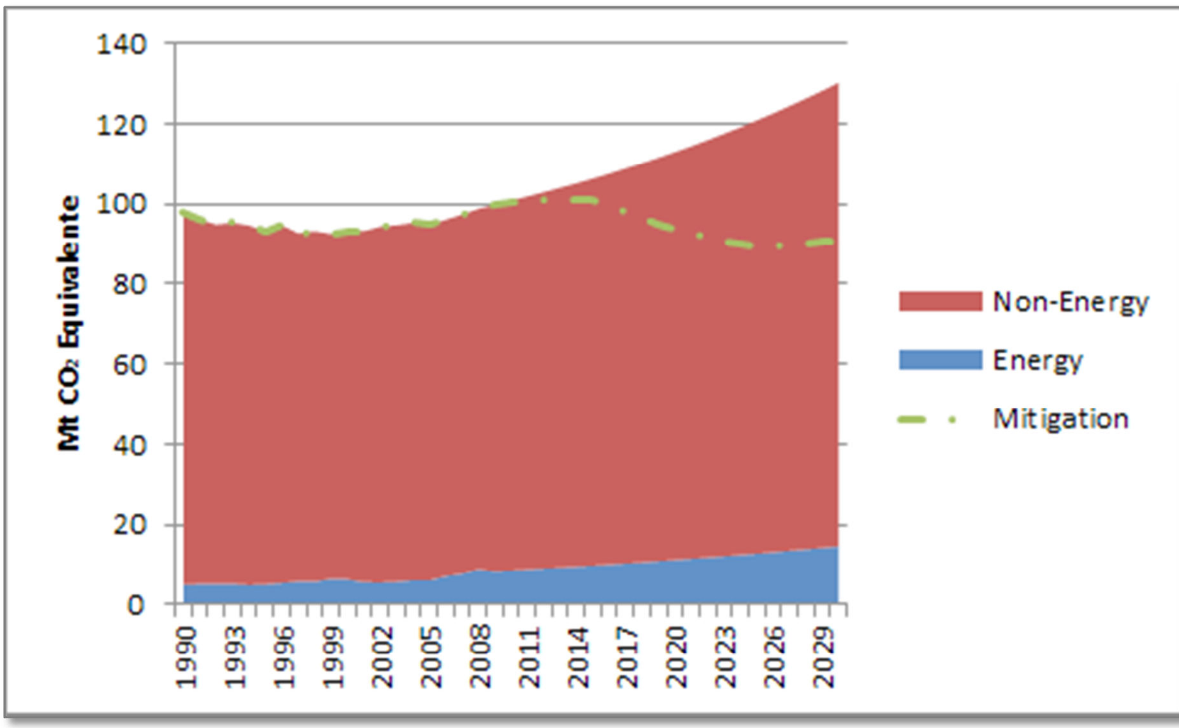

Figure 9: Total GHG Emissions in the Agriculture Sector in the BAU and Mitigation Scenarios

Electricity Generation

The baseline scenario represented a potential future where natural gas meets 34% of generation requirements and renewables meet about 20% of generation in 2030. New processes in the mitigation scenario included biomass (co-fired and with CCS), coal with CCS, offshore wind, natural gas with CCS, geothermal, small hydro installations, solar PV and concentrated solar generation.

[6] The total of Table 2 is not equal to that of Table 1 because the integrated model takes into account synergies and double counting between measures. The integrated results were lower than the independent results because of this.

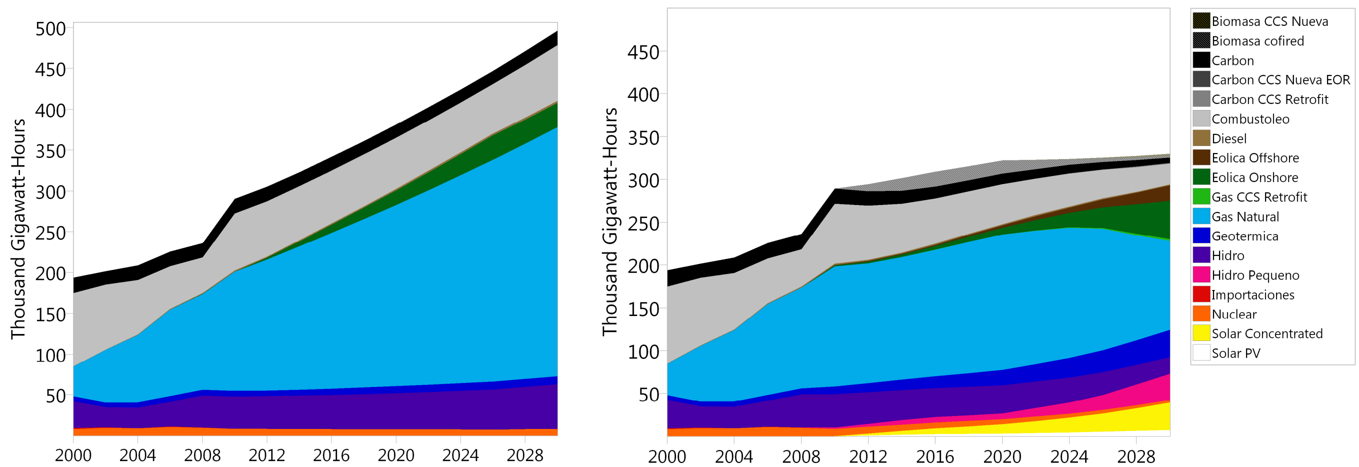

Figure 10: Total Electricity Generation in the BAU (left) and Mitigation (right) scenarios by Process

Two mitigation scenarios were evaluated in the electricity generation sector, one that looked at partial potential for renewables (increased small hydro, concentrated solar, onshore wind and natural gas and decreased residual fuel oil), and another which looked at the maximum potential for renewables as assumed by McKinsey (2009). The total reduction in electricity generation was due to reduced demands defined by the residential, commercial and industrial sector mitigation options. In the integrated scenario results, the overall emissions reductions took into account both reduced requirements for electricity generation (as defined by demand sector assumptions) and power plant technology changes.

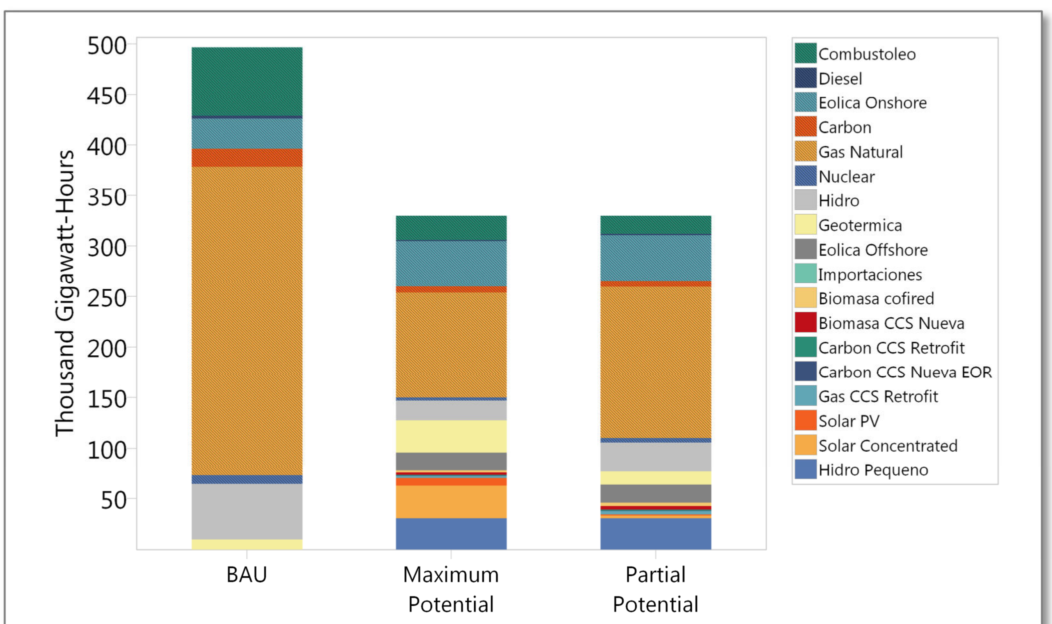

Figure 11: Total Electricity Generation in 2030 in the BAU compared with the Mitigation scenario for Partial and Maximum Potential for Renewables

Figure 12 highlights the avoided emissions in the mitigation scenario associated with renewables and non-fossil fuels producing 58% of electricity generation, well above the 35% target set by LAERFTE (Secretaría General, 2013).

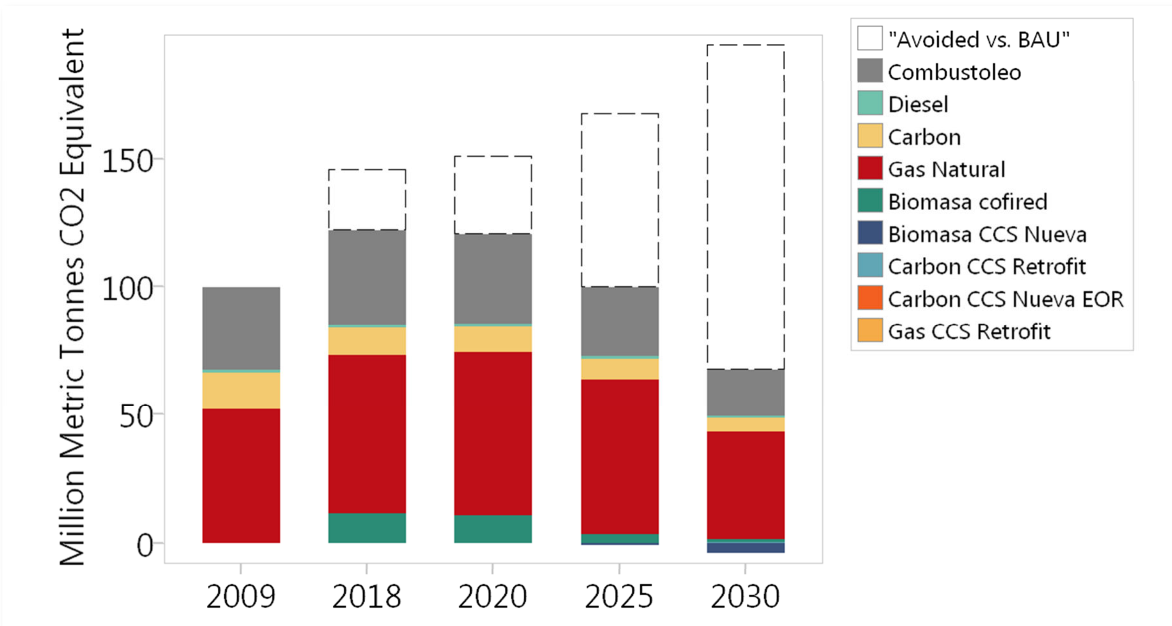

Figure 12: Total GHG Emissions Avoided from Electricity Generation in the Maximum Potential Scenario

Industry

Industrial baseline emissions were divided between direct combustion of fuels by sub sector and emissions from industrial processes.

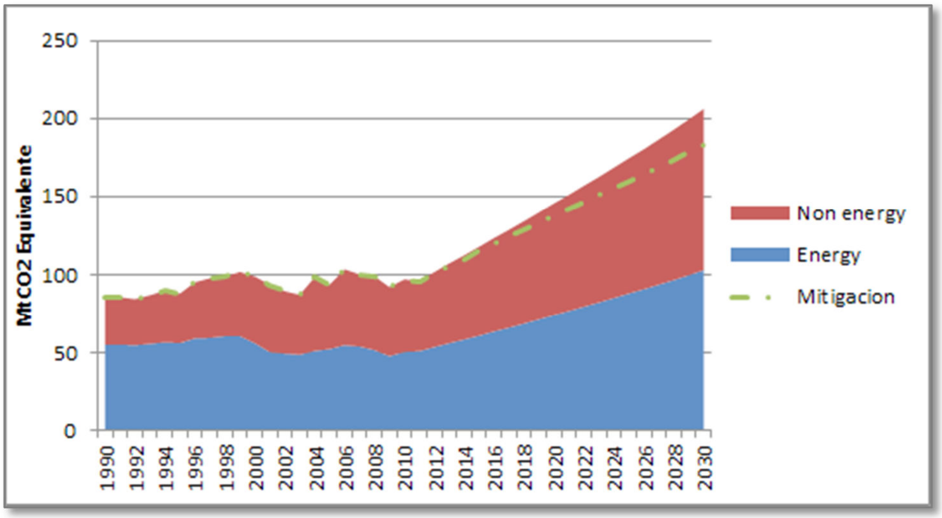

Figure 13: Total GHG Emissions in the BAU Scenario in the Industry Sector and Mitigation Potential

Primary mitigation measures were all related to energy consumption: energy efficiency in iron and steel, the use of waste as a fuel in the cement industry, increased use of charcoal chemicals and cogeneration as expected by PRONASE. As can be seen in Figure 14, the mitigation scenario incorporated small amounts of waste fuels and charcoal.

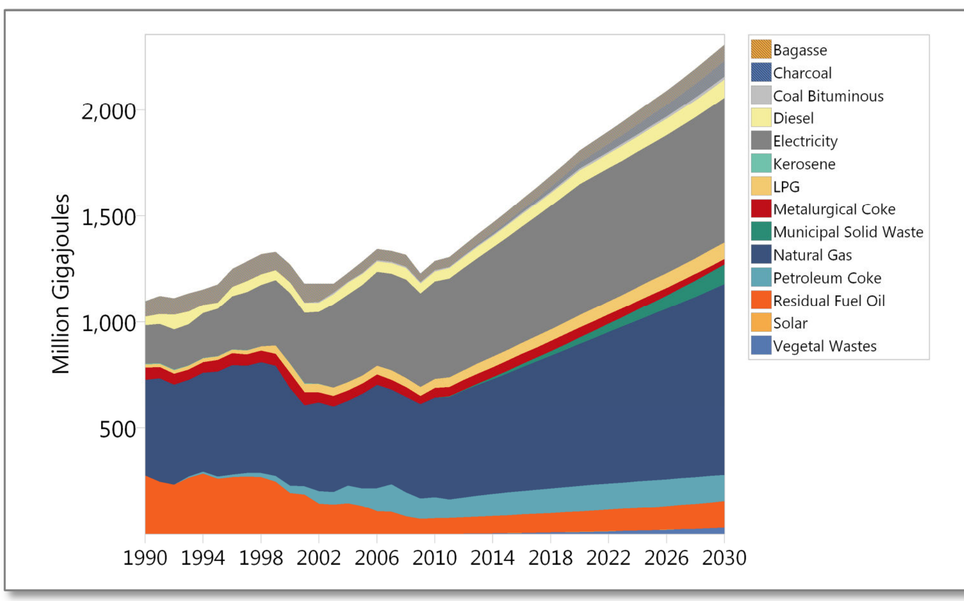

Figure 14: Energy Demand from all Industrial Subsectors by Fuel in the Mitigation scenario

Oil and Gas

GHG emissions from oil and gas activities included direct consumption of fuels, dominated by natural gas, and fugitive emissions. Due to a lack of available data, only one mitigation option was modeled – Improved planning for natural gas consumption.

Residential

The residential sector made use of a disaggregated data structure to easily represent technological changes in mitigation options. The mitigation actions with the largest measured impact were lighting technology shifts, solar hot water heaters and efficient appliances.

Many residential measures reduce consumption of electricity, which does not directly affect emissions within households. These emissions reductions would be seen at the power plant, which means that the reductions were accounted for in the electricity generation sector in the integrated model results.

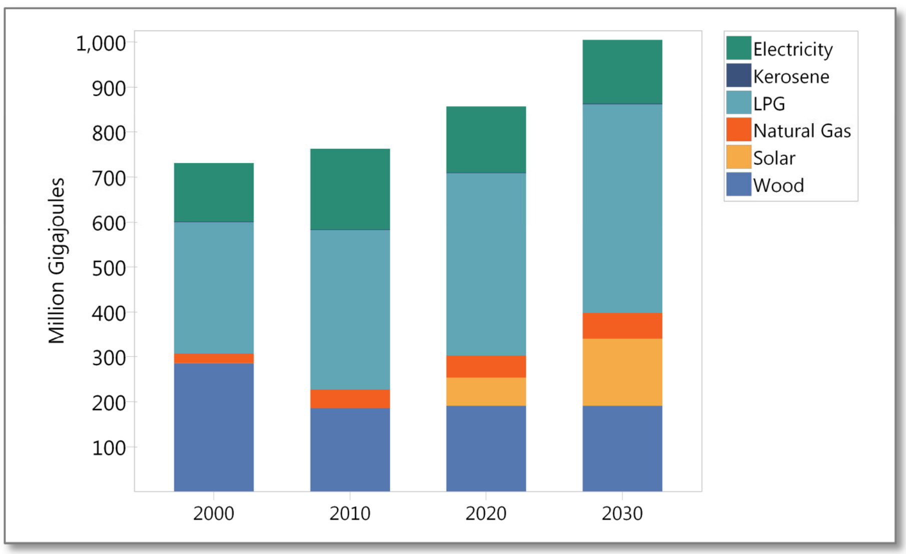

Figure 15: Energy consumption in households in the Mitigation scenario

Services

The commercial baseline is dominated by electric and LPG energy consumption. All mitigation measures within commercial buildings focus on reducing electricity consumption. We should note that because LEAP is an integrated model, all emissions benefits from the commercial measures were attributed to electricity generation (as reduced requirement for electricity) because no direct emissions occur at the end use.

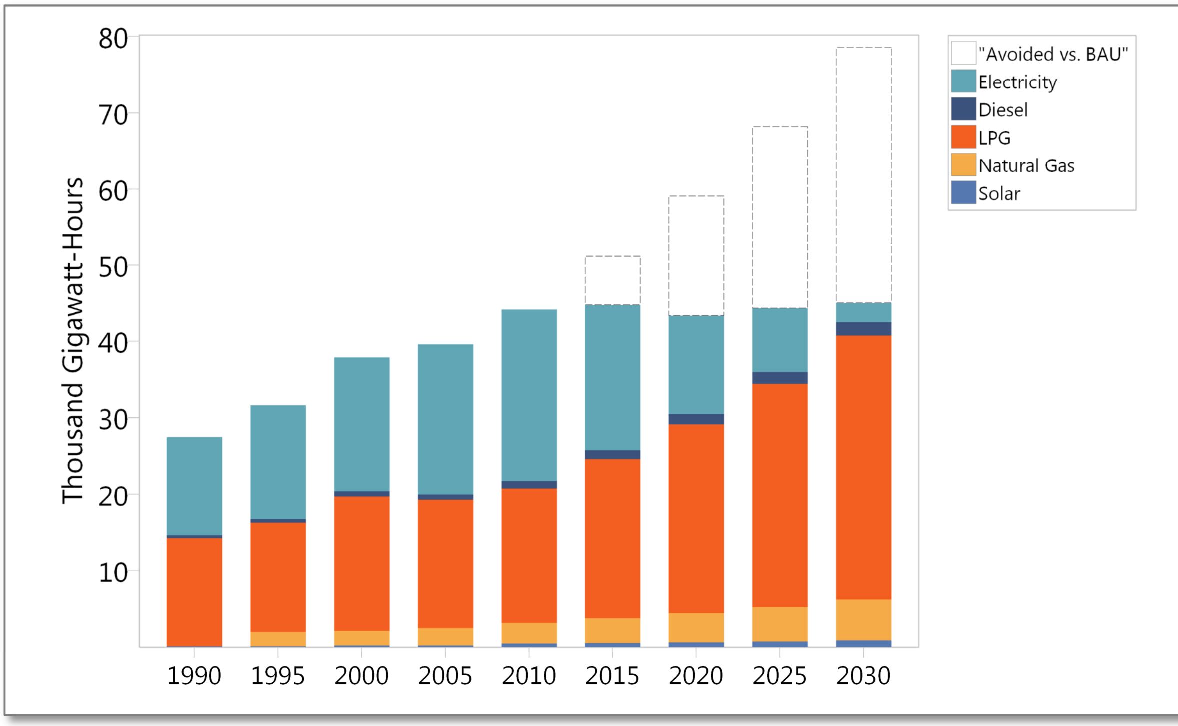

Figure 16: Avoided Electricity Consumption in the Services Sector in the Mitigation Scenario Compared to the Baseline

Transport

Emissions in the transport sector were divided into road, air, rail, maritime and metro.

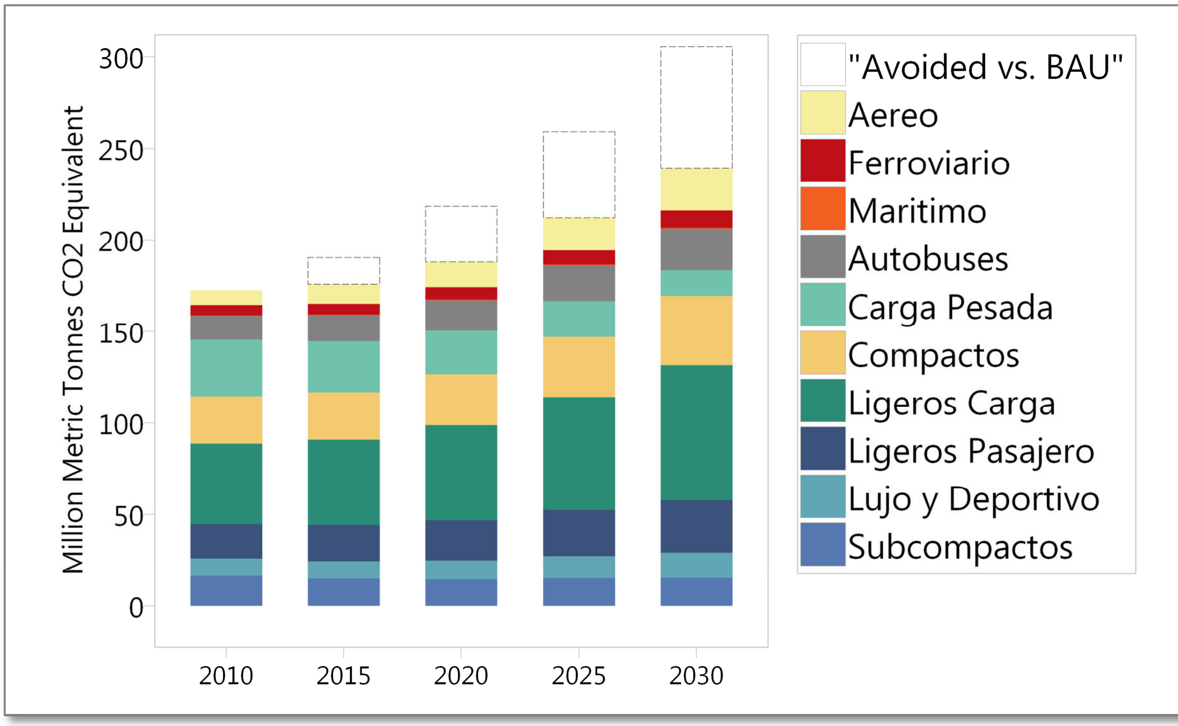

Figure 17: Total Avoided GHG Emissions from Mitigation Measures in the Transport Sector

The calculations for the portfolio of mitigation options resulted in rail freight, urban densification and the incorporation of biofuels use as the most important to overall GHG reductions.

Waste

Greenhouse gas emissions from the waste sector were dominated by wastewater and solid waste. Mitigation measures in this sector focus on recycling, composting and management of landfill gas.

Conclusions and Recommendations

Conclusions

This study focused on creating an emissions baseline and mitigation scenarios over the timeframe of 2009 to 2030 that would better meet the needs of INECC staff. SEI and UNAM developed three baseline scenarios to show the variability of GHG emissions to different GDP growth rates. We then developed a mitigation scenario consisting of 51 measures across all sectors.

This study shows that significant potential exists for reducing GHG emissions and mitigating climate change across energy and non-energy sectors in Mexico. The total mitigation potential of the combined measures was calculated to be 180 MtCO2e in 2020 and 450 MtCO2e in 2030, equating to 19% and 38% reductions compared to the baseline, respectively. Close to 30% of modeled emissions reductions are due to reduced electricity generation based on policies in the residential, commercial, industrial and power sectors.

President Felipe Calderón set the target of 30% emissions reductions by 2020 at COP 15 in Copenhagen, Denmark. The assumptions in the INECC 2013 analysis do not reach this goal. Further investigation will be needed by INECC to evaluate if current proposed mitigation options can have higher penetrations, or if new mitigation options should be evaluated to meet the target.

The Mexican Law for Renewable Energy and Funding of the Energy Transition (LAERFTE), written in 2008 and last updated in April 2013, set a target of reducing fossil generation to 65% by 2030, or 35% non-fossil generation (Secretaría General, 2013). The modeled mitigation scenario finds a potential of 58% generation by non-fossil fuels by 2030, far exceeding the law's goal. This analysis resulted in a high *potential* for renewable generation, but a crucial next step will be to evaluate the economic and political feasibility of reaching these goals.

INECC is now in possession of a well-documented model in LEAP that can and should be updated and maintained by staff. As new data is released, as new policies are signed, as new questions need to be explored, INECC can modify this LEAP model to continuously improve emissions projections in Mexico.

Recommendations

Costing Assumptions

The most important recommendation is to add estimates of cost and build in cost-benefit analysis in LEAP. This was originally a part of the scope of this Project, but modified expectations leave this task to the next stage of the model.

Meetings with Local Experts

As mentioned throughout this report, many assumptions have been made in the mitigation portfolio that were based on expert opinion or international reports. A recommended improvement would be to interview local experts to vet and improve technology performance and penetration assumptions in mitigation scenarios within each sector.

Short-Lived Climate Pollutants

We had discussed the potential inclusion of short-lived climate pollutants (SLCPs) in this LEAP model. Three SLFPs are commonly referenced: methane, tropospheric ozone and black carbon. These SLCPs have short lifetimes (compared with other pollutants) and impact human health, crops, ecosystems and global temperature.[7]

Though the inclusion of SLCPs was outside the scope of this particular project, SEI has concurrent projects that are working to add SLCF capabilities to LEAP. SEI is also pursuing other funds through collaboration with the Clean Air Climate Coalition (CACC) to develop national action plans related to SLCPs. We hope that these improvements and developments will make it easy to add data on SLCPs to the Mexico model in the future.

Co-benefits

We discussed the interest of INE to include an analysis of co-benefits such as health benefits, jobs, and externalities. Though these co-benefits are very important in understanding the potential impact of mitigation options, the quantification of them is beyond the scope of this project. We would be happy to help INE engage with stakeholders about the qualitative impacts of key mitigation options.

Scenario Analysis by State

LEAP includes the functionality to include regions as a part of a scenario analysis. SENER reports most energy data by Mexican State, and it would be interesting to make use of that by creating a regional energy model in LEAP. However, it may be more difficult to acquire non-energy data by state.

[7] To learn more about SLCFs, please see this UNEP synthesis report: http://www.unep.org/publications/ebooks/SLCF/

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Appendix One: Baseline Assumptions

Included in this appendix is a detailed explanation of the structure and assumptions behind the final version of the MLED data set output from the 2012-2013 MLED project. This data set was developed by SEI with significant input from INECC, WWF and UNAM teams.

Where possible, source files referenced in this document have been provided separately in an external Dropbox folder.

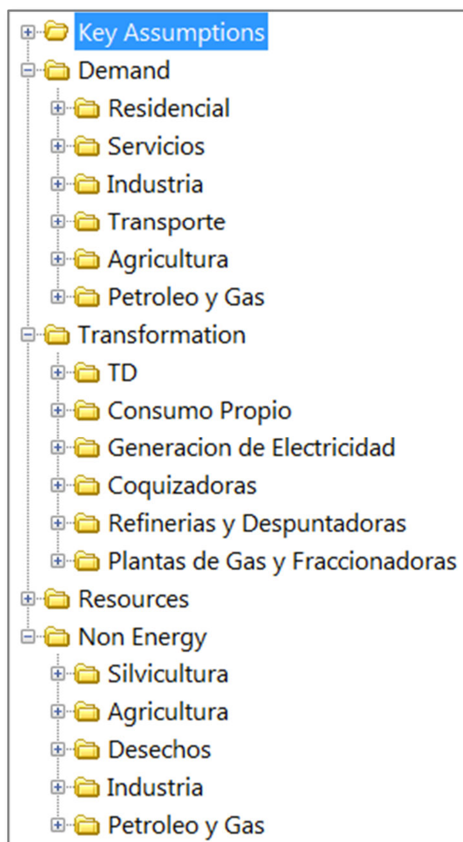
Data Set Summary

This data set includes a comprehensive picture of historical emissions in Mexico (energy demand, energy supply and non-energy) from 1990 to 2009 based mainly on the in-country data but supplementing with assumptions form the INECC team and SEI as needed. The energy data includes information on energy use by fuel in each major demand sector (households, commercial buildings and services, industry, transport, agriculture and demands in the oil and gas sector). On the supply side the data sets include information on transmission and distribution losses in addition to electricity production, oil refineries, and natural gas and coking plants. Non-energy emissions sources have also been accounted for in the forestry, agriculture, waste, industry and oil and gas sectors.

The data set also includes three baseline scenarios, each telling a story of how the Mexican energy system could develop over the time period of 2010 to 2030. Please note that the three baseline scenarios are identical except for their assumption about GDP projections. For all other variables documented below, assumptions for the 'Baseline" refer to all baseline scenarios.

The philosophy of this model was to create a relatively simple model that could easily be maintained, updated and improved as new data and official methodologies become available. We focused on using official Mexican data sources wherever possible, supplementing with assumptions from INECC staff and the SEI team as needed. We see this as a solid foundation to build on as a model for Mexico and hope this becomes a living model, being updated frequently.

This document is structured like the data set tree. For a high level look at the LEAP tree structure, please see a graphic of the tree on the right. Please note that the model itself was created in Spanish.



Key Assumptions

Key assumptions are independent variables used throughout the LEAP model. They are referenced separately from demand, transformation and non-energy branches.

Macroeconomic Variables

GDP ("PIB" in Spanish)

Current Accounts: Historical GDP data (in units of constant 2003 Mexican Pesos) was taken from the BIE (Banco de Información Económica) for 1993-2009.[8]

Baseline Scenario: GDP projections for years 2010 through 2030 were assumed based on an analysis of official data sources from the group of Iván Islas of INECC. This is documented in the file "PIB_escenarios_INE.xlsx"

Scenario	GDP growth rate from 2010-2030
BAU	3.2%
BAU Alta	4.2%
BAU Baja	2.2%

How it is used: This data is used in conjunction with additional variables to calculate an activity level for the Services, Industry, Transport and Agriculture sectors.

Income ("Ingresos")

All scenarios: Income is calculated as GDP/Number of Households to arrive at the pesos/household income.

LEAP Equation: PIB/Hogares[9]

How is it used: This variable is not used in the current analysis.

GDP per capita ("PIB per capita")

All scenarios: GDP per capita is calculated as GDP/Total population to arrive at the pesos/person.

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8 http://www.inegi.org.mx/sistemas/bie/ To replicate, go to Indicadores economicos de coyuntura/Producto Interno bruto trimestral, base 2003/ Series originales/ A precios de 2003/Valores absolutos and select PIB, actividades primarias, segundarias y tercerias. Exact LEAP inputs documented in file "PIB insumos a LEAP – BIE.xls."

9 Note: Both "PIB" and "Hogares" have variable aliases, which means that the full path of the variable referenced is hidden. To identify the exact location of each of these variables, please see the Analysis: Variable Aliases menu for a full list.

LEAP Equation: PIB/Poblacion

How is it used: This variable is not used in the current analysis.

Sectoral GDP Value Added ("Participación Sectorial del PIB")

Current Accounts: Historical sectoral GDP value added data (in units of % of total GDP) were taken from the BIE (Banco de Información Económica) for 1993-2009 for Primary, Secondary and Tertiary activities.[10] These three sectors did not sum to the total GDP reported by BIE, so the participation of public services to total GDP was assumed by SEI to be equal to the remainder.

Baseline: Projections from 2010-2030 were projected based on the calculated historical growth rate between 1993-2009 (all historical years available from BIE).

LEAP Equation: HistoricalGrowth(1993,2009))

Sector	Value added – Value in 2009	Value Added – Growth Rate from 2010-2030
Primary Activities (incl. Agriculture)	3.5%	0.2%
Secondary Activities (Commerce)	30.1%	-0.2%
Tertiary Activities (Industry)	64.4%	-0.5%
Public Services	1.9%	-2.4%

How it is used: This data is used in conjunction with Total GDP data to calculate an activity level for the Services (Commercial and Public), Industry, and Agriculture sectors.

Industrial GDP Value Added

Current Accounts: Historical years of GDP by sub sector were only available from the Banco de Información Económica (BIE) from 2007-2009. The BIE value added data is categorized differently than the National Energy Balances, so SEI created assumptions for how to map SENER to BIE Industry Categories (see table below).[11]

[10] http://www.inegi.org.mx/sistemas/bie/ To replicate, go to Indicadores economicos de coyuntura/Producto Interno bruto trimestral, base 2003/ Series originales/ A precios de 2003/Valores absolutos and select PIB, actividades primarias, segundarias y tercerias. Exact LEAP inputs documented in file "PIB insumos a LEAP – BIE.xls."

[11] All sectoral and industrial sector GDP data processing is documented in the file "PIB insumos historicos para LEAP – BIE.xls"

SENER National Energy Balances	**How to Map to BIE Categories**	
	Sector Code	Sector
Siderurgia	3311	331 Industrias metálicas básicas/3311 Industria básica del hierro y del acero
Cemento	3273	327 Fabricación de productos a base de minerales no metálicos > 3273 Fabricación de cemento y productos de concreto
Pemex Petro	324	324 Fabricación de productos derivados del petróleo y del carbón
Azúcar	311311	311 Industria alimentaria > 3113 Elaboración de azúcares, chocolates, dulces y similares 311311 Elaboración de azúcar de caña
Química	325	325 Industria química
Minería	Minería	Minería
Vídrio	3272	327 Fabricación de productos a base de minerales no metálicos > 3272 Fabricación de vidrio y productos de vidrio
Celulosa y Papel	322	322 Industria del papel
Cerveza y Malta	312120 + 311215	312 Industria de las bebidas y del tabaco > 3121 Industria de las bebidas 312120 Elaboración de cerveza AND 311 Industria alimentaria > 3112 Molienda de granos y de semillas y obtención de aceites y grasas 311215 Elaboración de malta
Aguas envasadas	312112	312 Industria de las bebidas y del tabaco > 3121 Industria de las bebidas 312112 Purificación y embotellado de agua
Construcción	Construccion	Construccion
Automotríz	336	336 Fabricación de equipo de transporte
Hule	3262	326 Industria del plástico y del hule > 3262 Fabricación de productos de hule
Aluminio	3313	331 Industrias metálicas básicas > 3313 Industria básica del aluminio Total de rama 3313
Fertilizantes	3253	325 Industria química > 3253 Fabricación de fertilizantes, pesticidas y otros agroquímicos
Tabaco	3122	312 Industria de las bebidas y del tabaco > 3122 Industria del tabaco
Otras	None	Calculation of remainder of Industrial GDP

Baseline: This variable is not used in this analysis because no official projections were found.

How it is used: This data is used in conjunction with Total GDP and secondary GDP data to calculate an activity level for the Industrial sub sectors.

Canacem Baseline GDP Assumption ("Cemento PIB Supuesto")

Current Accounts: For historical years we simply used total Industrial GDP.

Baseline: Canacem assumed a 2% average growth rate for GDP related to the sector.[12]

Equation: Growth(2%)

How it is used: This data is used to calibrate the production data from Canacem's baseline to be used with the consistent model assumptions for GDP growth. It is referenced in the Activity Level variable in the Cement sector.

Canacero Baseline GDP Assumption ("Siderurgia PIB Supuesto")

Current Accounts: For historical years we simply used total Industrial GDP.

Baseline: Canacero assumed a variable growth rate that varied from 5.4% to 3.4% over the period of 2010-2030.[13]

Equation: Growth(5.4%, 2011, 4.3%, 2012, 2.5%, 2013, 3.6%, 2014, 4.6%, 2015, 3.9%, 2027, 3.4%)

How it is used: This data is used to calibrate the production data from Canacero's baseline to be used with the consistent model assumptions for GDP growth. It is referenced in the Activity Level variable in the Iron and Steel sector.

Demographic Variables

Households ("Hogares")

Current Accounts: Historical households data comes from INEGI censuses. Data exists from 2000-2010 in 2 year increments. SEI assumes a linear trend between each data point.[14]

[12] This assumption was taken from the Canacem document "LB Canacem 23Nov11.doc"
[13] This assumption was taken from Canacero document "Línea Base Sector Acero Nov-2011.pptx," slide 15.
[14] Documented in file "INEGI Historical population data.xlsx"

Baseline: CONAPO has population and household projections until 2030. SEI calculated an average annual growth rate of 1.7% from their projections for the years 2010-2030 and used these projections in LEAP.[15]

Equation: Growth(1.7%)

How it is used: The households variable is used as the activity level within the residential sector.

Population ("Poblacion")

Current Accounts: Historical population data comes from INEGI censuses. Data exists from 2000-2010 in 2 year increments. SEI assumes a linear trend between each data point.[16]

Baseline: CONAPO has population and household projections until 2030. SEI calculated an average annual growth rate of 0.57% from their projections for the years 2010-2030 and used these projections.[17]

Equation: Growth(0.57%)

How it is used: Population data is used to calculate emissions per capita and various projections within the waste sector.

Residential Variables

Residential Calibration Factors

Current Accounts: The calibration factor is not used in historical years.

Baseline: The residential sector includes a bottom up model that calculates the total energy consumed in 8 types of end uses. To be able to use this data consistently with the historical data in LEAP from the SENER National Energy Balances, it is necessary to calibrate the historical data SENER to the SEI and INECC bottom up residential model. SEI calculated the calibration factor necessary to have continuous projections of energy consumption within the residential sector.

Electricity Calibration Factor	1.15
Other Fuels Calibration Factor	1.1

How it is used: These calibration factors are used to calculate projections for final energy intensities in the residential sector.

[15] Calculations and raw data documented in file "CONAPO hogares projections.xls"
[16] Documented in file "INEGI Historical population data.xlsx"
[17] Calculations and raw data documented in file "CONAPO population projections.xls"

Transport Variables

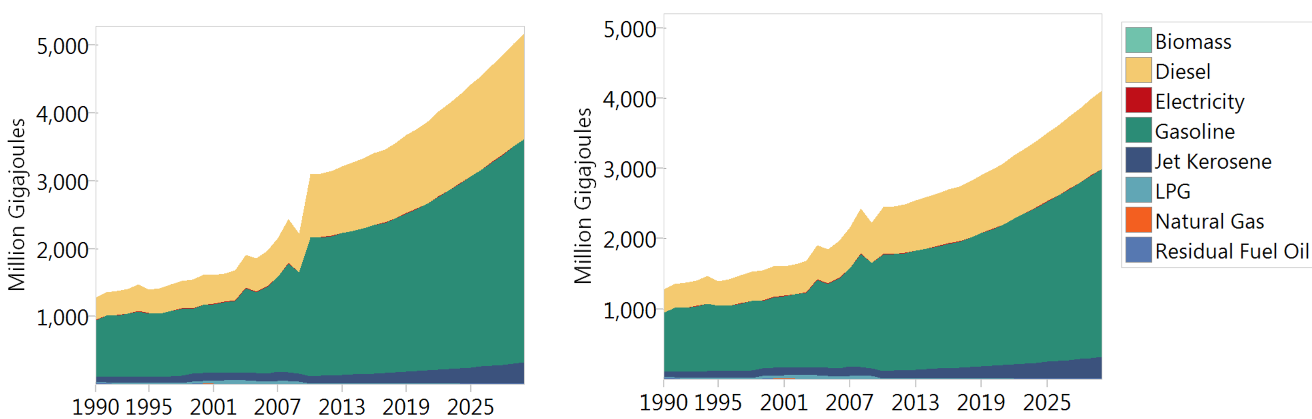
Transport Calibration Factors

Current Accounts: The calibration factor is not used in historical years.

Baseline: The CTS transport model is a bottom up model that calculates the total energy consumed by 7 different modes of transport. To be able to use this data consistently with the historical data in LEAP from the SENER National Energy Balances, it is necessary to calibrate the two data sources. SEI calculated the calibration factor necessary to have continuous projections of gasoline and diesel consumption within road transport. In the February 2013 training INECC staff agreed that we should calibrate to the year 2008 rather than 2009 because of the economic downturn.

Gasoline Calibration Factor	0.81
Diesel Calibration Factor	0.70

Before Calibration **After Calibration**



How it is used: These calibration factors are used to calculate projections for final energy intensities in the road transport sectors.

Agriculture Variables

Group 1 Growth

All Scenarios: The variable growth rate was calculated by the INE-McKinsey team in 2009 based on animal populations. It varies between about 0.8% and 0.9% annual growth.

How it is used: This variable is used to project the Enteric Fermentation and Manure Management emissions in the agricultural non-energy sector.

Group 2 Growth

All Scenarios: The variable growth rate was calculated by the INE-McKinsey team in 2009 based on agricultural soils. It varies between about 0.8% and 1.9% annual growth.

How it is used: This variable is used to project the Rice Cultivation, Agricultural Soils, Planned burning of soils, and Field Burnings of Agricultural Residues emissions in the agricultural non-energy sector.

More information is available in the documentation of the non-energy Agriculture sector.[18]

Waste Variables

All variables documented in the waste category of key assumptions for solid waste and wastewater are not currently used in the analysis as they were taken from the 2009 INE-McKinsey analysis and are no longer consistent with the recent 2010 update of the INEGEI. We hope that the INECC team can work with sectoral experts to improve on the assumptions and methodology to be consistent with the new INEGEI data.[19] The data structure has been left in LEAP to facilitate this update.

Assumptions for human waste are documented in the non-energy section.

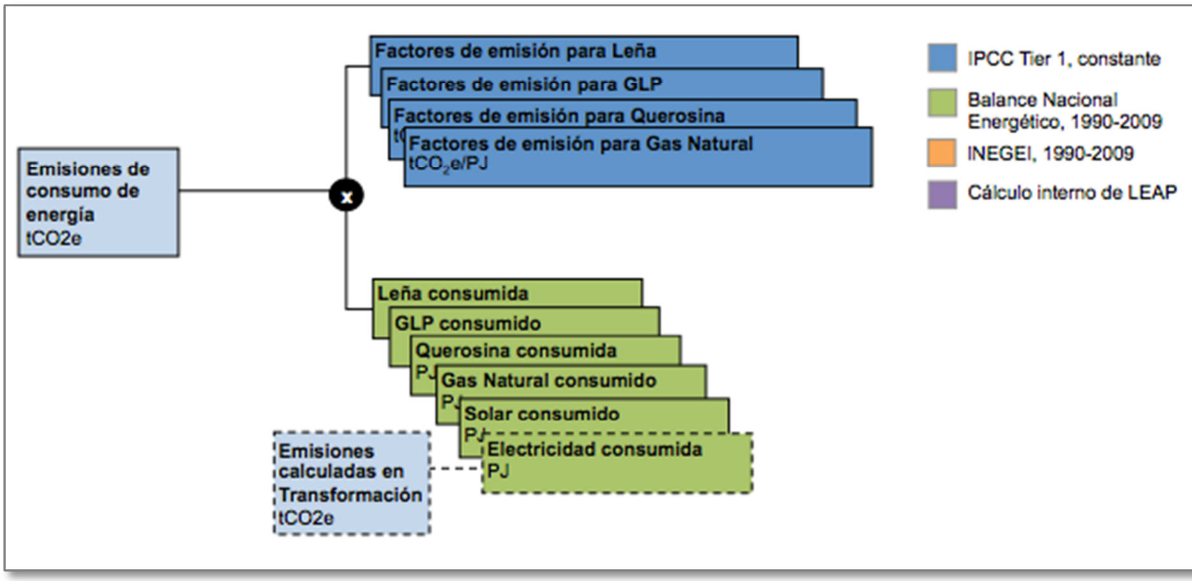
[18] Further documentation of the initial calculations from INE-McKinsey is available in the file "SEI_LineaBase_DesechosAgrForest.xlsx"
[19] The 2009 INE-McKinsey assumptions for the waste sector are documented in the "Desechos" tab of the file "SEI_LineaBase_DesechosAgrForest.xlsx"

Residential ("Residencial")

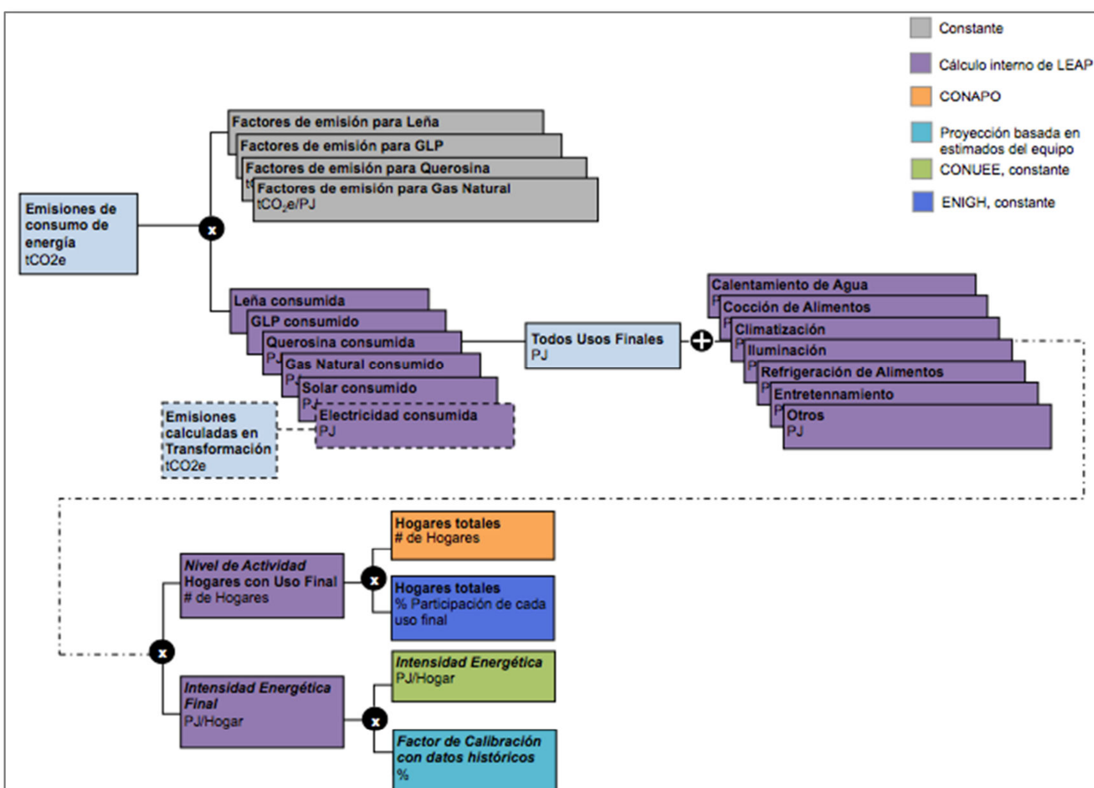
The Residential sector modeled in LEAP uses a top-down methodology for historical years and a bottom-up or end use methodology in future years. The bottom-up methodology was chosen to facilitate transparency within the model and to make it easier to create mitigation scenarios.

Calculation Diagram

Historical Years (1990-2009):



Baseline Years (2010-2030):



Activity Level

Current Accounts: Number of Households (See documentation of households).[20]

Baseline: Total number of Households and percent saturation of households that have various technologies. Included technologies are water heating, cooking, air conditioning, lighting, refrigeration, entertainment and other. The main source of these saturations is ENIGH 2010, supplemented with assumptions from SEI and Rigoberto Garcia.[21]

Total Energy

Current Accounts: Total energy consumed by fuel, measured in petajoules, was taken from SENER's National Energy Balances, and accessed through SIE for years 1990-2009.[22] This is a user variable, which means that it is not a default variable that is preset by LEAP or a particular methodology.

Baseline: This variable is not used (or visible) in future scenarios.

Final Energy Intensity

Current Accounts: In historical years, Final Energy Intensity is calculated as the total energy consumption by fuel divided by the total activity in the sector.

Equation: Total Energy / Total Activity [GJ/household]

Baseline: All final energy intensities are input as energy consumed per household for each technology in the baseline. The source of most of these values is Comisión Nacional para el Uso Eficiente de la Energía (CONUEE), though a few values were assumed by SEI or Rigoberto Garcia.[23]

Services ("Servicios")

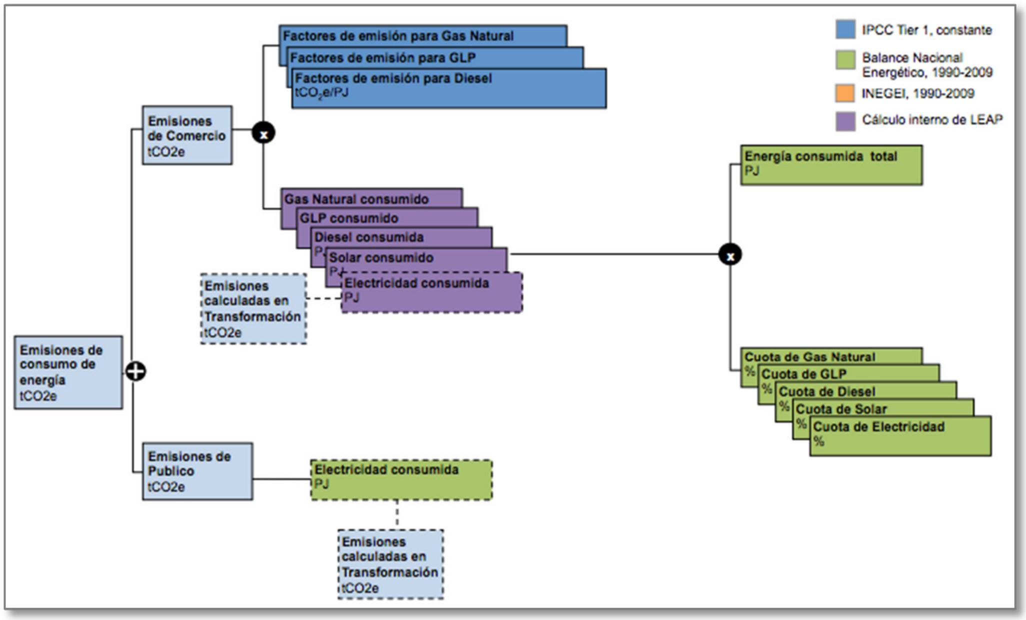
The Services sector is broken down into commercial (hotels, restaurants, etc.) and public services (electric water pumping and public lighting). When comparing to SENER Energy Prospective, it's

[20] In LEAP it looks like GDP is being used to calculate an activity level by having PIB and Hogares/PIB, but since no unique projection is made for the Hogares/PIB variable, PIB (GDP) cancels out and Households is the only driver. This structure is in place to facilitate adding income projcetions.
[21] ENIGH 2010, available online: http://www.inegi.org.mx/est/contenidos/proyectos/encuestas/hogares/regulares/enigh/enigh2010/ncv/default.aspx. All assumptions and calculations are documented in detail in the file "ENIGH_CONUEE_Residencial_SEI.xlsx"
[22] Accessed online: http://sie.energia.gob.mx/bdiController.do?action=temas from Sector Energético/Estadísticas Energéticas Nacionales/Balance Nacional de Energía 2011. Additional years of data were provided by INECC.
[23] [SENER] Secretaria de Energia y [CONUEE] Comisión Nacional para el Uso Eficiente de la Energía (2009), Potenciales de ahorro de energía por usos finales, México, CONUEE (6-7)

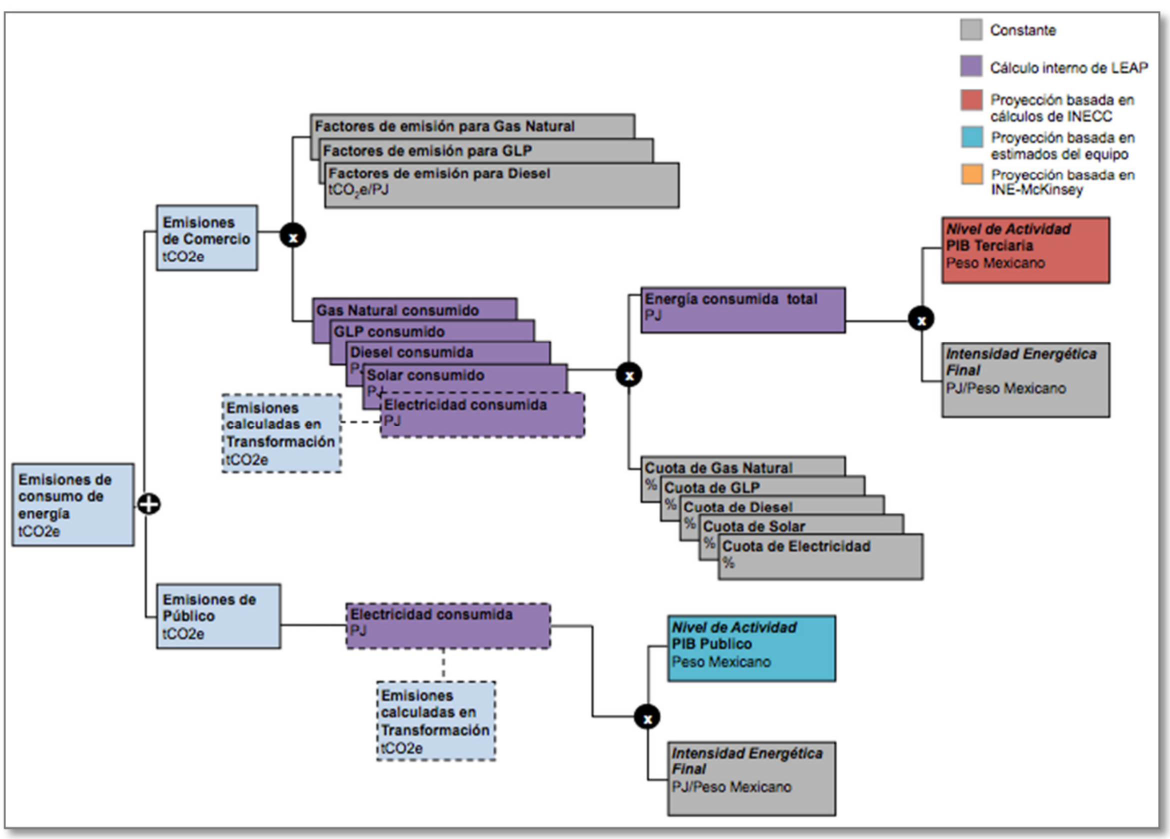
important to clarify how energy by sector is categorized. SENER included some natural gas and LPG consumption in the "public service" sector, which we re-categorized as commercial use for comparison to the national energy balances.

Calculation Diagram

Historical Years (1990-2009):



Baseline Years (2010-2030):



Activity Level

Commercial

All scenarios: Tertiary GDP as calculated by the total GDP multiplied by the value added (%) of GDP coming from tertiary activities (see GDP).

Equation: GDP * % Tertiary GDP

Public Services

All scenarios: Value added to GDP from Public Services (see GDP). This value was assumed to be the total GDP after current estimates of primary, secondary and tertiary GDPs were subtracted. This was an initial assumption from Rigoberto Garcia that was retained by the SEI team.

Equation: GDP * % Public Services GDP [Mexican Peso]

Future improvements: A potential improvement would be to find a more official projection of activity within the public services sector.

Total Energy

Current Accounts: Total energy consumed for each sector, measured in petajoules, was taken from SENER's National Energy Balances, and accessed through SIE for years 1990-2009.[24] This is a user variable, which means that it is not a default variable that is preset by LEAP or a particular methodology. The data included in this variable is only used when there is an equation that specifically calls it.

Baseline: This variable is not used (or visible) in future scenarios.

Final Energy Intensity

Current Accounts: In historical years, the final energy intensity is calculated using Activity Level and Total energy data.

Equation: Total Energy / Activity Level [GJ/peso]

Baseline: It is assumed that there is no change in the energy consumed per unit of GDP after 2009. This is an assumption from the SEI team after discussions of various modeling methodologies with INECC in October, 2012. We discussed whether it made more sense to use historical growth rates of energy intensities (as calculated in Current Accounts), but often the trends were inconsistent, so we decided for this version to do something simple and transparent – holding the energy intensity constant.

[24] Accessed online: http://sie.energia.gob.mx/bdiController.do?action=temas from Sector Energético/Estadísticas Energéticas Nacionales/Balance Nacional de Energía 2011. Additional years of data were provided by INECC.

Equation: Growth(0)

Future Improvements: Future versions of the model would benefit from meeting with sectoral stakeholders and making official assumptions how efficiency improvements (i.e. energy use per unit of activity level) will be incorporated into the baseline.

Fuel Share

Current Accounts: The Fuel Share (% of total PJ consumed by fuel) is calculated from SENER's national energy balances.

Baseline: Fuel shares are held constant after 2009.

Future Improvements: Future versions of the model would benefit from meeting with sectoral stakeholders and making official assumptions about how fuel consumption will shift in each sector.

*The fuel share variable is only used in the commercial sector because public services only use electricity. This methodology is indicated by the green category icon. The Public services sector has a regular yellow category icon, which indicates that no fuel share variable is used.

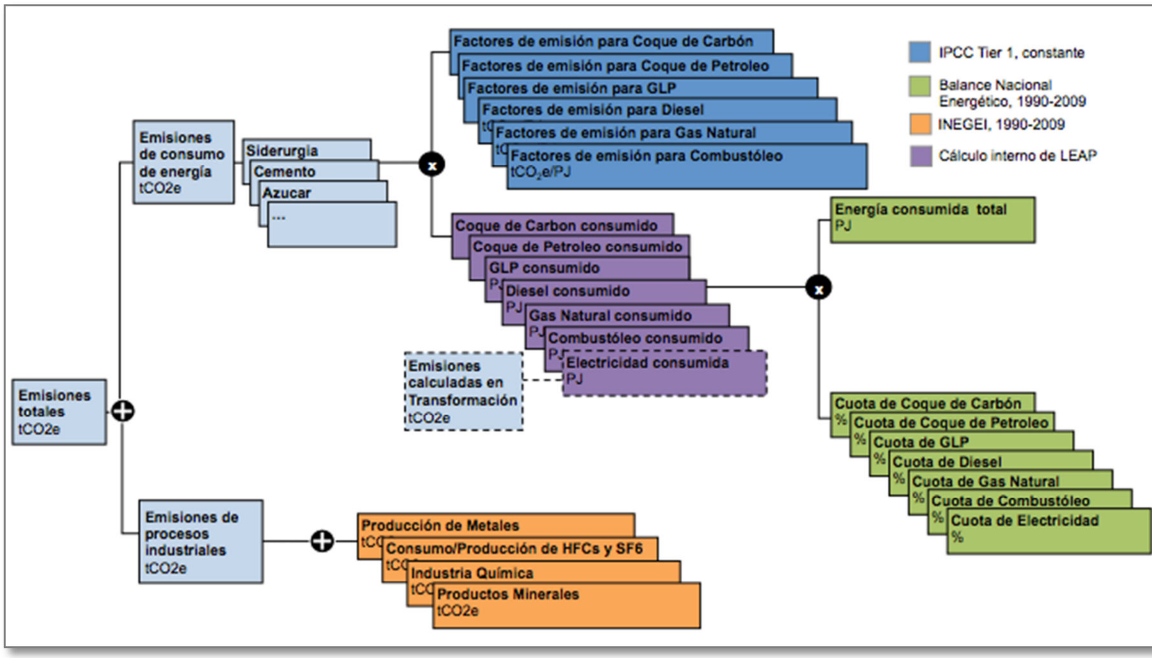
Industry ("Industria")

The industry sector includes accounting of greenhouse gas emissions from energy consumed in demand sectors as well as process emissions. Non-energy emissions from industrial processes are documented in the Non-Energy part of this appendix.

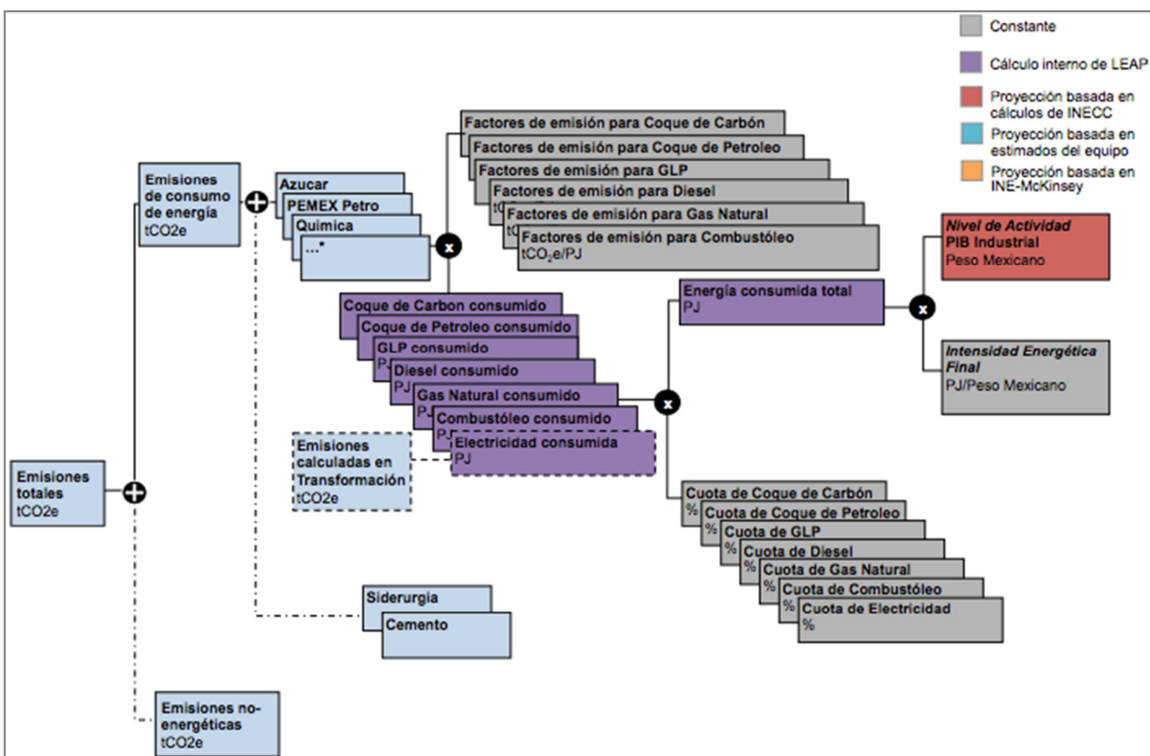
The industry sector is broken down into 16 sub sectors and one category for other industries. These categories were taken from the National Energy Balances. Previous emissions baselines have often such disaggregated data structures. Though the energy balances provide energy data at this level of disaggregation, we were not able to find official activity level data for all sectors. We had originally hoped to use sub-sectoral GDP projections (e.g. Mexican Pesos of GDP from the cement industry) as an activity level, but the Banco de Información Económica (BIE) only provided this for 5 years of data (not enough for a historical trend projection) and no official projections (for more information, please see Industrial GDP). Because there was no official projection for sub-sectoral GDP projections, all sectors have the default activity level of total industrial GDP. This applies to all sectors except cement and iron and steel, where official sectoral production data was used.

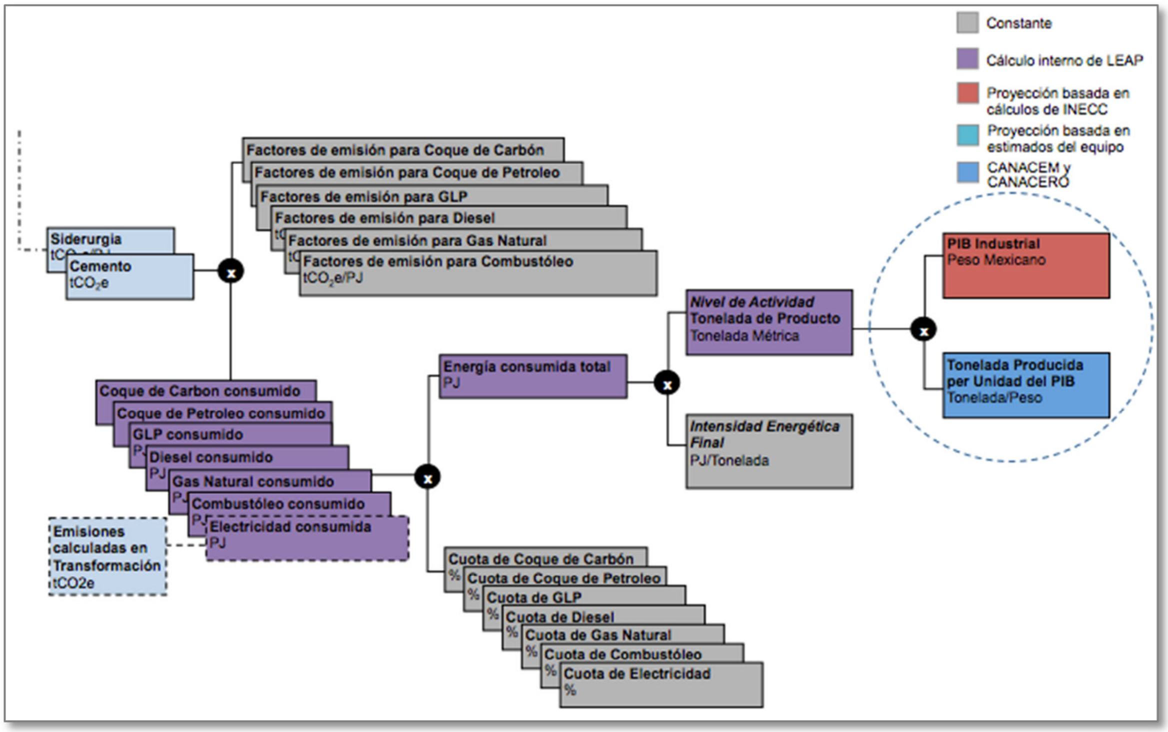
Calculation Diagram

Historical Years (1990-2009):



Baseline Years (2010-2030):





Activity Level

Iron and Steel – All Scenarios: In the Iron and Steel sector, official production data was available from Canacero. We calculated the metric tonnes of iron and steel produced per unit of GDP (using assumptions from Canacero) and then multiplied by the INECC assumptions for GDP so that we would have projections of production that varied by our different scenarios of GDP growth.

Equation: Iron and Steel Production * INECC GDP/Canacero GDP [Metric Tonne]

Note: INECC GDP assumptions and Canacero GDP assumptions are documented above in the Key Assumptions section. Production assumptions are documented below.

Cement – All Scenarios: In the cement sector, official cement production data was available from Canacem. We calculated the metric tonnes of cement produced per unit of GDP (using assumptions from Canacem) and then multiplied by the INECC assumptions for GDP so that we would have projections of production that varied by our different scenarios of GDP growth.

Equation: Cement Production * INECC GDP/Canacem GDP [Metric Tonne]

Note: INECC GDP assumptions and Canacem GDP assumptions are documented above in the Key Assumptions section. Production assumptions are documented below.

All other sub sectors – All Scenarios: Secondary GDP as calculated by the total GDP multiplied by the value added (%) of GDP coming from tertiary activities (see GDP).

Equation: GDP * % Secondary GDP

Total Energy

Current Accounts: Total energy consumed for each sector, measured in petajoules, was taken from SENER's National Energy Balances, and accessed through SIE for years 1990-2009.[25] This is a user variable, which means that it is not a default variable that is preset by LEAP or a particular methodology. The data included in this variable is only used when there is an equation that specifically calls it.

Baseline: This variable is not used (or visible) in future scenarios.

Final Energy Intensity

Current Accounts: In historical years, the final energy intensity is calculated using Activity Level and Total energy data.

Equation: Total Energy / Activity Level [GJ/peso]

Baseline: It is assumed that there is no change in the energy consumed per unit of GDP after 2009. This is an assumption from the SEI team after discussions of various modeling methodologies with INECC in October, 2012. We discussed whether it made more sense to use historical growth rates of energy intensities (as calculated in Current Accounts), but often the trends were inconsistent, so we decided for this version to do something simple and transparent – holding the energy intensity constant.

Equation: Growth(0)

Future Improvements: Future versions of the model would benefit from meeting with sectoral stakeholders and making official assumptions how efficiency improvements (i.e. energy use per unit of activity level) will be incorporated into the baseline.

Fuel Share

Current Accounts: The Fuel Share (% of total PJ consumed by fuel) is calculated from SENER's national energy balances.

Baseline: Fuel shares are held constant after 2009.

[25] Accessed online: http://sie.energia.gob.mx/bdiController.do?action=temas from Sector Energético/Estadísticas Energéticas Nacionales/Balance Nacional de Energía 2011. Additional years of data were provided by INECC.

Future Improvements: Future versions of the model would benefit from meeting with sectoral stakeholders and making official assumptions about how fuel consumption will shift in each sector.

Cement Production

Current Accounts: Historical data for 1990-2010 was provided by BIE, distributed by INEGI, Estadísticas históricas de México 2009.[26]

Baseline: Production data for cement in metric tonnes was provided by Canacem for years 2011-2030. This is a user variable in LEAP at the "Cemento" branch which is referenced by the Activity Level variable.

Iron and Steel Production

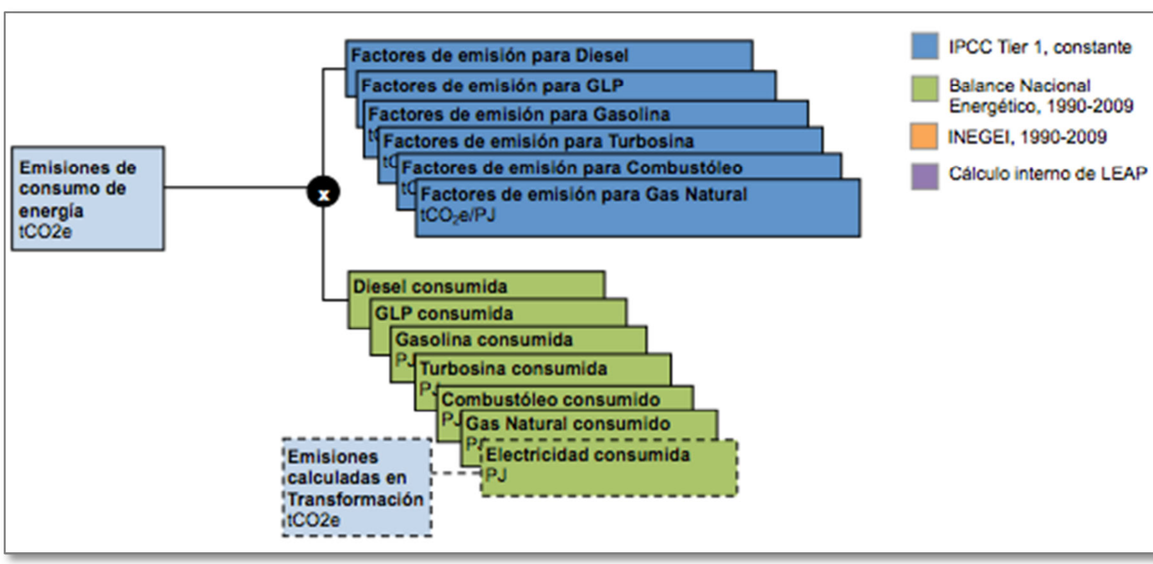
All scenarios: All scenarios: Production data for iron and steel in metric tonnes was provided by Canacero for years 2006-2030. This is a user variable in LEAP at the "Siderurgia" branch which is referenced by the Activity Level variable.

Transport ("Transporte")

The transport sector, like the residential sector, uses top down data for historical years and a bottom-up end use analysis for scenarios. The baseline scenario breaks down end uses into road transport and other, which includes rail, air, sea and metro.

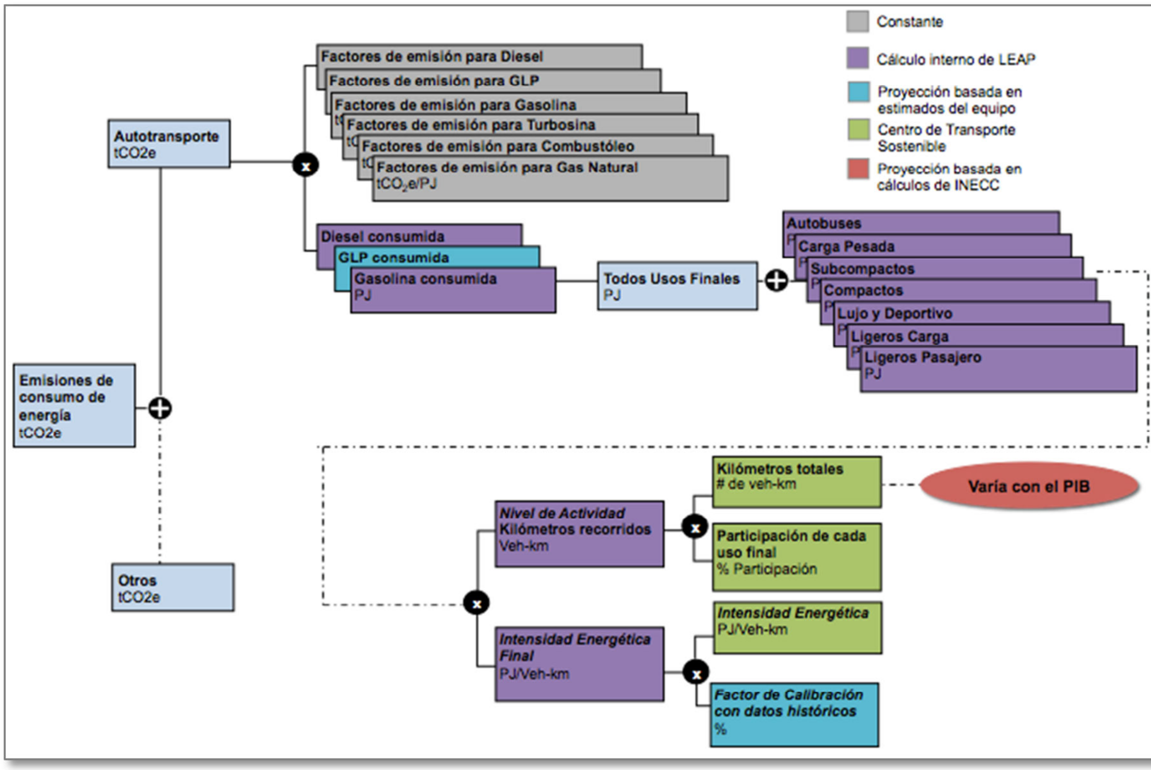
Calculation Diagram

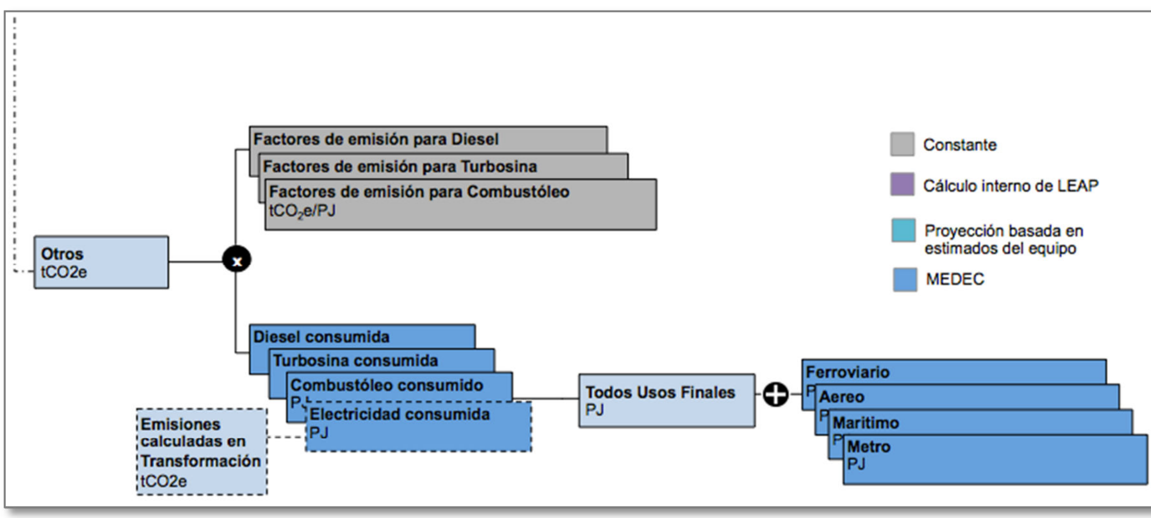
Historical Years (1990-2009):



[26] All Cement and Iron and Steel production data is documented in the "Industrial_Produduccion_cemento_acero.xlsx" file.

Baseline Years (2010-2030):





Activity Level

Current Accounts: The activity level is not used in current accounts since total energy is reported directly by fuel from national energy balances. At the Transporte\Historico branch you can see only Share data that informs LEAP as to when to make use of the energy data at those branches (i.e. only in years 1990-2009).

Baseline – Road transport: The activity level for road transport is vehicle-kilometers, with data mainly coming from Centro de Transporte Sostenible (CTS). Vehicle-kilometer data is provided for 7 sub sectors of the fleet from 2010-2030.[27]

Equation: GDP (elasticity 1.3)*Vehicle-km/peso [vehicle-km]

Note: SENER and other energy projections in the transport sector indicate that activity within the sector will grow faster than GDP. In the February 2013 training we decided that an elasticity of 1.3 was appropriate because gave results most similar to SENER Prospectiva. This is a very simple assumption that should be updated in the future with stakeholders in the transport sector. An elasticity of 1.3 in this case indicates that the activity level will grow 1.3 times faster than the main assumption for GDP for that scenario.

Note: The CTS model provides vehicle-kilometer projections by mode for a user-specified GDP growth rate. We wanted to include the ability to change the GDP growth rate in LEAP rather than externally in the CTS Excel workbook, so we backed out the vehicle-km per peso and used LEAP's GDP projections. This allows the user to make changes to GDP projections in LEAP and immediately see resulting calculations without the need to run an external model. This process was discussed with a representative of CTS in the February 2013 training. Basic assumptions are shown below from CTS.[28]

Mode of Transport	Fuel Consumed	% of Vehicle-km in 2010
Bus (Autobus)	Diesel	3.6
HDVs (Carga Pesada)	Diesel	8.6
Subcompact (Subcompactos)	Gasoline	20.5
Compact (Compactos)	Gasoline (99.99%) LPG (0.11%)	22.2
Luxury and Sport (Lujo y Deportivo)	Gasoline	7.7
LDV – freight (Ligeros Carga)	Gasoline (99.65%) LPG (0.35%)	26.1
LDV – passenger (Ligeros Pasajero)	Gasoline (99.998%) LPG (0.002%)	11.3

[27] Further documentation of the official CTS model is available (in Spanish) in the "CTS – Metodología de Línea Base.docx" file
[28] The CTS model with SEI calculations and LEAP inputs is documented in the file "Línea Base todos los vehículos 210612 FINAL.xls"

The CTS baseline did not include LPG as a fuel in any sector, so with additional information from INECC, SEI added LPG to the appropriate modes of transport. The contribution is small, but this allows for continuity from historical numbers to projections.[29]

Baseline – Other modes of transport: Growth rates for energy consumption from rail, air, sea and metro sectors were taken from the MEDEC data set as no official sources could be found that contained this level of disaggregated data.[30]

Mode of Transportation	Fuel	Energy Consumption in 2009 [PJ]	Growth rate in Energy consumption from 2010-2030
Rail	Diesel	77	0%
Air	Jet Kerosene	112	5.3%
Sea	Residual Fuel Oil	4	0.9%
Metro	Electricity	4	3.6%

Total Energy

Current Accounts: Total energy consumed for each sector, measured in petajoules, was taken from SENER's National Energy Balances, and accessed through SIE for years 1990-2009.[31] This is a user variable, which means that it is not a default variable that is preset by LEAP or a particular methodology. The data included in this variable is only used when there is an equation that specifically calls it.

Baseline: This variable is not used (or visible) in future scenarios.

Final Energy Intensity

Current Accounts: In historical years total energy is used to calculate final energy consumption.

Baseline: In the end-use transport model, final energy intensities are input in units of megajoules per vehicle-km. This data comes from the CTS baseline model and varies . The raw data did not match up with the historical data from the SENER National Energy Balance. To ensure consistency, we used a calibration factor to ensure continuity between 2009 (SENER) and 2010 (CTS) data. For more information on the calibration factors, see the Key Assumptions documentation.

[29] These assumptions are documented in the file "Distribución_Flota_GLP_INECC-LEAP.xlsx"
[30] The MEDEC LEAP data set is available for download on the COMMEND website: http://www.energycommunity.org/default.asp?action=45
[31] Accessed online: http://sie.energia.gob.mx/bdiController.do?action=temas from Sector Energético/Estadísticas Energéticas Nacionales/Balance Nacional de Energía 2011. Additional years of data were provided by INECC.

Equation: CTS Energy Intensity * Calibration Factor

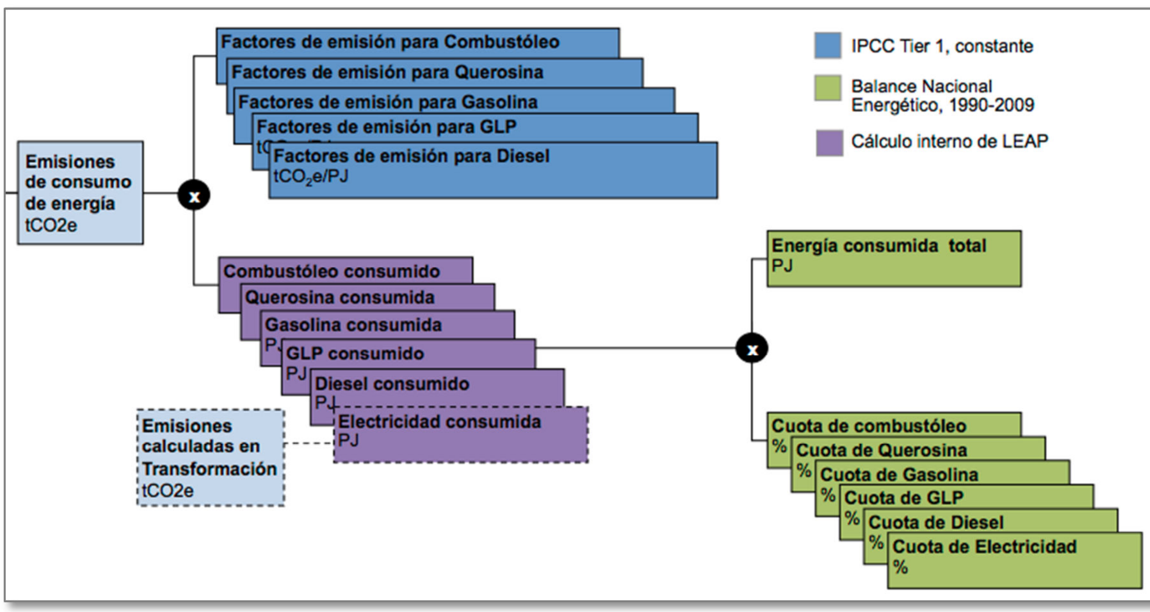
Note: Final Energy Intensity is only used in road transportation sectors in scenarios.

Agriculture ("Agricultura")

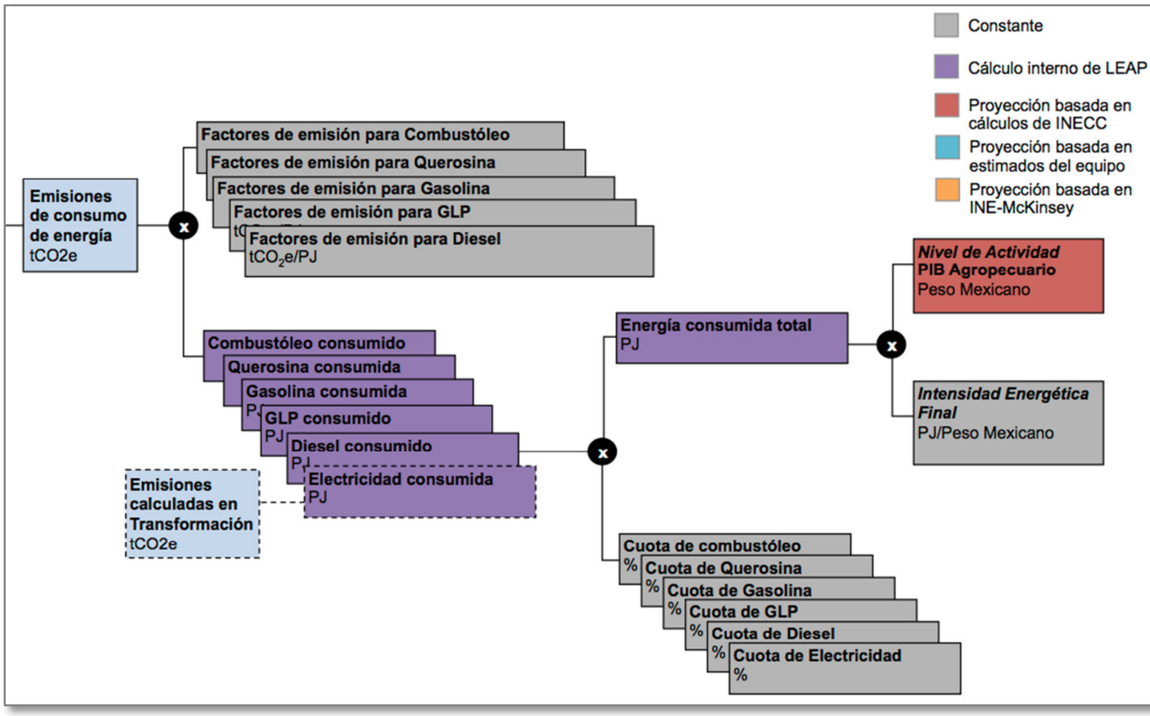
The Agriculture sector includes both energy and non-energy related emissions. These are accounted for separately in the model and are therefore documented separately in this Appendix. Please see the non-energy sector documentation for more information.

Calculation Diagram

Historical Years (1990-2009):



Baseline Years (2010-2030):



Activity Level

All scenarios: Primary GDP as calculated by the total GDP multiplied by the value added (%) of GDP coming from tertiary activities (see GDP).

Equation: GDP * Primary GDP

Total Energy

Current Accounts: Total energy consumed for each sector, measured in petajoules, was taken from SENER's National Energy Balances, and accessed through SIE for years 1990-2009.[32] This is a user variable, which means that it is not a default variable that is preset by LEAP or a particular methodology. The data included in this variable is only used when there is an equation that specifically calls it.

Baseline: This variable is not used (or visible) in future scenarios.

[32] Accessed online: http://sie.energia.gob.mx/bdiController.do?action=temas from Sector Energético/Estadísticas Energéticas Nacionales/Balance Nacional de Energía 2011. Additional years of data were provided by INECC.

Final Energy Intensity

Current Accounts: In historical years, the final energy intensity is calculated using Activity Level and Total energy data.

Equation: Total Energy / Activity Level [GJ/peso]

Baseline: It is assumed that there is no change in the energy consumed per unit of GDP after 2009. This is an assumption from the SEI team after discussions of various modeling methodologies with INECC in October, 2012. We discussed whether it made more sense to use historical growth rates of energy intensities (as calculated in Current Accounts), but often the trends were inconsistent, so we decided for this version to do something simple and transparent – holding the energy intensity constant.

Equation: Growth(0)

Future Improvements: Future versions of the model would benefit from meeting with sectoral stakeholders and making official assumptions how efficiency improvements (i.e. energy use per unit of activity level) will be incorporated into the baseline.

Fuel Share

Current Accounts: The Fuel Share (% of total PJ consumed by fuel) is calculated from SENER's national energy balances.

Baseline: Fuel shares are held constant after 2009.

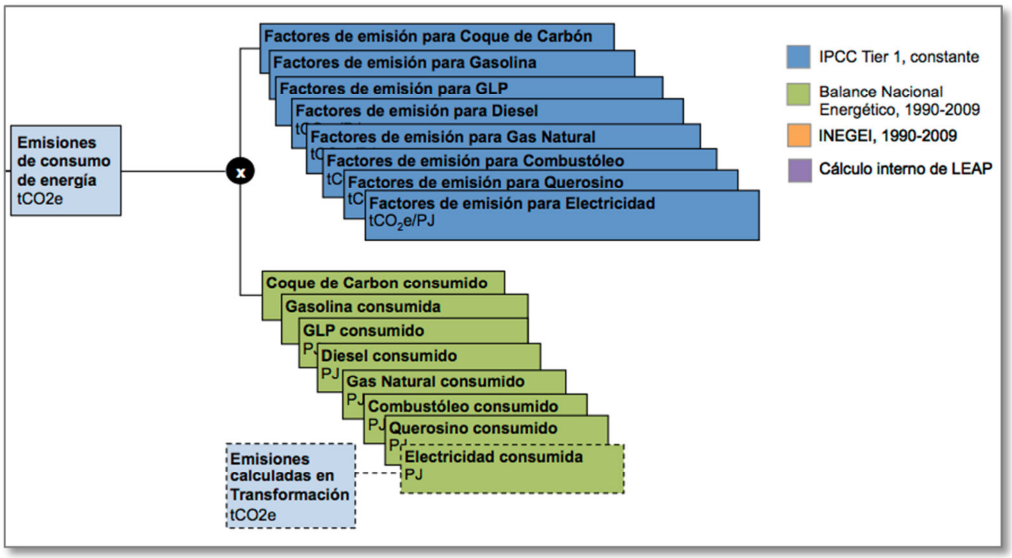
Future Improvements: Future versions of the model would benefit from meeting with sectoral stakeholders and making official assumptions about how fuel consumption will shift in each sector.

Oil and Gas ("Petroleo y Gas")

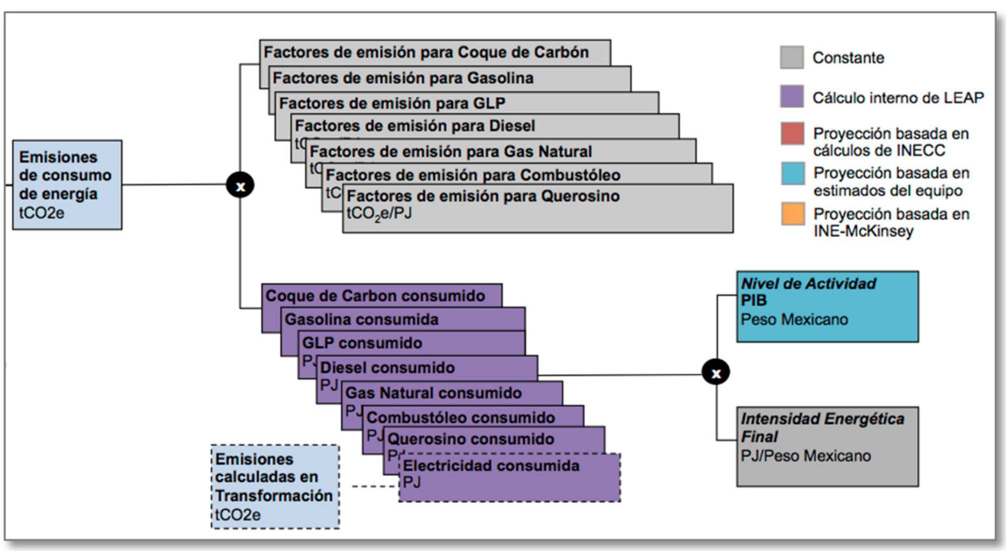
The Oil and Gas sector listed in the Demand branches represents the fuels consumed in oil and gas transformation processes.

Calculation Diagram

Historical Years (1990-2009):



Baseline Years (2010-2030):



Activity Level

Current Accounts: No sectoral GDP is calculated for internal consumption within the oil and gas sector, and therefore total GDP was used as the Activity Level in this sector.

Baseline: We looked at projections from SENER Prospectiva for the Oil and Gas sector because there was no official indicator of activity within the sector. Comparing SENER Prospectiva numbers for 2010-2026 we decided that projecting based on GDP with an elasticity of 0.5 gave a similar trend, meaning that the activity in this sector is expected to grow half as fast as total GDP for the scenario.

Equation: GrowthAs(GDP,0.5)

Total Energy

Current Accounts: Total energy consumed for each fuel, measured in petajoules, was taken from SENER's National Energy Balances in the category of Own Use, and accessed through SIE for years 1990-2009.[33] This is a user variable, which means that it is not a default variable that is preset by LEAP or a particular methodology. The data included in this variable is only used when there is an equation that specifically calls it.

Baseline: This variable is not used (or visible) in future scenarios.

Final Energy Intensity

Current Accounts: In historical years, the final energy intensity is calculated using Activity Level and Total energy data.

Equation: Total Energy / Activity Level [GJ/peso]

Baseline: It is assumed that there is no change in the energy consumed per unit of GDP after 2009. This is an assumption from the SEI team after discussions of various modeling methodologies with INECC in October, 2012. We discussed whether it made more sense to use historical growth rates of energy intensities (as calculated in Current Accounts), but often the trends were inconsistent, so we decided for this version to do something simple and transparent – holding the energy intensity constant.

Equation: Growth(0)

Future Improvements: Future versions of the model would benefit from meeting with sectoral stakeholders and making official assumptions how efficiency improvements (i.e. energy use per unit of activity level) will be incorporated into the baseline.

[33] Accessed online: http://sie.energia.gob.mx/bdiController.do?action=temas from Sector Energético/Estadísticas Energéticas Nacionales/Balance Nacional de Energía 2011. Additional years of data were provided by INECC.

Electricity

Transmission and Distribution

Current Accounts: Transmission and distribution data were downloaded from SIE from SENER's National Energy Balances.[34]

Baseline: No official projections were available for transmission and distribution losses. Therefore it was assumed that losses would be held constant at the 2009 value, 18.87%.

Own Use

Current Accounts: Own use data were downloaded from SIE from SENER's National Energy Balances.[35]

Baseline: No official projections were available for transmission and distribution losses. Therefore it was assumed that losses would be held constant at the 2009 value, 4.63%.

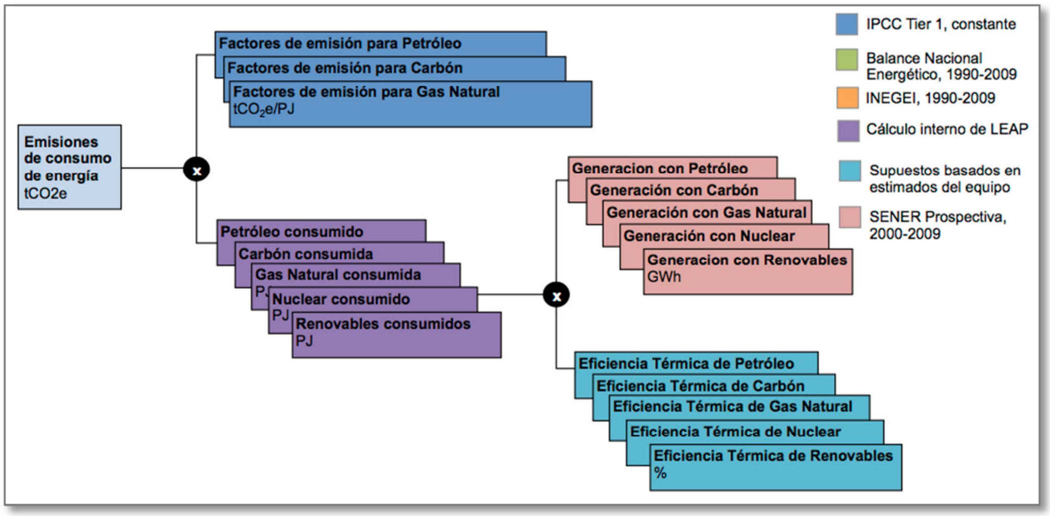
Electricity Generation

The baseline projection of electricity generation in Mexico includes 8 types of processes. We grouped power plants by fuel consumed, not by specific type of power plant. The processes included in the baseline are imports, residual fuel oil, diesel, coal, natural gas, nuclear, hydroelectricity, geothermal and onshore wind. LEAP's simulation calculations are demand-driven, which means that in each year, LEAP is calculating electricity generation requirements to meet electricity demand as defined in LEAP's demand branches. In this way, LEAP is ensuring consistency between demand and supply.

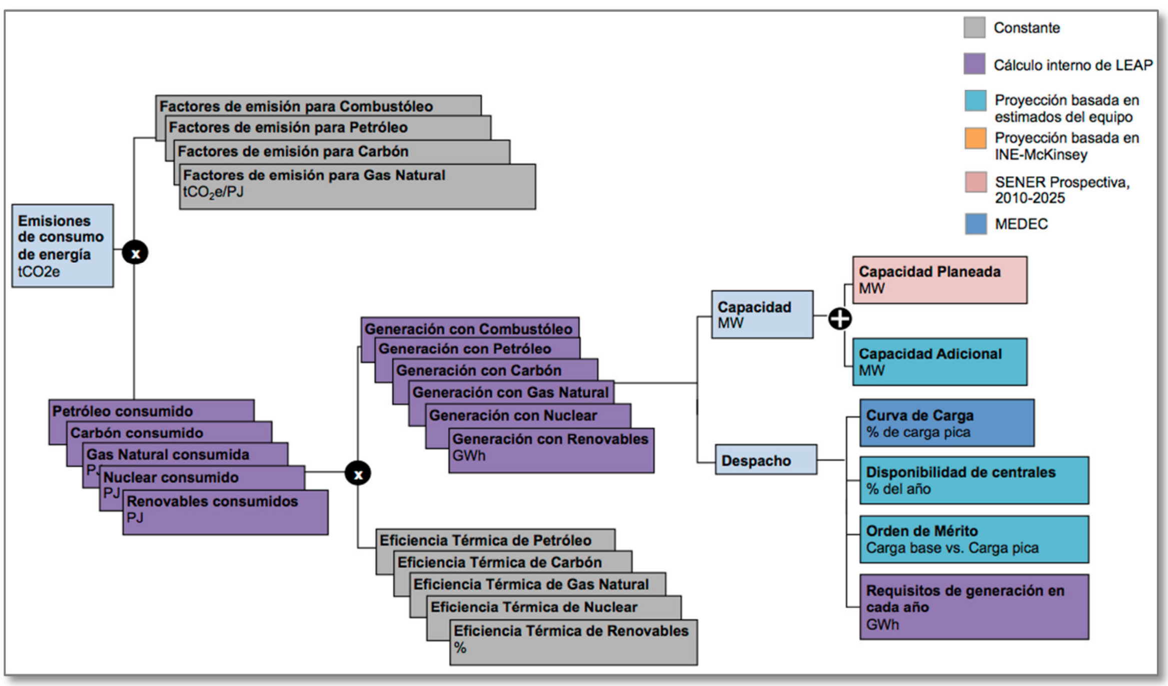
[34] The raw data is available in the file "SENER, BNE perdidas electricas.xlsx"
[35] The raw data is available in the file "SENER, BNE perdidas electricas.xlsx"

Calculation Diagram

Historical Years (2000-2009):



Future Years (2010-2030):



First Simulation Year

This variable keeps track of which calculation method is being used to calculate electricity generation for each process. The First Simulation Year indicates a transition from a historical method, where generation is entered directly, and a simulation method, where LEAP calculates generation based on available capacity and a selected dispatch rule.

All Scenarios: The first scenario year is set to be 2010, meaning that historical data is input for historical years up to 2009, and LEAP will simulate electricity generation in years 2010-2030.

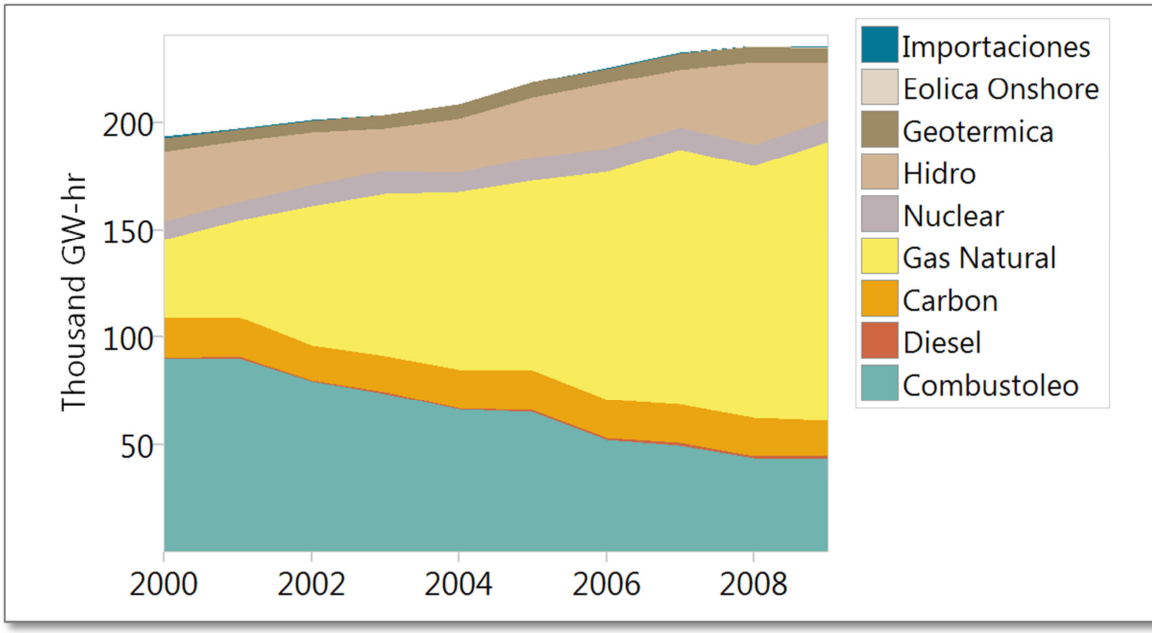
Historical Production

Current Accounts: Historical electricity generation from 2000-2009 has been taken from SENER Prospectiva, Cuadro 23 (they cite CFE). No official data was available before 2000.[36] To map SENER categories to our processes in LEAP, we used the following system:

SENER Category	LEAP Category
Termoeléctrica convencional	Residual Fuel Oil
Dual	Natural Gas
Ciclo combinado	Natural Gas
Turbogás	Natural Gas
Combustión interna	Diesel
Hidroeléctrica	Hydro
Carboeléctrica	Coal
Nucleoeléctrica	Nuclear
Geotermoeléctrica	Geothermal
Eoloeléctrica	Onshore Wind

[36] All LEAP data processing and import templates can be found in "SENER Prospectiva 2010-2026 Electricidad Import.xlsx"

Historical Production of Electricity 2000-2009



Baseline: This variable is not used in the baseline scenario because the first simulation year is set to be 2010 for all processes.

Exogenous Capacity

This variable tracks existing and planned power plant capacity in MW.

Current Accounts: Historical electric capacity by fuel type from 2000-2009 has been taken from SENER Prospectiva, Cuadro 7 (they cite CFE). No official data was available before 2000.[37] This data is not currently used as the First Scenario year is set to be 2010, but is helpful to have as a reference.

Baseline: Planned capacity between 2010 and 2026 was taken from SENER Prospetiva, Cuadro 31 (they cite CFE). No official projections were available from 2027-2030.

Endogenous Capacity

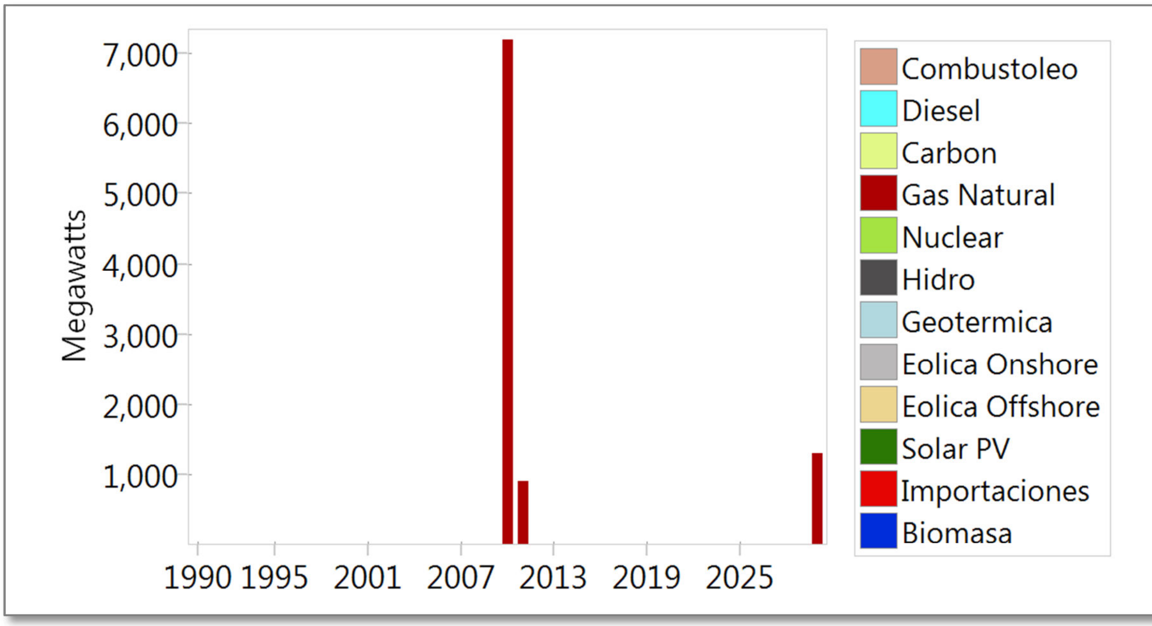
This variable allows LEAP to internally calculate additional capacity values required to maintain a minimum planning reserve margin. In this case, the planning reserve margin was calculated by LEAP to be 15%. Ideally, a planning reserve margin would be provided by CFE in the future.

Current Accounts: This variable is not used in current accounts.

[37] All LEAP data processing and import templates can be found in "SENER Prospectiva 2010-2026 Electricidad Import.xlsx"

Baseline: The baseline assumption is that Natural Gas power plants will be added in increments of 100 MW as needed. This means that if demand grows faster than SENER Prospectiva expects, then LEAP will add additional natural gas power plants to meet demand. This is especially necessary because SENER data does not extend past 2026.

Endogenous Capacity Added (in addition to exogenous capacity)



Maximum Availability

Current Accounts: This variable is not used in current accounts.

Baseline: The availability of each process, or the percentage of hours in a year that that process can be used, has been assumed by the SEI team.

Process Efficiency

Current Accounts: This variable is not used in current accounts.

Baseline: The thermal efficiency of each process has been assumed by the SEI team.

Dispatch Rule

Current Accounts: This variable is not used in current accounts.

Baseline: The dispatch rule is set to Merit Order, which means that available processes are dispatched by the variable "Merit Order."

Merit Order

Current Accounts: This variable is not used in current accounts.

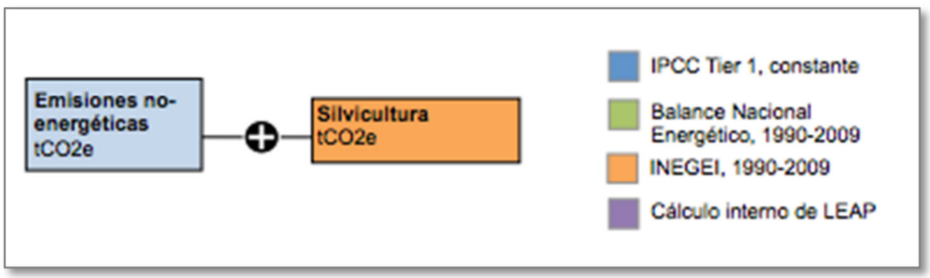
Baseline: It was assumed that Imports were peak load processes, and all others were base load processes. This was a SEI assumption, agreed to by participants in the February 2013 training with INECC.

Forestry

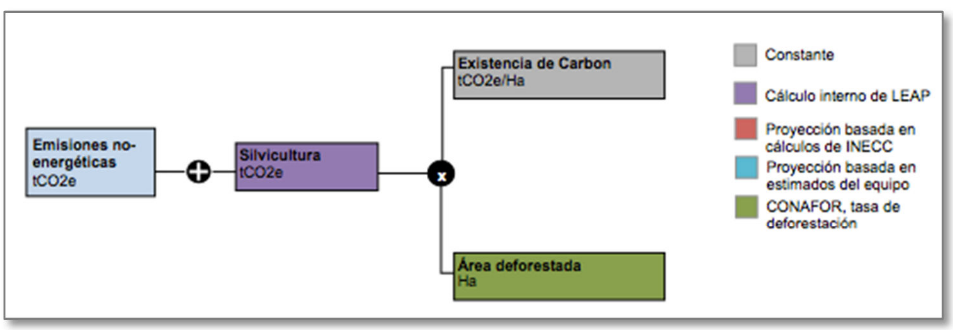
LEAP focuses on the energy sector, but still allows for user-created modeling within non-energy sectors. In many cases this means that user variables have been created at non-energy branches to appropriately model future emissions.

Calculation Diagram

Historical Years (1990-2009):



Baseline Years (2010-2030):



GWP100

This Global Warming Potential 100 variable is a user variable, meaning it has been created specifically for the purpose of this model.

Current Accounts: Historical data for emissions in the forestry sector came directly from the INECC inventory, INEGEI, for years 1990-2009.[38]

[38] Historical non-energy emissions are documented in the file "INEGEI 1990 a 2010_SEI.xlsx"

Deforestation Rate

The deforestation rate was set to be a constant 0.4% from the CONAFOR “Estudio de la dínamica de cambio 1993-2003” report.

Carbon Stock

Carbon stock is only available in 2006 from the CONAFOR “Estudio de la dínamica de cambio 1993-2003” report.

Total Wooded Land

This is calculated as the total wooded land minus the deforested land in the previous year.

Equation: PrevYearValue(Total Wooded Land [MHa])-PrevYearValue(Deforested Area [MHa]) [Ha]

Deforested Area

Deforested area is calculated as the total wooded area multiplied by the deforestation rate.

Equation: Total Wooded Area * Deforestation Rate [Ha]

Effect Loading

Current Accounts: In historical years, LEAP simply uses the emissions directly from INEGEI, in this case set equal to the GWP100 variable.

Baseline: Total emissions are calculated as the current carbon stock multiplied by the total deforested area.

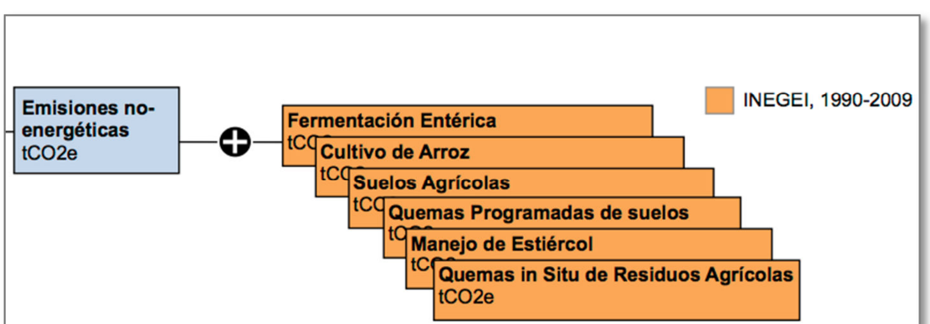
Equation: Carbon Stock * Deforested Area [Grammes CO_2]

Agriculture (non-energy)

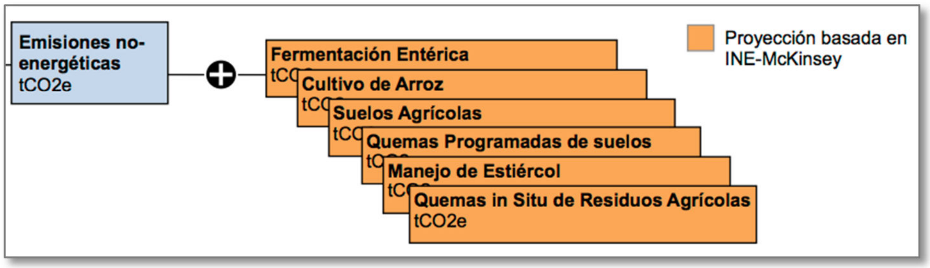
The agriculture sector includes six emissions sources (as categorized by the INEGEI): enteric fermentation, rice cultivation, agricultural soils, planned burning of lands, field burnings of agricultural residues, manure management.

Calculation Diagram

Historical Years (1990-2009):



Baseline Years (2010-2030):



GWP100

This Global Warming Potential 100 variable is a user variable, meaning it has been created specifically for the purpose of this model to allow CO_2 equivalent values in INEGEI to be converted back to original pollutants.

Current Accounts: Historical data for emissions in the agriculture sector came directly from the INECC inventory, INEGEI, for years 1990-2009 in units of billion grammes of CO_2 equivalent.[39]

Effect Loading

Current Accounts: In historical years, LEAP converts CO_2 equivalent values from INEGEI, dividing by global warming potential values to get billion grammes of methane and nitrous oxide.

Equation for Methane: GWP100/21 [Grammes CH_4]

Equation for Nitrous Oxide: GWP100/310 [Grammes N_2O]

Baseline: Total emissions are expected to grow at sector-specific growth rates set by the 2009 INE-McKinsey work. Group 1 and 2 growth rates are documented under Key Assumptions above.

Enteric Fermentation and Manure Management:

Equation: Growth(Group 1 Growth)

Rice Cultivation, Agricultural Soils, Planned burning of lands, and Field Burnings of Agricultural Residues

Equation: Growth(Group 2 Growth)

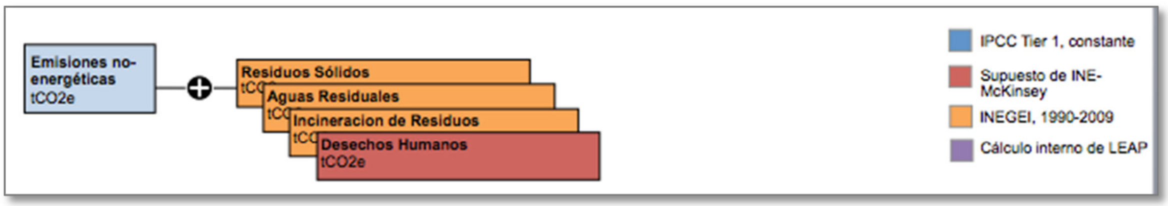
[39] Historical non-energy emissions are documented in the file "INEGEI 1990 a 2010_SEI.xlsx"

Waste

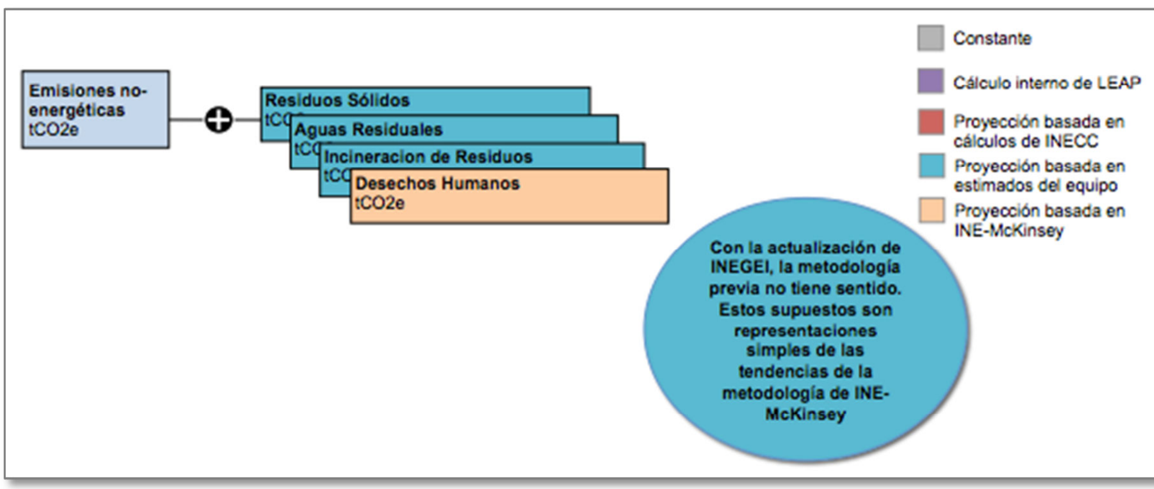
The waste sector in this model includes four subcategories: solid waste, wastewater (industrial and municipal), incineration of waste, and human waste. The first three categories come from the INEGEI analysis, and the human waste estimations are from the 2009 INE-McKinsey analysis.

Calculation Diagram

Historical Years (1990-2009):



Baseline Years (2010-2030):



GWP100

This Global Warming Potential 100 variable is a user variable, meaning it has been created specifically for the purpose of this model to allow CO_2 equivalent values in INEGEI to be converted back to original pollutants.

> **Current Accounts**: Historical data for emissions in the waste sector came directly from the INECC inventory, INEGEI, for years 1990-2009 in units of billion grammes of CO_2 equivalent.[40]

Note: This variable is not used in the Human Waste subcategory as the calculations are done directly in the Effect Loading variable.

[40] Historical non-energy emissions are documented in the file "INEGEI 1990 a 2010_SEI.xlsx"

Effect Loading

Current Accounts: In historical years, LEAP converts CO_2 equivalent values from INEGEI, dividing by global warming potential values to get billion grammes of methane and nitrous oxide.

Equation for INEGEI sectors (Solid Waste, Wastewater, Waste Incineration):

Carbon Dioxide: GWP100 [Grammes CH_4]

Methane: GWP100/21 [Grammes CH_4]

Nitrous Oxide: GWP100/310 [Grammes N_2O]

Equation for Human waste: Population [person] * Per capita protein consumption * Fraction of Nitrogen in Protein * Emission factor[41]

[Mt N_2O]

Baseline: The 2009 INE-McKinsey work was based on the 2006 version of INEGEI. The more recent version of INEGEI in 2010 incorporated different accounting techniques that made the previous INE-McKinsey disaggregated methodology inconsistent with the new historical data. Because of this, all INEGEI categories have been given a very simple growth rate based on the trend from the previous analysis, but all other waste variables are not being used to calculate future emissions.

Solid Waste:

Equation: Growth(1.5%)

Wastewater and Waste Incineration:

Equation: Growth(0.5%)

Human Waste:

Equation: Population [person] * Per capita protein consumption * Fraction of Nitrogen in Protein * Emission factor

This is the same equation that is used in current accounts. The only variable that is changing is the population growth rate, as defined in key assumptions.

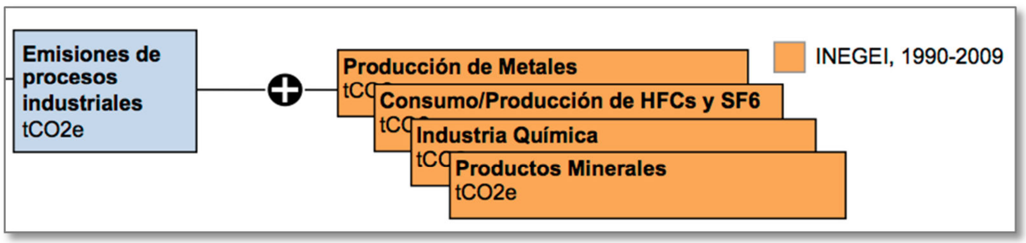
[41] These assumptions were all based on the constant IPCC defaults used in the 2009 INE-McKinsey work. They are further documented in Rows 191-197, Sheet "Desechos" in the file "SEI_LineaBase_DesechosAgrForest.xlsx"

Industry

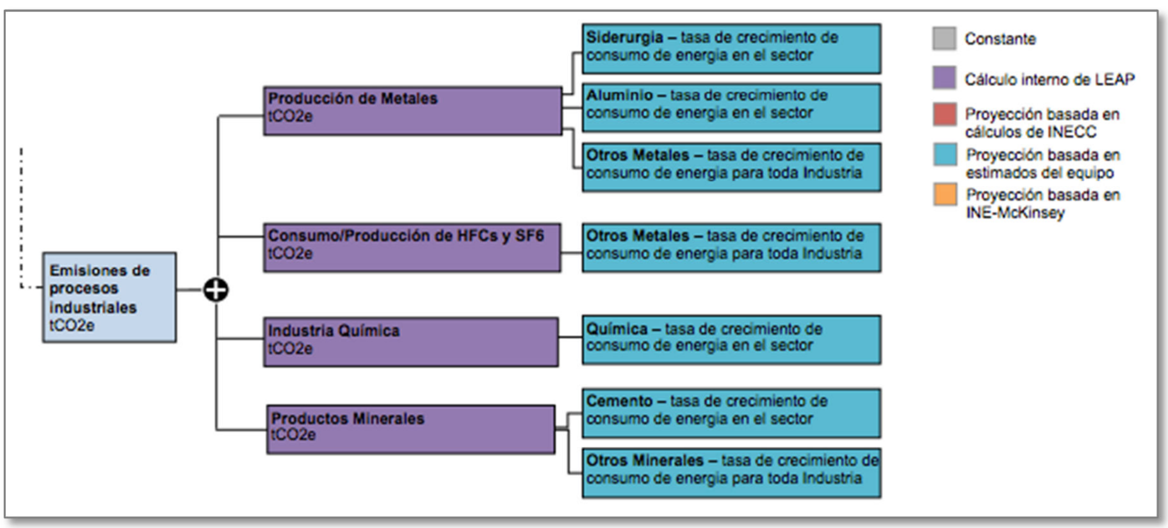
The industry sector includes emissions from energy combustion as well as process emissions. The energy combustion emissions are documented in the energy demand section above. We broke out process emission categories based on key industrial sectors: Production of Metals (Iron and steel, Aluminum, and other), Consumption of HFCs and SF6, Production of HFCs and SF6, Chemical Industry, and Mineral Products (Cement and other).

Calculation Diagram

Historical Years (1990-2009):



Baseline Years (2010-2030):



GWP100

This Global Warming Potential 100 variable is a user variable, meaning it has been created specifically for the purpose of this model to allow CO_2 equivalent values in INEGEI to be converted back to original pollutants.

Current Accounts: Historical data for process emissions in the industry sector came directly from the INECC inventory, INEGEI, for years 1990-2009 in units of billion grammes of CO_2 equivalent.[42]

Effect Loading

Current Accounts: In historical years, LEAP converts CO_2 equivalent values from INEGEI, dividing by global warming potential values to get billion grammes of the original pollutant.

Equation by pollutant (all sectors):

Carbon Dioxide: GWP100	[Grammes CH_4]
Methane: GWP100/21	[Grammes CH_4]
Nitrous Oxide: GWP100/310	[Grammes N_2O]
Perfluoromethane: GWP100/6500	[Grammes CF_4]
Perfluoroethane: GWP100/9200	[Grammes C_2F_6]
Hydrofluorocarbon: GWP100/11700	[Grammes HFC 23]
Sulfur Hexafluoride: GWP100/23900	[Grammes SF_6]

Baseline: In the baseline scenario, each category is assumed to grow as the demand for the subsector grows. If there is no subsector specific to the emissions source, we assume emissions grow as energy demand grows for the whole sector. Since we are linking back to demand, this sector is dependent on the demand assumptions for Industry as well as the GDP assumptions for each scenario. This is a very simple assumption made by SEI to ensure that we are being consistent with our projections within the same sector.

Equation for Iron and Steel: GrowthAs(Demand\Industry\Iron and Steel: Total Energy Consumption)

Equation for Aluminum: GrowthAs(Demand\Industry\Aluminum: Total Energy Consumption)

Equation for Chemicals: GrowthAs(Demand\Industry\Chemicals: Total Energy Consumption)

Equation for Cement: GrowthAs(Demand\Industry\Cement: Total Energy Consumption)

[42] Historical non-energy emissions are documented in the file "INEGEI 1990 a 2010_SEI.xlsx"

Equation for all others: GrowthAs(Demand\Industry: Total Energy Consumption)

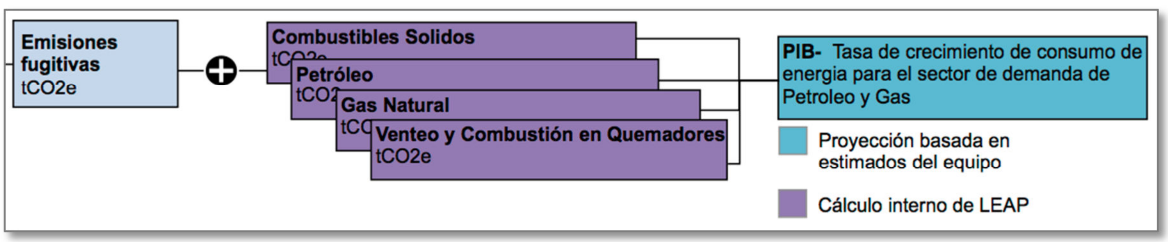
Oil and Gas

Emissions from the oil and gas sector come from fuels combusted directly for oil and gas sector processes as well as fugitive emissions. Direct combustion of fuels in the oil and gas sector is documented in the demand branches section. Fugitive emissions are documented from solid fuels, petroleum and natural gas in addition to gas flaring.

Calculation Diagram

Historical Years (1990-2009):

Baseline Years (2010-2030):



GWP100

This Global Warming Potential 100 variable is a user variable, meaning it has been created specifically for the purpose of this model to allow CO_2 equivalent values in INEGEI to be converted back to original pollutants.

Current Accounts: Historical data for fugitive emissions in the oil and gas sector sector came directly from the INECC inventory, INEGEI, for years 1990-2009 in units of billion grammes of CO_2 equivalent.[43]

Effect Loading

Current Accounts: In historical years, LEAP converts CO_2 equivalent values from INEGEI, dividing by global warming potential values to get billion grammes of the original pollutant.

Equation for Methane: GWP100/21 [Grammes CH_4]

[43] Historical non-energy emissions are documented in the file "INEGEI 1990 a 2010_SEI.xlsx"

Baseline: In the baseline scenario, we assume that all emissions will grow at the same rate as total energy demand within the oil and gas sector. This is a very simple assumption made by SEI to ensure that we are being consistent with our projections within the same sector.

Equation: GrowthAs(Demand\Oil and Gas: Total Energy Consumption)

Appendix Two: Mitigation Assumptions

Introduction to Mitigation Modeling

In recent years, the Mexican government has completed various studies focusing on building future climate mitigation capacity within the country. This project focused on revising these past efforts and building them into LEAP to accompany the new baseline created in the first phase of the project. The main focus of this mitigation portfolio was to build a transparent physical representation of potential mitigation projects in Mexico.

We reviewed the 2009 mitigation efforts completed by McKinsey and the INECC team.[44] Those actions that were well documented enough were included in the 2013 analysis along with new policies enacted since 2009 and policies included in other national mitigation studies. We built on the 2009 work by using McKinsey approaches with official data and projections from the baseline

Mitigation actions are represented in LEAP with individual scenarios, grouped in packages by sector and each sectoral scenario is grouped together in a total mitigation scenario. When viewing the model, emission reductions for a particular scenario compared to the baseline (e.g. efficient electric appliances) may be different as a part of the total mitigation scenario. This is because LEAP is an integrated model that considers the combined effect of demand and supply measures together. Unlike a cost curve that would evaluate mitigation actions individually, in LEAP, the mitigation benefit of the efficient refrigerators will be smaller as a part of a mitigation scenario that has more low-carbon fuels generating electricity.

All mitigation options are compared back to a baseline scenario. By default, mitigation options are compared back to a baseline scenario with 3.2% GDP growth.

The philosophy was to create a model that was simple and transparent, with a structure that could be continuously improved and changed by INECC staff. Documentation of the modeling assumptions and methodologies is included in this appendix and within the Notes section of the LEAP model. This appendix documents sectors in the same order as sectors appear in the LEAP tree.

Residential

Sector Overview

The residential sector is disaggregated by end use in scenarios, which facilitates mitigation modeling because the sector includes a physical accounting of where energy is used in households.

[44] Documented in the file "20100317 Modelo Central Mitigacion – corregido final.xls"

Mitigation Actions

Lighting

Philosophy: The McKinsey model in 2009 included three residential scenarios involving lighting, but the documented assumptions did not give a full picture of the change of technologies because all scenarios were separate.

Scenario name in LEAP: R1: Focos

Lever Name in McKinsey 2009: This scenario combines the following 3 scenarios from McKinsey:

- L.2.1.1.1 Lighting – switch incandescent to LEDs, residential
- L.2.1.1.2 Lighting – switch CFLs to LEDs, residential
- Switch all incandescent to CFLs (external)

Variables Affected:

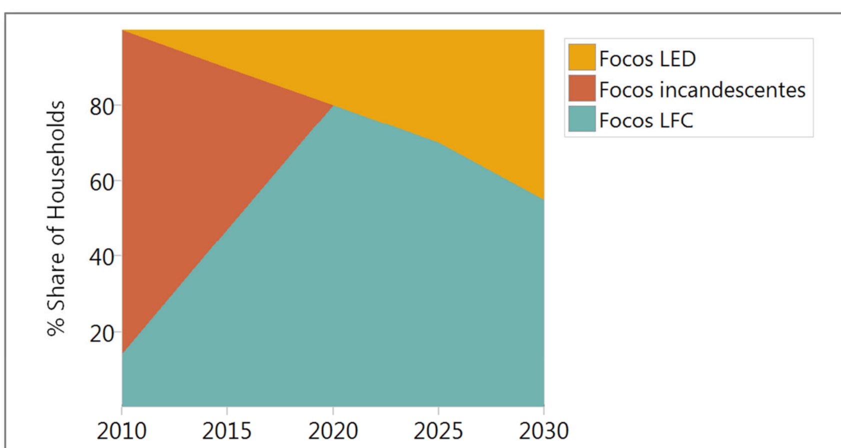
Demand\Residencial\Projections\Iluminacion\Focos Electricos\

- Activity Level
- Focos LFC: Final Energy Intensity
- Focos incandescentes: Final Energy Intensity
- Focos LED: Final Energy Intensity

Assumptions:

	Assumption	Source
Activity Level [%] - **LFC** - **Incandescentes** - **LED**	 Remainder(100) InterpFSY(2020,0) Interp(2010,0,2015,10,2020,20,2035,30,2030,45)	SEI assumes a slow transition to CFLs and LEDs as incandescents stop being used by 2020 (loosely based on McKinsey assumptions)

Gaps in current data: The best way to improve this mitigation action is to use real lighting targets for penetration of different technologies, rather than the current simplified activity level projections.



Air Conditioning

Scenario name in LEAP: R2: HVAC – Aire Acondicionado

Lever Name in McKinsey 2009: This scenario combines the following 2 scenarios from McKinsey:

- L.2.1.3.2 Retrofit HVAC maintenance - residential
- L.2.1.3.3 Retrofit HVAC – air conditioning, residential

Variables Affected:

Demand\Residencial\Projections\Climatizacion:

- Activity Level
- Final Energy Intensity

Assumptions:

	Assumption	Source
Activity Level [%]	Interp(2010,0,2030,100)	SEI assumes a slow transition to more efficient HVAC systems from existing devices (loosely based on McKinsey assumptions)
Final Energy Intensity [kWh/household]	Existente: Final Energy Intensity[kW-hr]*(1-0.19-0.15)	SEI assumes that retrofitted HVAC systems will be 34% (19+15) more efficient than existing systems. The 34% number comes from "Appliances savings potential" from McKinsey 2009.

Gaps in current data: A next step would be to include official targets for technology penetration and efficiency improvements.

Appliances

Philosophy: There is a difference in categorization of end uses between the INECC 2013 baseline and McKinsey's model. McKinsey's appliances bundle includes dehumidifiers, air cleaners, exhaust fans, ceiling fans, dishwashers, refrigerators and clothes washers. SEI applies McKinsey's assumptions to ceiling fans, refrigerators and other residential electricity use. We added a new branch for high efficiency (HE) technologies to facilitate this modeling.

Scenario Name in LEAP: R3: Electrodomesticos

Lever Name in McKinsey 2009: L.2.1.4.0 Appliances – residential.

Variables Affected:

Demand\Residencial\Projections\

- Climatizacion\Ventilador\HE alta eficiencia: Activity Level, Final Energy Intensity
- Refrigeracion de alimentos\Refrigeradoras\HE alta eficiencia: Activity Level, Final Energy Intensity
- Otros\HE alta eficiencia: Activity Level, Final Energy Intensity

Assumptions:

	Assumption	Source
Activity Level [%]	Interp(2010,0,2030,100)	SEI assumes a slow transition to high efficiency appliances from existing devices (loosely based on McKinsey assumptions)
Final Energy Intensity [kWh/household]	Existente:Final Energy Intensity[kW-hr]*(1-0.35)	SEI assumes that new high efficiency appliances will be 35% more efficient than current devices. The 35% number comes from "Appliances savings potential" from McKinsey 2009.

Gaps in current data: A next step would be to expand the end-use structure to include more devices, and then use local data for potential efficiency improvements by device, which would be more accurate than international McKinsey data. The current version of the model does not include efficiency improvements in the baseline due to a lack of agreement of official data sources and INECC staff, but this would be a helpful improvement as well.

Consumer Electronics

Philosophy: SEI assumes that McKinsey's category of "consumer electronics" is best represented by the Entertainment end use in the 2013 model. We created a branch for high efficiency (HE) electronics to facilitate this modeling.

Scenario name in LEAP: R4: Electronica de consumo

Lever Name in McKinsey 2009: L.2.1.6.0 Electronics – consumer, residential.

Variables Affected:

Demand\Residencial\Projections\Entretenamiento\HE alta eficiencia:

- Activity Level

- Final Energy Intensity

Assumptions:

	Assumption	Source
Activity Level [%]	Interp(2010,0,2030,100)	SEI assumes a slow transition to high efficiency electronics from existing devices (loosely based on McKinsey assumptions)
Final Energy Intensity [kWh/household]	Existente:Final Energy Intensity[kW-hr]*(1-0.17)	SEI assumes that new high efficiency appliances will be 17% more efficient than current devices. The 17% number comes from "Appliances savings potential" from McKinsey 2009.

Gaps in current data: A next step would be to expand the end-use structure to include more devices, and then use local data for potential efficiency improvements by device, which would be more accurate than international McKinsey data. The current version of the model does not include efficiency improvements in the baseline due to a lack of agreement of official data sources and INECC staff, but this would be a helpful improvement as well.

Water Heaters

Philosophy: McKinsey assumes that solar hot water heating would have a 35% of hot water heating by 2030, but in our baseline scenario, we had assumed that electricity was only 7% of the total hot water demand. SEI therefore modified assumptions so that solar technologies would simply replace electric and LPG technologies by 2030.

Scenario name in LEAP: R5: Calentadoras de Agua

Lever Name in McKinsey 2009: L.2.1.8.1 Water Heating – replacement of electric, residential

Variables Affected:

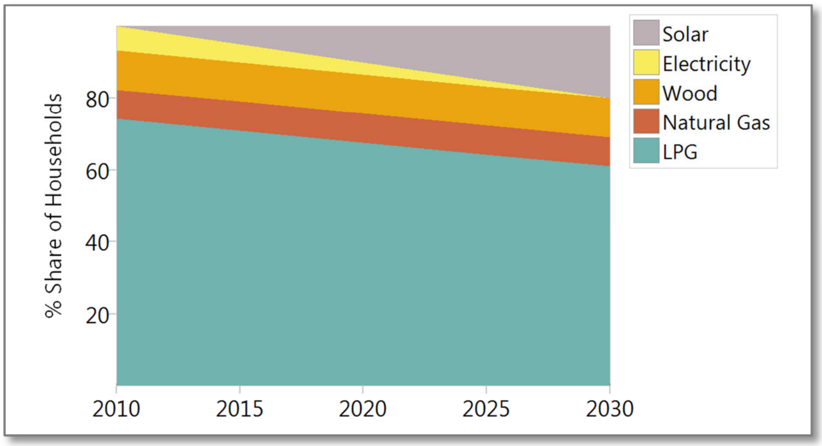
Demand\Residencial\Projections\Calentamiento de agua\

- Electricity: Activity Level
- Solar: Activity Level

Assumptions:

	Assumption	Source
Activity Level [%]		SEI assumes a slow transition

- **Electricity**	Interp(2010,baseyearvalue,2030,0)	to solar hot water heating,
- **Solar**	Interp(2010,0,2030,20)	replacing electric and LPG
- **LPG**	Remainder(100)	technologies.



Gaps in current data: We recommend meeting with residential stakeholders to use national official data for expected technology penetrations.

New Stoves

Philosophy: MEDEC included an efficient new stoves measure that focused on installing improved wood 50% more efficient than in all households that currently have traditional open fires. MEDEC assumes that these new stoves are 50% more efficient than open fires. SEI assumes that this transition happens slowly over time.

Scenario name in LEAP: R6: Estufas Nuevas

Lever Name in McKinsey 2009: This measure was not included in McKinsey.

Variables Affected:

Demand\Residencial\Projections\Coccion de alimentos\Wood:

- Final Energy Intensity

Assumptions:

	Assumption	Source
Final Energy Intensity [GJ/household]	Interp(2010,BaselineValue,2030,BaselineValue*0.5)	SEI assumes a slow transition to efficient wood stoves. MEDEC assumes a 50% efficiency improvement over baseline devices.

Gaps in current data: We recommend meeting with residential stakeholders to use national official data for expected technology penetrations.

McKinsey Measures not Included

The only measure not included in the INECC 2013 portfolio was L.2.1.5.5 (residential building retrofits) because the final model showed a result of zero mitigation potential.

Services

Sector Overview

The Services sector is modeled in a top-down approach, which means that we do not have data on individual technologies or devices within this sector that use energy, we only know the total. To model our mitigation options in this sector, we use a total energy methodology, which allows us to enter negative energy "wedges" into LEAP, instead of using an activity level or device-specific data. We also make use of user-created variables to document key variables needed to calculate energy savings from each measure.

Mitigation Measures

Lighting – Change of technology

Philosophy: Since this sector does not have end use data for the baseline, we created many user variables to add transparency to the calculations of energy savings from switches in lighting options in this sector. Each variable has specific settings that can be checked by right clicking on it and selecting "variable properties." We use LEAP's Total Energy methodology, so total energy savings are calculated in the Total Energy variable and the Activity Level variable is not used.

Scenario name in LEAP: C1: Cambio de Focos, comercial

Lever Name in McKinsey 2009: This scenario combines the following 3 scenarios from McKinsey:

- L.2.2.1.1 Lighting – switch incandescent to LEDs, commercial
- L.2.2.1.2 Lighting – switch CFLs to LEDs, commercial
- L.2.2.1.3 Lighting – T12 to T8/T5, commercial

Variables Affected:

Demand\Servicios\Comercial\Mitigacion\Iluminacion\

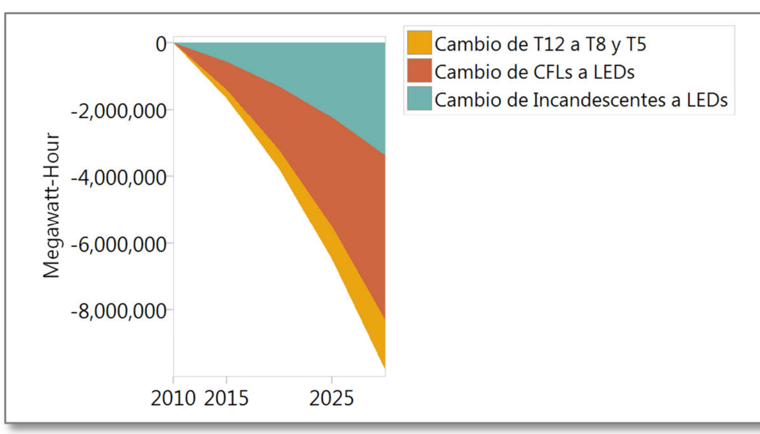
- Lumen hora demanda comercial (lumen-hour demand commercial), Watts per Lumen LED
- Cambio de Incandescentes a LEDs: Total Energy, Penetracion de LEDs de incandescentes, Watts per Lumen Incandescente
- Cambio de CFLs a LEDs: Total Energy, Penetracion de LEDs de CFLs, Watts per Lumen CFL

- Cambio de T12 a T8 y T5: Total Energy, Penetracion de T8 T5, Watts per Lumen T12, Watts per Lumen T8 T5

Assumptions:

	Assumption	Source
Lumen hora demand comercial	Interp(2010, 1181385252, 2015, 1368723810, 2020, 1564301946, 2025, 1781492903, 2030, 2021132271)	McKinsey 2009 assumes the total lumen-hours of demand in the commercial sector.
Watts per Lumen - **T8 T5** - **T12**	 - 0.0105 - 0.0137	McKinsey 2009
Watts per Lumen - **LED** - **CFL** - **Incandescente**	 - 1/150 - 1/45 - 1/12	SEI assumption
Penetration of technology - **LEDs vs. Incandescentes** - **LEDs vs. CFLs** - **T8/T5 vs. T12**	 - Interp(2010,0,2030,2) - Interp(2010,0,2030,11) - Interp(2010,22,2030,60)-Interp(2010,22,2030,37	SEI Assumption based on McKinsey lever assumptions.
Total Energy	(-) Total Lumen-hour demand * (Baseline Watts/lumen – Mitigation Watts/lumen)*Penetration of technology	SEI Assumption

Gaps in current data: We recommend trying to create an end-use structure for the commercial sector to facilitate a more transparent mitigation scenario and to ensure consistency between baseline and mitigation assumptions.



Lighting – Improved Controls

Philosophy: This scenario is approached similarly to the previous lighting scenario. We use LEAP's Total Energy methodology coupled with user variables to calculate energy savings.

Scenario name in LEAP: C2: Controles en Iluminacion

Lever Name in McKinsey 2009: This scenario combines the following two scenarios from McKinsey:

- L.2.2.1.4 Lighting – new build controls, commercial
- L.2.2.1.2 Lighting – retrofit controls, commercial

Variables Affected:

Demand\Servicios\Comercial\Mitigacion\Iluminacion\

- Lumen hora demanda comercial (lumen-hour demand commercial)
- Controles en nueva iluminacion: Total Energy, Penetracion de controles, Watts per Lumen Existente Promedio, Ahorros de controles nuevos
- Controles en retrofit iluminacion: Total Energy, Penetracion de controles retrofit, Ahorros de controles retrofit

Assumptions:

	Assumption	Source
Lumen hora demand comercial	Interp(2010, 1181385252, 2015, 1368723810, 2020, 1564301946, 2025, 1781492903, 2030, 2021132271)	McKinsey 2009 assumes the total lumen-hours of demand in the commercial sector.
Watts per Lumen existente promedio	- 0.019	L.2.2.1.5 McKinsey 2009 - average commercial W/lm
Penetration of technology - **Controles Nuevos** - **Controles Retrofit**	- Interp(2010,0,2030,100)-Interp(2010,0,2030,50) - (Interp(2010,0,2030,100)-Interp(2010,0,2030,10))*Interp(2010,.76, 2015,.68, 2020,.59, 2025,.53, 2030,.48)	SEI Assumption based on McKinsey lever assumptions.
Ahorros - **Nuevos** - **Retrofit**	- 50% - 29%	Percent savings potential comes from McKinsey 2009
Total Energy	(-) Total Lumen-hour demand * (Average Watts/lumen)*Penetration of technology*% Energy Savings	SEI Assumption

Gaps in current data: We recommend verifying the McKinsey efficiency and penetration data with local stakeholders.

HVAC Retrofits

Philosophy: We use LEAP's Total Energy methodology coupled with user variables to calculate energy savings.

Scenario name in LEAP: C3: HVAC - Retrofit

Lever Name in McKinsey 2009: This scenario combines the following two scenarios from McKinsey:

- L.2.2.3.0 Retrofit HVAC, commercial
- L.2.2.1.2 Retrofit HVAC controls, commercial

Variables Affected:

Demand\Servicios\Comercial\Mitigacion\HVAC\

- Uso de energia Comercial Total (total electricity use in the commercial sector), Participacion de HVAC en consume de energia Comerc (Share of HVAC in total Commercial electricity use)
- Retrofit HVAC: Total Energy, Penetracion de HE HVAC, Ahorros de HE HVAC
- Retrofit Controles: Total Energy, Penetracion de HVAC Controles, Ahorros de HVAC Controles

Assumptions:

	Assumption	Source
Uso de energia comercial total	Interp(2010, 37896604.77, 2015, 42539996.09, 2020, 48507519.88, 2025, 54215901.62, 2030, 59672728.81)	McKinsey 2009 assumes total Comercial MWh
Participacion de HVAC en consumo de energia comercial	20%	L.2.2.1.5 McKinsey
Penetration of technology - **HVAC Retrofit** - **Controles**	 - Interp(2010,25,2020,100)-Interp(2010,25,2030,55) - Interp(2010,6,2030,100)-Interp(2010,6,2030,8)	SEI Assumption based on McKinsey lever assumptions.
Ahorros - **Retrofit** - **Controles**	 - 17% - 15%	Percent savings potential comes from McKinsey 2009
Total Energy	(-) Total Commercial Electricity Use*Share of HVAC electricity use*Penetration of	SEI Assumption

	mitigation measure*% Energy Savings	

Gaps in current data: We recommend verifying the McKinsey efficiency and penetration data with sectoral experts.

Appliances

Philosophy: We use LEAP's Total Energy methodology coupled with user variables to calculate energy savings.

Scenario name in LEAP: C4: Electrodomesticos - Comercial

Lever Name in McKinsey 2009:

- L.2.2.4.0 Appliances – refrigerators, commercial

Variables Affected:

Demand\Servicios\Comercial\Mitigacion\Electrodomesticos\

- Uso de energia Comercial Total (total electricity use in the commercial sector)
- HE electrodomesticos: Participacion de electrodomesticos en Comercial (Share of appliances in total Commercial electricity use), Participacion de HE electrodomesticos, Ahorros de HE electrodomesticos

Assumptions:

	Assumption	Source
Uso de energia comercial total	Interp(2010, 37896604.77, 2015, 42539996.09, 2020, 48507519.88, 2025, 54215901.62, 2030, 59672728.81)	McKinsey 2009 assumes total Comercial MWh
Participacion de electrodomesticos en comercial	8%	McKinsey L.2.2.4.0
Participacion de HE electrodomesticos	Interp(2010,29,2030,100)-Interp(2010,29,2030,48)	McKinsey 2009
Ahorros de HE electrodomesticos	17%	Percent savings potential comes from McKinsey 2009
Total Energy	(-) Total Commercial Electricity Use*Share of appliance electricity use*Penetration of high efficiency appliances *% Energy Savings	SEI Assumption

Gaps in current data: We recommend verifying the McKinsey efficiency and penetration data with sectoral experts.

Office Electronics

Philosophy: We use LEAP's Total Energy methodology coupled with user variables to calculate energy savings.

Scenario name in LEAP: C5: Electronicos de Oficina

Lever Name in McKinsey 2009:

- L.2.2.6.0 Electronics - office, commercial

Variables Affected:

Demand\Servicios\Comercial\Mitigacion\Electronicos\

- Uso de energia Comercial Total (total electricity use in the commercial sector)
- HE Electronicos: Participacion de Electronicos en demanda comercial (Share of electronics in total Commercial electricity use), Participacion de HE electronicos, Ahorros de HE electronicos

Assumptions:

	Assumption	Source
Uso de energia comercial total	Interp(2010, 37896604.77, 2015, 42539996.09, 2020, 48507519.88, 2025, 54215901.62, 2030, 59672728.81)	McKinsey 2009 assumes total Comercial MWh
Participacion de electronicos en comercial	8%	L.2.2.6.0 McKinsey
Participacion de HE electrodomesticos	Interp(2010,3,2030,100)-Interp(2010,3,2030,29)	McKinsey 2009
Ahorros de HE electrodomesticos	48%	Percent savings potential comes from McKinsey 2009
Total Energy	(-) Total Commercial Electricity Use*Share of electronics electricity use*Penetration of high efficiency electronics *% Energy Savings	SEI Assumption

Gaps in current data: We recommend verifying the McKinsey efficiency and penetration data with sectoral experts.

Water Heaters

Philosophy: We use LEAP's Total Energy methodology coupled with user variables to calculate energy savings.

Scenario name in LEAP: C6: Calentadoras de Agua - Comercio

Lever Name in McKinsey 2009:

- L.2.2.8.1 Electronics – Water Heating – replacement of electric, commercial

Variables Affected:

Demand\Servicios\Comercial\Mitigacion\Calentadoras de Agua\

- Uso de energia Comercial Total (total electricity use in the commercial sector)
- Cambio de electrica a solar: Participacion de calentamiento de agua en comercio (Share of hot water heating in total Commercial electricity use), Participacion de solar

Assumptions:

	Assumption	Source
Uso de energia comercial total	Interp(2010, 37896604.77, 2015, 42539996.09, 2020, 48507519.88, 2025, 54215901.62, 2030, 59672728.81)	McKinsey 2009 assumes total Comercial MWh
Participacion de calentamiento de agua en comercial	20%	McKinsey 2009
Participacion de Solar	Interp(2010,2,2030,35)-Interp(2010,2,2030,5)	McKinsey 2009
Total Energy	(-) Total Commercial Electricity Use*Share of water heating electricity use*Penetration of solar technology	SEI Assumption

Gaps in current data: We recommend verifying the McKinsey efficiency and penetration data with sectoral experts.

McKinsey Measures not Included

Two measures from McKinsey were not modeled in this sector related to building efficiency:

- L.2.2.5.1_0_ Aggregated New Build efficiency package, commercial
- L.2.2.5.2 Retrofit Building envelope, commercial

These two measures were based on assumptions of energy savings per m^2 of floor space, but we do not have access to McKinsey's assumptions about total floor space. A next iteration of this model should explore official assumptions of floor space projections and include these measures.

Industry

Sector Overview

The industry sector is modeled by sub-sector, so has more disaggregation than the commercial sector, for example, but does not have data by end use or device and is therefore a top down methodology. Some measures in this sector are modeled as fuel switching or efficiency improvements in the baseline data structure, while others are modeled as negative energy savings wedges.

Mitigation Measures

Efficiency in Iron and Steel

Philosophy: McKinsey has two levers that model efficiency improvements in the iron and steel sector. It was not clear what specific actions would be implemented to achieve these savings or whether the two measures should be added together. SEI has assumed that the two measures together can save 0.5% per year in efficiency.

Scenario name in LEAP: I1: Eficiencia, siderurgia

Lever Name in McKinsey 2009: This scenario is a combination of two levers:

- L.3.1.7.0 Energy Efficiency (general)
- L.3.1.13.0 Energy efficiency II (general)

Variables Affected:

Demand\Industria\Siderurgia\Baseline:

- Final Energy Intensity

Assumptions:

	Assumption	Source
Final Energy Intensity	Growth(-0.5%)	McKinsey 2009 assumes 0.3% and 0.2%, respectively, for annual improvement potential from energy efficiency measures. SEI has assumed that they are additive.

Gaps in current data: We recommend verifying the McKinsey assumptions and replace the total figure with improvements from specific measures.

Alternate Fuels in Cement

Scenario name in LEAP: I2: Combustibles alternativos, cemento

Lever Name in McKinsey 2009: This scenario is a combination of two levers:

- L.3.2.3A.00 Alternative fuels - Waste
- L.3.2.3B.00 Alternative fuels - Bio

Variables Affected:

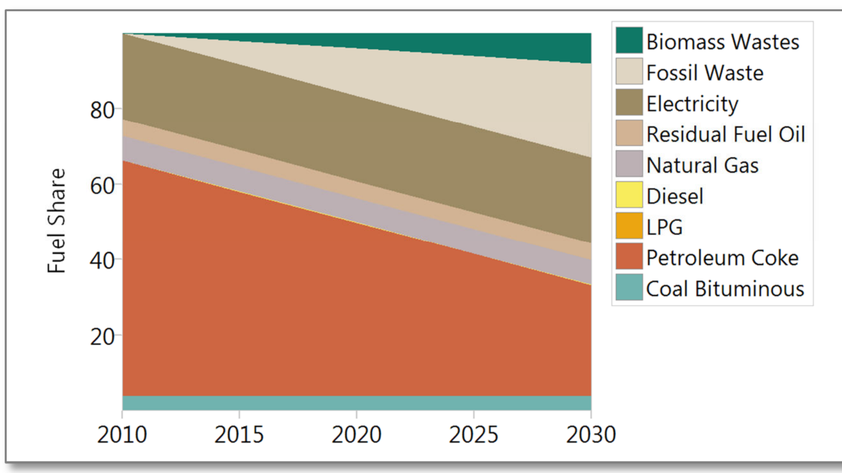
Demand\Industria\Cemento\Baseline:

- Fuel Share
- Environmental Loading

Assumptions:

Assumption		Source
Fuel Share - **Fossil Waste** - **Biomass Waste**	 - Interp(2010,0,2030,25) - Interp(2010,0,2030,8)	McKinsey 2009
Fuel Share - **Petroleum Coke**	- Remainder(100)	SEI assumes that the new fuels will replace Petroleum Coke, the dominant fuel from the baseline.
Environmental Loading	0	McKinsey 2009 assumed no emissions from new waste fuels

Gaps in current data: We recommend discussing the fuel share assumptions with sectoral experts.



Fuel Switching in Chemicals

Scenario name in LEAP: I3: Cambio de combustibles, quimica

Lever Name in McKinsey 2009: This scenario is a combination of two levers:

- L.3.4.30.0 Fuel shift oil to gas, new build
- L.3.4.31.0 Fuel shift oil to gas, retrofit

Variables Affected:

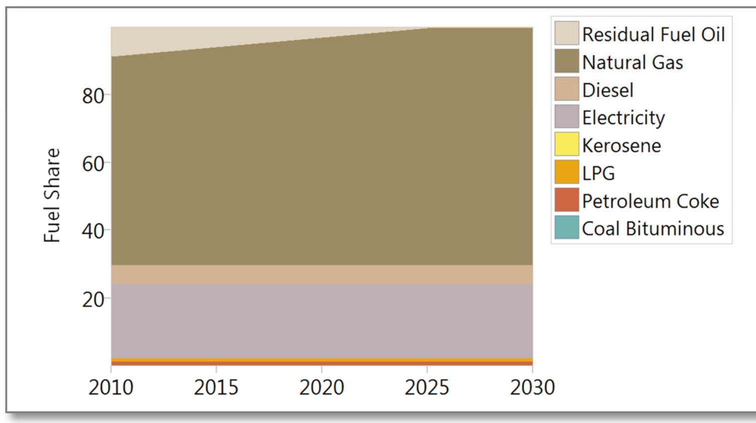
Demand\Industria\Quimica\Baseline:

- Fuel Share

Assumptions:

	Assumption	Source
Fuel Share - **Natural Gas** - **Residual Fuel Oil**	 - InterpFSY(2030,70) - Remainder(100)	McKinsey 2009 assumed a 80% penetration of Natural gas replacing fuel oil. Based on the INECC 2013 baseline, this did not make sense, so SEI assumed a 70% penetration.

Gaps in current data: We recommend discussing the fuel share assumptions with sectoral experts.



PRONASE Cogeneration

Philosophy: We use LEAP's Total Energy methodology coupled with estimates from the Programa Nacional para el Aprovechamiento Sustentable de la Energia (PRONASE) about potential electricity savings to calculate emissions for this measure.

Scenario name in LEAP: I4: Cogeneracion PRONASE

Lever Name in McKinsey 2009:

- Cogeneracion (Pronase) (external)

Variables Affected:

Demand\Industria\Mitigacion\Cogeneracion PRONASE:

- Total Energy

Assumptions:

	Assumption	Source
Total Energy [TWh]	-Interp(2010,0,2020, 4, 2030,48.3)	McKinsey 2009 used PRONASE's estimates for a low and high scenario. SEI assumed the high scenario. (The low scenario assumed energy savings of 2 TWh in 2020 and 24.2 TWh in 2030.)

Gaps in current data: These numbers should be checked with PRONASE to see if any updates have been made to the original estimates.

Charcoal in Industry

Philosophy: This external measure was provided in the MEDEC 2009 mitigation study with the goal of meeting 75% of industrial coke demand in Mexico with charcoal (carbon vegetal). The measure also included the target of producing more charcoal for urban residential and commercial consumption, but SEI has only focused on industrial demand. Iron and Steel is the only subsector that uses significant metallurgical coke (SEI has assumed that only coal coke is replaced).

Scenario name in LEAP: I5: Cambio de Coque a Carbon Vegetal

Lever Name in McKinsey 2009: This measure was not included in the McKinsey study.

Variables Affected:

Demand\Industria\Siderurgia\Baseline:

- Fuel Share

Assumptions:

	Assumption	Source
Fuel Share [%] - **Metallurgical Coke** - **Charcoal**	 - Interp(2010,baselinevalue,2030, baselinevalue*0.25) - Remainder(100)	Based on MEDEC's assumptions, SEI assumed that coke would slowly transition to being used only 25% of the value in the baseline while charcoal fills the need.

Gaps in current data: These numbers should be vetted with local sectoral experts.

McKinsey Measures not Included

Many measures in the industry sector were not able to measured due to a lack of sufficient documentation in McKinsey and a lack of disaggregation in the baseline. Most commonly, penetrations were given for a particular type of technology, but there is no official data in Mexico or assumptions from McKinsey about the total number of that technology in Mexico. Other measures had assumptions that did not match with other national data used in the baseline. For example, levers L.3.4.8.0 and L.3.4.9.0 focus on a fuel shift in the chemical industry from coal to biomass, but the National Energy Balances do not report coal being consumed in that sector, and for this reason those two levers were excluded.

The full list of levers not included in the current analysis is below. The next iteration of the mitigation model would benefit from extended data collection within the key industries (iron and steel, cement, sugar and chemicals) to flush out the potential to model mitigation actions.

L.3.1.10.0 Coke substitution, new build
L.3.1.11.0 Coke substitution, retrofit
L.3.1.2.0 Co-generation - New build
L.3.1.3.0 Co-generation - Retrofit
L.3.1.4.0 Direct Casting, new build
L.3.1.5.0 Smelt reduction, new build
L.3.1.6.0 Smelt reduction, retrofit
L.3.1.8.0 CCS, new build
L.3.1.9.0 CCS, retrofit
L.3.2.4A.00 Post combustion CCS- Retrofit
L.3.2.4B.00 Post combustion CCS- New capacity
L.3.2.5A.00 Waste heat recovery
L.3.4.10.0 CCS Ammonia, new build
L.3.4.11.0 CCS Ammonia, retrofit
L.3.4.12.0 CCS Direct energy, new build
L.3.4.13.0 CCS Direct energy, retrofit
L.3.4.17.0 Process intensification, energy, level 1
L.3.4.18.0 Process intensification, energy, level 2
L.3.4.19.0 Process intensification, energy, level 3
L.3.4.2.0 Motor Systems, new build
L.3.4.20.0 Catalyst optimization, process, level 1
L.3.4.23.0 Catalyst optimization, energy, level 1
L.3.4.24.0 Catalyst optimization, energy, level 2
L.3.4.25.0 Catalyst optimization, energy, level 3
L.3.4.26.0 CHP, new build
L.3.4.27.0 CHP, retrofit
L.3.4.28.0 Ethylene Cracking, new build
L.3.4.29.0 Ethylene cracking, retrofit
L.3.4.3.0 Motor Systems, retrofit
L.3.4.30.0 Fuel shift oil to gas, new build
L.3.4.31.0 Fuel shift oil to gas, retrofit
L.3.4.4.0 N2O Decompisition of Adipic acid, new build

L.3.4.5.0 N2O Decompisition of Adipic acid, retrofit
L.3.4.6.0 N2O Decompisition of Nitric acid, new build
L.3.4.7.0 N2O Decompisition of Nitric acid, retrofit
L.3.4.8.0 Fuel shift coal to biomass, new build
L.3.4.9.0 Fuel shift coal to biomass, retrofit
L.3.6.1.0 Other Industry
Co-generation, other industry
Co-generation, sugar

Transport

Sector Overview

The transport sector has a disaggregated baseline structure for road transport. In most cases, individual measures are modeled based on the baseline structure set up in the INECC 2013 model with assumptions from the McKinsey 2009 analysis. This means that though the assumptions are similar, the results are often different because of the use of different baselines.

Mitigation Measures

Sugarcane biofuel

Philosophy: This McKinsey lever gives the assumption that sugarcane will reach 10.5% penetration by 2015. SEI assumes that this will happen in LDVs only, replacing gasoline. This means that this will impact the subcompact, compact, sports and passenger duty categories from CTS.

Scenario name in LEAP: T1: Cana de Azucar Biofuel

Lever Name in McKinsey 2009:

- L.4.1.BE.4 Sugarcane

Variables Affected:

Demand\Transporte\Projections\Todos Usos Finales\Autotransporte\

- Subcompactos\Cana de Azucar: Activity Level, Final Energy Intensity
    - Cana de Azucar\Environmental Loading
- Compactos\Cana de Azucar: Activity Level, Final Energy Intensity
    - Cana de Azucar\Environmental Loading
- Lujo y Deportivo\Cana de Azucar: Activity Level, Final Energy Intensity
    - Cana de Azucar\Environmental Loading
- Ligeros Pasajero\Cana de Azucar: Activity Level, Final Energy Intensity
    - Cana de Azucar\Environmental Loading

Assumptions:

Variable	Assumption	Source
Activity Level [% share of veh-km] - Subcompact - Compact - Luxury/Sport - Passenger Duty	Interp(2010,0,2015,10.45)	McKinsey 2009.
Final Energy Intensity [MJ/veh-km]	Gasolina:Final Energy Intensity[MJ]*(32/21)	SEI based on McKinsey energy content assumptions. McKinsey 2009 includes the assumption that Gasoline has an energy content of 32 MJ/l and bioethanol has the energy content of 21 MJ/l
Environmental Loading [Gramme CO_2/MJ]	26	McKinsey 2009.

Gaps in current data: All assumptions should be vetted by local experts to verify that the international numbers used by McKinsey make sense for Mexico. Additionally, the assumptions about which modes of transport will be best suited to biofuel use should be discussed by stakeholders in the transport sector.

Switchgrass Biofuel

Philosophy: This McKinsey lever gives the assumption that switchgrass will reach 14.6% penetration by 2030. SEI assumes that this will happen in LDVs only, replacing gasoline. This means that this will impact the subcompact, compact, sports and passenger duty categories from CTS.

Scenario name in LEAP: T2: Switchgrass Biocombustible

Lever Name in McKinsey 2009:

- L.4.1.BE.8 Switchgrass

Variables Affected:

Demand\Transporte\Projections\Todos Usos Finales\Autotransporte\

- Subcompactos\Switchgrass: Activity Level, Final Energy Intensity
  - Switchgrass\Environmental Loading
- Compactos\Switchgrass: Activity Level, Final Energy Intensity
  - Switchgrass\Environmental Loading
- Lujo y Deportivo\Switchgrass: Activity Level, Final Energy Intensity
  - Switchgrass\Environmental Loading

- Ligeros Pasajero\Switchgrass: Activity Level, Final Energy Intensity
    - Switchgrass\Environmental Loading

Assumptions:

Variable	Assumption	Source
Activity Level [% share of veh-km] - Subcompact - Compact - Luxury/Sport - Passenger Duty	Interp(2015,0,2020,7.275,2025,10.91,2030,14.55)	McKinsey 2009.
Final Energy Intensity [MJ/veh-km]	Gasolina:Final Energy Intensity[MJ]*(32/21)	SEI based on McKinsey energy content assumptions. McKinsey 2009 includes the assumption that Gasoline has an energy content of 32 MJ/l and bioethanol has the energy content of 21 MJ/l
Environmental Loading [Gramme CO_2/MJ]	25	McKinsey 2009.

Gaps in current data: All assumptions should be vetted by local experts to verify that the international numbers used by McKinsey make sense for Mexico. Additionally, the assumptions about which modes of transport will be best suited to biofuel use should be discussed by stakeholders in the transport sector.

HDV Efficiency Improvements

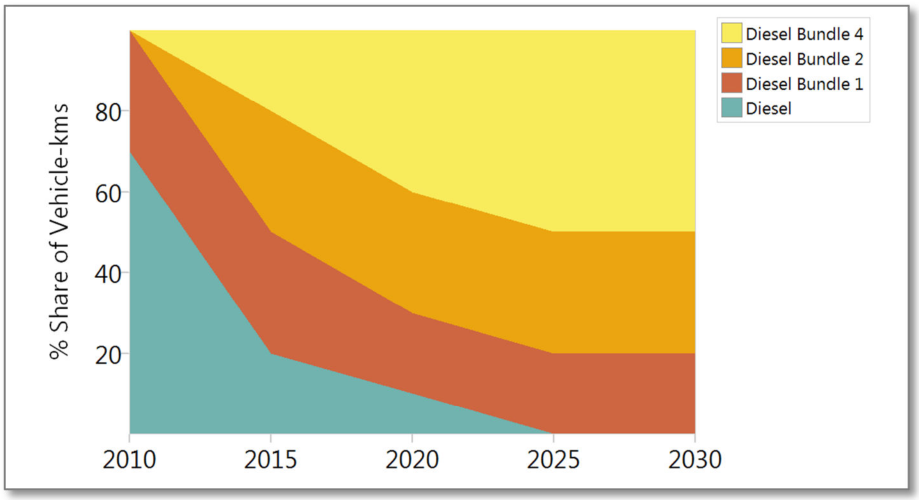
Philosophy: This McKinsey scenario is a combination of multiple McKinsey levers targeting efficiency in heavy duty vehicles. The original McKinsey set includes 4 bundles of efficiency improvements, but the second iteration of the model (RawModelOutput mod) and all subsequent McKinsey results exclude bundle 3 (and show zero mitigation abatement), though the penetrations appear to have remained the same for the other bundles. SEI concluded that this was inconsistent as documented, and modified the penetrations for bundles 1 and 2 to give a more realistic picture of how efficiency improvements might play out for HDVs.

McKinsey Assumptions:

HDV Diesel Bundle 0	percent	100.0%	70.0%	0.0%	0.0%	0.0%	0.0%
HDV Diesel Bundle 1	percent	0.0%	30.0%	30.0%	10.0%	0.0%	0.0%

HDV Diesel Bundle 2	percent	0.0%	0.0%	30.0%	10.0%	0.0%	0.0%
HDV Diesel Bundle 3	percent	0.0%	0.0%	20.0%	40.0%	50.0%	50.0%
HDV Diesel Bundle 4	percent	0.0%	0.0%	20.0%	40.0%	50.0%	50.0%

SEI Assumptions:



Scenario name in LEAP: T3: HDV Eficiencia

Lever Name in McKinsey 2009: This lever combines 3 McKinsey levers as shown below:

- L.4.1.H.D1
- L.4.1.H.D2
- L.4.1.H.D4
- Additionally, the original McKinsey output used L.4.1.H.D3 (bundle 3)

Variables Affected:

Demand\Transporte\Projections\Todos Usos Finales\Autotransporte\Carga Pesada

- Diesel Bundle 1: Activity Level, Final Energy Intensity
- Diesel Bundle 2: Activity Level, Final Energy Intensity
- Diesel Bundle 4: Activity Level, Final Energy Intensity

Assumptions:

Variable	Assumption	Source
Activity Level [% share		SEI assumption to fill gaps of

of veh-km] - Bundle 1 - Bundle 2 - Bundle 4	 - Interp(2010,30, 2015,30, 2020, 20) - Interp(2010,0, 2015,30) - Interp(2010,0, 2015, 20, 2020, 40, 2025, 50)	not using bundle 3.
Final Energy Intensity [MJ/veh-km] - Bundle 1 - Bundle 2 - Bundle 4	 - Diesel:Final Energy Intensity[MJ]*(1-Interp(2010, 0.005, 2015, 0.0175, 2020, 0.03)) - Diesel:Final Energy Intensity[MJ]*(1-Interp(2010, 0.0108, 2015, 0.03756, 2020, 0.06395, 2025,0.0688)) - Diesel:Final Energy Intensity[MJ]*(1-Interp(2010, 0.03553, 2015, 0.06162, 2020, 0.110753, 2025, 0.120016, 2030, 0.12923))	SEI created equations to calculate final energy intensity from McKinsey's assumptions about efficiency improvements over time. For example, bundle 1 results in a 3% efficiency improvement by 2025, where bundle 4 results in a 13% efficiency improvement by 2025.

Gaps in current data: All assumptions should be vetted by local experts to verify that the international numbers used by McKinsey and the assumptions made by SEI make sense for the transport sector in Mexico. Additionally, the assumptions about which modes of transport will be best suited to biofuel use should be discussed by stakeholders in the transport sector.

LDV Efficiency Improvements

Philosophy: This McKinsey scenario explores efficiency improvements in gasoline-powered light duty vehicles. The output of McKinsey's 2009 analysis included abatement results for 4 bundles of LDV efficiency improvements, but documented penetrations for all bundles is zero, apart from LDV bundle 1. Because of this, SEI has only modeled the first efficiency bundle. SEI has assumed that LDV includes the CTS categories of subcompact, compact, luxury and sports cars and light passenger.

Scenario name in LEAP: T4: LDV Eficiencia

Lever Name in McKinsey 2009:

- L.4.1.L.G1

Variables Affected:

Demand\Transporte\Projections\Todos Usos Finales\Autotransporte\

- Subcompactos\Gasolina Bundle 1: Activity Level, Final Energy Intensity
- Compactos\Gasolina Bundle 1: Activity Level, Final Energy Intensity
- Lujo y Deportivo\Gasolina Bundle 1: Activity Level, Final Energy Intensity
- Ligeros Pasajero\Gasolina Bundle 1: Activity Level, Final Energy Intensity

Assumptions:

Variable	Assumption	Source
Activity Level [% share of veh-km]	Interp(2015,0,2020,6,2025,9,2030,13)	McKinsey 2009.
Final Energy Intensity [MJ/veh-km]	Gasolina:Final Energy Intensity[MJ]*(1-0.1339)	SEI created an equation to calculate final energy intensity from McKinsey's assumptions about efficiency improvements, about 13% compared with baseline gasoline consumption.

Gaps in current data: All assumptions should be vetted by local experts to verify that the international numbers used by McKinsey and the assumptions made by SEI make sense for the transport sector in Mexico. Additionally, stakeholders in the transport sector should discuss the assumptions about which modes of transport will be best suited to biofuel use.

Metro and BRT

Philosophy: This external lever from the McKinsey analysis looked at the number of new subway and bus rapid transit lines that could be added to urban areas in Mexico. SEI has modeled this in a top-down capacity looking only at the total emissions per metro and BRT line. Ideally, this would be modeled by looking at vehicle-kilometers displaced by the new transportation, which would be more complete and consistent with the rest of the modeling in the transport sector. Though this measure has been included, it should be noted that it is not fully represented in the model, because there is no modeling of the energy consumed for each metro and BRT line. This should be updated as soon as possible.

Scenario name in LEAP: T5: Metro y BRT

Lever Name in McKinsey 2009:

- Modern public transport system (Metro and BRT) (external)

Variables Affected:

Demand\Transporte\Projections\Todos Usos Finales\Autotransporte\Mitigacion\Metro y BRT

- BRT: Numero de Lineas, Environmental Loading
- Metro: Numero de Lineas, Environmental Loading

Assumptions:

Variable	Assumption	Source
Numero de Lineas		McKinsey 2009.

- **BRT**	- Interp(2010,0,2030,230)	
- **Metro**	- Interp(2010,0,2030,18)	
Environmental Loading [tCO_2e] - **BRT** - **Metro**	- -10^6*0.05*BRT:Numero de Lineas[Lineas] - -10^6*0.25*Metro:Numero de Lineas[Lineas]	McKinsey 2009 provided esimates of CO2 emissions per line of new transit (they cite Metrobus DF report for BRT emission factor and Low Carbon Growth Plan for Metro).

Gaps in current data: The most important gaps are the needs for energy and vehicle- or passenger-km data related to the projections of impacts from new BRT and metro lines. This will ensure that total energy is being accounted for across the model as well as it will ensure consistency in the overall transport modeling.

Urban Densification

Philosophy: MEDEC included a measure in the transport sector to promote policies to develop and preserve urban centers, focusing on creating easy access to work, school and commercial centers. MEDEC included assumptions about total gasoline and diesel consumption reduced by these measures. SEI assumed that the reduction in energy consumption could be represented by a decrease in total vehicle-km traveled.

Scenario name in LEAP: T6: Densification

Lever Name in McKinsey 2009: Not included in McKinsey 2009.

Variables Affected:

Demand\Transporte\Projections\Todos Usos Finales\Autotransporte\

- Activity Level

Assumptions:

Variable	Assumption	Source
Activity Level [veh-km/peso]	Interp(2010,BaselineValue,2030,BaselineValue*0.95)	SEI

Gaps in current data: We recommend consulting with transport experts to verify that the densification measures proposed by the MEDEC team are sensible in 2013 and that they can be accurately represented by a decrease in vehicle-km.

Bicycles

Philosophy: MEDEC included a measure in the transport sector to implement infrastructure for non-motorized transport and bicycles.

Scenario name in LEAP: T7: Bicycles

Lever Name in McKinsey 2009: Not included in McKinsey 2009.

Variables Affected:

Demand\Transporte\Projections\Todos Usos Finales\Autotransporte\Bicicletas

- Activity Level

Assumptions:

Variable	Assumption	Source
Activity Level [share of vehicle-km]	Interp(2010,0,2030,6)	MEDEC included the assumption percent of trips by bicycle in 2030 in Mexico, which was equal to 6%. SEI assumed this could be modeled as a total share of vehicle-km in 2030.

Gaps in current data: SEI's assumption that six percent of vehicle-km would be achieved through bicycles is very ambitious. This could be improved by getting a better estimate of average distance of trips by bike and number of bike trips per year.

Rail Freight

Philosophy: MEDEC included a measure in the transport sector to increase rail transport of freight. SEI assumes that this rail activity will replace HDVs (Carga Pesada).

Scenario name in LEAP: T8: Carga por ferrocarril

Lever Name in McKinsey 2009: Not included in McKinsey 2009.

Variables Affected:

Demand\Transporte\Projections\Todos Usos Finales\Autotransporte\

- Autotransporte: Activity Level, Vehiculo km reducida en carga
- Otros\Ferroviario\All: Eficiencia de ferrocarril, km por ferrocarril, Total Energy

Assumptions:

Variable	Assumption	Source
Road: Activity Level [vehicle-km/peso]	BaselineValue-Vehiculo km Reducida en Carga[veh-km]/(PIB*1000)	SEI assumes that total road veh-km will decrease as total rail fright increases.
Road: Activity Level [share of vehicle-km] - **Carga Pesada** - **Others**	 - BaselineValue*Interp(2010,1,2030,0.3) - BaselineValue*Interp(2010,1,2030,1.1)	As total veh-km decreases due to decreased road freight, the share of other modes of road transport will increase. SEI assumes this will be by a factor of 1.1 compared to the baseline.
Veh-km reduced in road freight [veh-km]	Interp(2010,0,2030,(100/70)*0.37*321000000/.03)	SEI calculates the vehicle km reduced from the measure from road freight using data from CTS. 37% penetration comes from MEDEC
Rail Efficiency (Efficiencia de Ferrocarril)	0.033	SEI
Km by Rail (km por ferrocarril)	Interp(2010,8132,2030,48150000)	SEI, based on MEDEC assumptions.
Total Energy	Interp(2010,77, 2030,77+(All:km por Ferrocarril[km]/All:Eficiencia de Ferrocarril[km/litro])*ConvertFuelUnits(liter,pj, diesel))	SEI calculates the addition of energy used by this measure.

Gaps in current data: Many of the assumptions for this measure have been made by SEI and the MEDEC analysis. We recommend reviewing the road and rail projections with local transport experts to ensure consistency with other national projections.

McKinsey Measures not Included

Levers that were not included were LDV gasoline efficiency levers (L.4.1.L.G2-4, and L.4.1.L.GHF) due to zero percent penetrations. The external lever controlled Imports of used vehicles was also not included, due to a lack of documentation and understanding of how the underlying assumptions matched with the CTS baseline data.

Electricity Generation

Sector Overview

Electric generation scenarios lump individual technologies together in one scenario to ensure consistency within the integrated supply-side calculations in LEAP. This is different than the sectoral actions which are documented in individual scenarios within demand sectors. SEI has created two scenarios within electricity generation – one partial potential scenario and one maximum potential scenario, which make use of McKinsey's two variables "InstalledBase" (E1) and

"MaxInstalledBase" (E2) capacity assumptions. Mitigation options documented below will include assumptions from both E1 and E2 scenarios. *Please note that the E2 scenario is the one included in the final mitigation scenario because it is the only tested scenario that meets the LAERFTE goal of 65% max fossil fuel usage by 2025.*[45]

New Mitigation Technologies

Offshore Wind

Lever Name in McKinsey 2009: L.1.1.14 Off shore wind

Variables Affected:

Transformation\Generacion de Electricidad\Processes:

- Exogenous Capacity
- Process Efficiency
- Maximum Availability
- Merit Order

Assumptions:

	Assumption	Source
E1 - Exogenous Capacity [MW]	0	"InstalledBase" from McKinsey 2009 (they cite UNDP, EER, Dena)
E2 - Exogenous Capacity [MW]	Interp(2010,100, 2015, 251.5, 2020, 632.5, 2025, 1590.6, 2030, 4000)	"MaxInstalledBase" from McKinsey 2009 (they cite IEA)
Process Efficiency [%]	100%	SEI
Maximum Availability [%]	49-51%	"ProdUptime" form McKinsey 2009 (they cite Vestas)
Merit Order [%]	1 (base load)	SEI

Gaps in current data: A next step would be to find local projections of electric generating capacity instead of the IEA projections used by McKinsey.

Co-fired Biomass

Lever Name in McKinsey 2009: L.1.1.10 Biomass co-firing

Variables Affected:

Transformation\Generacion de Electricidad\Processes:

[45] diputados.gob.mx/LeyesBiblio/pdf/LAERFTE.pdf

- Exogenous Capacity
- Process Efficiency
- Maximum Availability
- Merit Order

Transformation\Generacion de Electricidad\Processes\Biomasa cofired\Feedstock fuels:

- Feedstock Fuel Share

Assumptions:

	Assumption	Source
E1 - Exogenous Capacity [MW]	0	"InstalledBase" from McKinsey 2009
E2 - Exogenous Capacity [MW]	Interp(2010, 0, 2015, 3883.7, 2020, 3868.5, 2025, 1557.2, 2030, 1047)	"MaxInstalledBase" from McKinsey 2009
Process Efficiency [%]	43-46%	"EnergyEfficiency" from McKinsey 2009
Maximum Availability [%]	85-87%	"ProdUptime" form McKinsey 2009
Merit Order [%]	1 (base load)	SEI
Feedstock Fuel Share	10% Biomass, 90% coal	McKinsey

Gaps in current data: A next step would be to find more accurate local data about co-firing in Mexico (percentage share of feedstock fuels, biomass properties, etc.). Additionally, it is not clear from McKinsey's assumptions whether these co-fired plants are new builds or retrofits.

Biomass with CCS New Build

Lever Name in McKinsey 2009: L.1.1.11 Biomass CCS new built

Variables Affected:

Transformation\Generacion de Electricidad\Processes:

- Exogenous Capacity
- Process Efficiency
- Maximum Availability
- Merit Order

Transformation\Generacion de Electricidad\Processes\Biomasa CCS Nueva\Feedstock fuels\Biomass:

- Environmental Loading

Assumptions:

	Assumption	Source
E1 - Exogenous Capacity [MW]	0	"InstalledBase" from McKinsey 2009
E2 - Exogenous Capacity [MW]	Interp(2010, 0, 2015, 3.5, 2020, 21.7, 2025, 160.8, 2030, 1186)	"MaxInstalledBase" from McKinsey 2009
Process Efficiency [%]	16-21%	"EnergyEfficiency" from McKinsey 2009
Maximum Availability [%]	80%	"ProdUptime" form McKinsey 2009
Merit Order [%]	1 (base load)	SEI
Environmental Loading – CO_2	-29.9 * FractionOxidized * (CO2/c)*.9	McKinsey

Gaps in current data: The environmental loading factor of McKinsey (90% of biogenic CO_2) is quite optimistic. We would recommend discussing with local stakeholders what the correct emission factor is.

Coal CCS New Build with EOR

Lever Name in McKinsey 2009: L.1.1.3 Coal CCS new built with EOR

Variables Affected:

Transformation\Generacion de Electricidad\Processes:

- Exogenous Capacity
- Process Efficiency
- Maximum Availability
- Merit Order

Transformation\Generacion de Electricidad\Processes\Carbon CCS Nueva EOR\Feedstock fuels\Coal Bituminous:

- Environmental Loading

Assumptions:

	Assumption	Source
E1 - Exogenous Capacity [MW]	0	"InstalledBase" from McKinsey 2009
E2 - Exogenous Capacity [MW]	Interp(2010,0, 2015, 0.2, 2020, 1.2, 2025, 8.2, 2030, 55.9)	"MaxInstalledBase" from McKinsey 2009
Process Efficiency [%]	36-40%	"EnergyEfficiency" from McKinsey 2009

Maximum Availability [%]	79-87%	"ProdUptime" form McKinsey 2009
Merit Order [%]	1 (base load)	SEI
Environmental Loading – CO_2	25.8 * FractionOxidized * (CO2/c)*0.1	SEI (IPCC tier 1 emission factor multiplied by 10%, meaning 10% of CO_2 is being released, 90% is being captured)

Solar PV

Lever Name in McKinsey 2009: L.1.1.15 Solar PV

Variables Affected:

Transformation\Generacion de Electricidad\Processes:

- Exogenous Capacity
- Process Efficiency
- Maximum Availability
- Merit Order

Assumptions:

	Assumption	Source
E1 - Exogenous Capacity [MW]	Interp(2010,0,2025,344.1,2030,678.2)	"InstalledBase" from McKinsey 2009 (they cite EPIA, Greenpeace, IEA)
E2 - Exogenous Capacity [MW]	Interp(2010,100, 2015, 3000, 2020, 4481.4, 2025, 6694.4, 2030, 10000.2)/2	"MaxInstalledBase" from McKinsey 2009 (they cite EPIA, Greenpeace, IEA). SEI assumes that this is divided by two because the same value is given for both PV and concentrating systems.
Process Efficiency [%]	100%	SEI
Maximum Availability [%]	17%	"ProdUptime" form McKinsey 2009
Merit Order [%]	1 (base load)	SEI

Concentrated Solar

Lever Name in McKinsey 2009: L.1.1.16 Solar conc.

Variables Affected:

Transformation\Generacion de Electricidad\Processes:

- Exogenous Capacity
- Process Efficiency
- Maximum Availability
- Merit Order

Assumptions:

	Assumption	Source
E1 - Exogenous Capacity [MW]	Interp(2025,0,2030,422.3)	"InstalledBase" from McKinsey 2009 (they cite EPIA, Greenpeace, IEA)
E2 - Exogenous Capacity [MW]	Interp(2010,100, 2015, 3000, 2020, 4481.4, 2025, 6694.4, 2030, 10000.2)/2	"MaxInstalledBase" from McKinsey 2009 (they cite EPIA, Greenpeace, IEA). SEI assumes that this is divided by two because the same value is given for both PV and concentrating systems.
Process Efficiency [%]	100%	SEI
Maximum Availability [%]	38-73%	"ProdUptime" form McKinsey 2009
Merit Order [%]	1 (base load)	SEI

Geothermal

Lever Name in McKinsey 2009: L.1.1.17 Geothermal

Variables Affected:

Transformation\Generacion de Electricidad\Processes:

- Exogenous Capacity
- Process Efficiency
- Maximum Availability
- Merit Order

Assumptions:

	Assumption	Source
E1 - Exogenous Capacity [MW]	Interp(2010,965, 2015, 1187.2, 2020, 1304.4, 2025, 1464.7, 2030, 1625)	"InstalledBase" from McKinsey 2009 (they cite UDI)
E2 - Exogenous Capacity [MW]	Interp(2010,1255.8, 2015, 1677.8, 2020, 2241.4, 2025, 2994.5, 2030,	"MaxInstalledBase" from McKinsey 2009 (they cite UDI).

	4000.6)	
Process Efficiency [%]	100%	SEI
Maximum Availability [%]	84-91%	"ProdUptime" form McKinsey 2009
Merit Order [%]	1 (base load)	SEI

Small Hydro

Lever Name in McKinsey 2009: L.1.1.18 Small Hydro

Variables Affected:

Transformation\Generacion de Electricidad\Processes:

- Exogenous Capacity
- Process Efficiency
- Maximum Availability
- Merit Order

Assumptions:

	Assumption	Source
E1 - Exogenous Capacity [MW]	0	"InstalledBase" from McKinsey 2009 (they cite ESHA)
E2 - Exogenous Capacity [MW]	Interp(2010, 500, 2015, 2057, 2020, 2236, 2025, 4729, 2030, 10001)	"MaxInstalledBase" from McKinsey 2009 (they cite ESHA).
Process Efficiency [%]	100%	SEI
Maximum Availability [%]	84-91%	"ProdUptime" form McKinsey 2009
Merit Order [%]	1 (base load)	SEI

Retrofit Mitigation Technologies

Coal CCS Retrofit

Lever Name in McKinsey 2009: L.1.1.5 Coal CCS retrofit

Variables Affected:

Transformation\Generacion de Electricidad\Processes:

- Exogenous Capacity
- Process Efficiency
- Maximum Availability

- Merit Order

Transformation\Generacion de Electricidad\Processes\Carbon CCS Retrofit\Feedstock fuels\Coal Bituminous:

- Environmental Loading

Assumptions:

	Assumption	Source
E2 - Exogenous Capacity – Coal Retrofit [MW]	Interp(2010,0,2015,1.89,2020,12.06,2025,80.51, 2030,445.17)	"MaxInstalledBase" from McKinsey 2009
E2 - Exogenous Capacity – Current Coal [MW]	BaseYearValue-**Carbon CCS Retrofit:Exogenous Capacity[MW]**	SEI (no new coal power plants built and current capacity will be replaced with retrofits)
Process Efficiency [%]	30-34%	"EnergyEfficiency" from McKinsey 2009
Maximum Availability [%]	69-77%	"ProdUptime" form McKinsey 2009
Merit Order [%]	1 (base load)	SEI
Environmental Loading – CO_2	25.8 * FractionOxidized * (CO2/c)*0.1	SEI (IPCC tier 1 emission factor multiplied by 10%, meaning 10% of CO_2 is being released, 90% is being captured)

Gas CCS Retrofit

Lever Name in McKinsey 2009: L.1.1.3 Coal CCS new built with EOR

Variables Affected:

Transformation\Generacion de Electricidad\Processes:

- Exogenous Capacity
- Process Efficiency
- Maximum Availability
- Merit Order

Transformation\Generacion de Electricidad\Processes\Carbon CCS Nueva EOR\Feedstock fuels\Coal Bituminous:

- Environmental Loading

Assumptions:

	Assumption	Source
E2 - Exogenous Capacity – Gas Retrofit [MW]	Interp(2010,0, 2015, 15.4, 2020, 72.6, 2025, 469.6, 2030, 3050.4)	"MaxInstalledBase" from McKinsey 2009
E2 - Exogenous Capacity Gas Current [MW]	BaselineValue-Gas CCS Retrofit:Exogenous Capacity[MW]	SEI (current capacity will be replaced with retrofits)
Process Efficiency [%]	38-47%	"EnergyEfficiency" from McKinsey 2009
Maximum Availability [%]	26-32%	"ProdUptime" form McKinsey 2009
Merit Order [%]	1 (base load)	SEI
Environmental Loading – CO_2	25.8 * FractionOxidized * (CO2/c)*0.1	SEI (IPCC tier 1 emission factor multiplied by 10%, meaning 10% of CO_2 is being released, 90% is being captured)

Other Mitigation Technologies

Shift from Oil to Gas

Philosophy: This external lever is not well documented, so SEI assumed that natural gas would replace 50% of oil (residual fuel oil).

Lever Name in McKinsey 2009: Oil to gas shift in power (external)

Variables Affected:

Transformation\Generacion de Electricidad\Processes:

- Exogenous Capacity

Assumptions:

	Assumption	Source
E1 - Exogenous Capacity	Interp(2010,BaselineValue,2030,BaselineValue*0.5)	SEI

Smart Grid

Philosophy: There is no documentation of this lever outside of emissions abatement results. SEI has assumed that smart grid measures can be represented by the decrease of transmission and distribution losses from 19% (baseline value) to 15% (SEI assumption) by 2030.

Lever Name in McKinsey 2009: SCADA (smart grid) (external)

Scenario Name in LEAP 2013: E3: Smart Grid

Variables Affected:

Transformation\TD\Processes:

- Losses

Assumptions:

	Assumption	Source
Losses	Interp(2010,baselinevalue,2030,15)	SEI

Gaps in current data: This measure would be greatly improved by acquiring physical data on the improvements of the SCADA smart grid potential project.

Increased Efficiency in Thermoelectric Plants

Philosophy: This external lever, does not include documentation of any specific action that would cause efficiency improvements, nor does it quantify the improvement in energy efficiency. SEI has assumed a 0.5% growth in efficiency per year.

Lever Name in McKinsey 2009: Increased efficiency of thermoelectric plants

Variables Affected:

Transformation\Generacion de Electricidad\Processes:

- Process Efficiency

Assumptions:

	Assumption	Source
Process Efficiency [%]	**Growth(0.5%)**	SEI

Replace New Coal Power Plants with Increased Gas Generation

Lever Name in McKinsey 2009: Externa - Replacing coal new builds with increased gas generation

Variables Affected:

Transformation\Generacion de Electricidad\Processes:

- Exogenous Capacity

Assumptions:

	Assumption	Source

Exogenous Capacity – Current Coal [MW]	**BaseYearValue**-Carbon CCS Retrofit:Exogenous Capacity[MW]	SEI (no new coal power plants built and current capacity will be replaced with retrofits)

McKinsey Measures not Included

All McKinsey levers were included.

Oil and Gas

Sector Overview

The oil and gas sector does not include many mitigation options in the INECC 2013 analysis, primarily due to the fact that activity data from PEMEX was not available to disaggregate the baseline.

Mitigation Measures

Reduced Natural Gas Consumption through Planning

Philosophy: McKinsey included a mitigation level for "planning" which would result in reduced consumption of natural gas in the oil and gas sector. SEI assumed that this could be applied to all natural gas consumption reported by the National Energy Balances.

Scenario name in LEAP: P1: Planificacion

Lever Name in McKinsey 2009:

- L.3.5.18.0 Planning

Variables Affected:

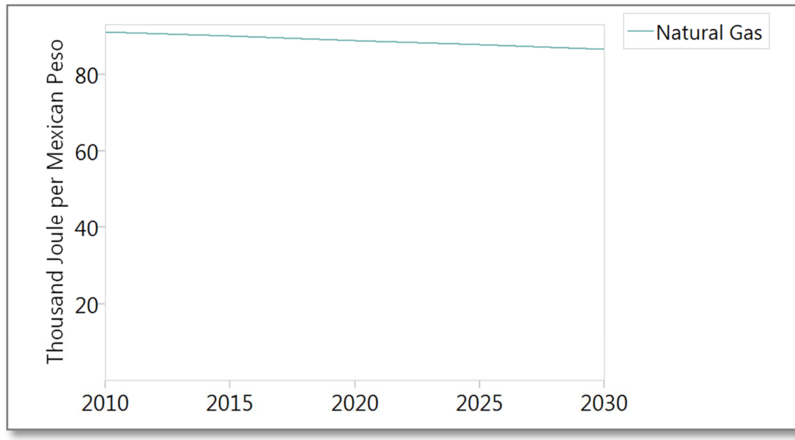
Demand\Petroleo y Gas\All\Natural Gas:

- Final Energy Intensity

Assumptions:

	Assumption	Source
Final Energy Intensity [GJ/peso]	Interp(2010, BaselineValue, 2030, BaselineValue*0.95)	McKinsey L.3.5.18.0 assumes that 5% of natural gas fuel usage can be saved by planning. SEI assumes a slow transition from 0% savings compared to the baseline to 5% savings in 2030.

Gaps in current data: As with the rest of this sector, this measure would be improved through conversations with PEMEX representatives to acquire more detail on the specific projects planned for the next 20 years.



McKinsey Measures not Included

All but one lever from the 2009 McKinsey analysis were not modeled in the INECC 2013 model due to a lack of sufficient documentation in McKinsey and a lack of physical accounting of baseline emissions. Levers were not included for one or more of the following reasons:

- Documentation included percent improvements, but no absolute numbers
- Assumptions were based on number of refineries of a particular size (barrels of output/day), and we did not have access to this kind of break down from an official source in Mexico.
- Assumptions were detailed, but there was no qualitative description of the lever and no obvious calculation of emissions from the given data.

The full list of levers not included in the current analysis is below. The next iteration of the mitigation model would benefit from a partnership with PEMEX staff to add official data and disaggregation to the oil and gas baseline and to gain a better understanding of the physical characteristics of potential mitigation options.

L.3.5.1.0 Behavioral/procedural changes
L.3.5.2.0 Improved maintenance & process control
L.3.5.3.0 Energy efficiency projects requiring CAPEX at process unit level
L.3.5.4.0 Energy efficiency projects requiring CAPEX at overall plant level (co-generation)
L.3.5.5.0 Carbon Capture and Storage
L.3.5.6.0 Reduced flaring
L.3.5.7.0 More energy efficient new builds in upstream
L.3.5.8.0 Energy efficiency projects requiring CAPEX at process unit level in upstream oil and gas
L.3.5.9.0 Behavioral changes and improved maintenance & process control in upstream oil and gas production
L.3.5.10.0 Carbon Capture and Storage in upstream operations

L.3.5.15.0 Replace Seals
L.3.5.16.0 Maintain Compressors
L.3.5.17.0 Distribution Maintenance

Forestry

Sector Overview

All non-energy sectors were modeled very closely on the McKinsey 2009 analysis, much like the baseline. With the limited time to consult with INECC staff and local sectoral experts, we used McKinseys assumptions for all McKinsey levers. In the forestry sector, we did not have a disaggregated baseline, so we used a top-down approach and included only total emissions from 2010 to 2030 as calculated by McKinsey.

Mitigation Measures

Slash and Burn Agriculture Conversion

Scenario name in LEAP: S1: Reduccion de Deforestacion de Slash and Burn

Lever Name in McKinsey 2009:

- L.5.1.1 Reduced Deforestation from Slash & Burn Agriculture Conversion

Pastureland Conversion

Scenario name in LEAP: S2: Reduccion de Deforestacion de Conversion de Pastizal

Lever Name in McKinsey 2009:

- L.5.1.2 Reduced Deforestation from Pastureland Conversion

Reduced Intensive Agriculture Conversion

Scenario name in LEAP: S3: Reduccion de Conversion de Agricultura Intensiva

Lever Name in McKinsey 2009:

- L.5.1.3 Reduced Intensive Agriculture Conversion

Pastureland Afforestation

Scenario name in LEAP: S4: Aforestacion de Pastizal

Lever Name in McKinsey 2009:

- L.5.2.1 Pastureland Afforestation

Cropland Afforestation

Scenario name in LEAP: S5: Aforestacion de Tierras Agricolas

Lever Name in McKinsey 2009:

- L.5.2.2 Cropland Afforestation

Degraded Forest Reforestation

Scenario name in LEAP: S6: Resforestacion de Bosques Degrados

Lever Name in McKinsey 2009:

- L.5.2.3 Degraded Forest Restoration

Forest Management

Scenario name in LEAP: S7: Gestion Forestal

Lever Name in McKinsey 2009:

- L.5.2.4 Forest Management

New Plantations

Philosophy: This mitigation option was analyzed by the MEDEC study with the goal of creating 1.5 Million hectares of plantations in the agriculture and forestry sectors. For the purpose of this study, we included the emissions benefits in the Forestry sector.

Scenario name in LEAP: S8: Plantaciones

Lever Name in McKinsey 2009: This scenario was not included in McKinsey 2009.

Variables Affected:

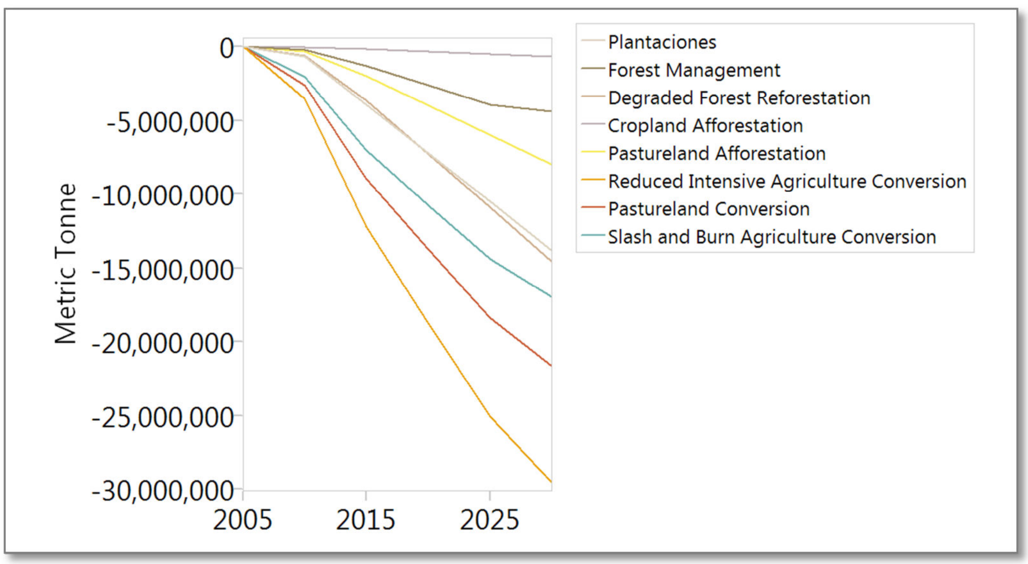
Non Energy/Silvicultura/Mitigacion/

- Slash and Burn Agriculture Conversion: Effect Loading
- Pastureland Conversion: Effect Loading
- Reduced Intensive Agriculture Conversion: Effect Loading
- Pastureland Afforestation: Effect Loading
- Cropland Afforestation: Effect Loading
- Degraded Forest Reforestation: Effect Loading
- Forest Management: Effect Loading
- Plantaciones: Effect Loading

Assumptions:

	Assumption	Source
Effect Loading [$MtCO_2e$]		
- **Slash and Burn**	- - InterpFSY(2010, 2.041, 2015, 7.001, 2020, 10.783, 2025, 14.412, 2030, 16.951)	McKinsey 2009

-	**Pastureland Conversion**	-	-InterpFSY(2010, 2.607, 2015, 8.942, 2020, 13.773, 2025, 18.409, 2030, 21.652)	
-	**Agriculture Conversion**	-	-InterpFSY(2010, 3.553, 2015, 12.19, 2020, 18.776, 2025, 25.095, 2030, 29.517)	
-	**Pastureland Afforestation**	-	-InterpFSY(2015, 1.989, 2020, 3.978, 2025, 5.968, 2030, 7.957)	
-	**Cropland Afforestation**	-	-InterpFSY(2015, 0.167, 2020, 0.335, 2025, 0.502, 2030, 0.67)	
-	**Forest Restoration**	-	-InterpFSY(2015, 3.636, 2020, 7.272, 2025, 10.909, 2030, 14.545)	
-	**Forest Management**	-	-InterpFSY(2015, 3.636, 2020, 7.272, 2025, 10.909, 2030, 14.545)	
-	**New Plantations**	-	-InterpFSY(2030, 13.8)	MEDEC



McKinsey Measures not Included

McKinsey lever L.5.1.4 (Reduced Timber Harvesting) was not included in this analysis because the emission reduction results were zero in all study years.

Agriculture

Sector Overview

All non-energy sectors were modeled very closely on the McKinsey 2009 analysis, much like the baseline. With the limited time to consult with INECC staff and local sectoral experts, we used McKinseys assumptions for all McKinsey levers. We used a top-down approach and included only total emissions from 2010 to 2030 as calculated by McKinsey.

Mitigation Measures

Tillage and residue management practices

Scenario name in LEAP: A1: Gestion de Labranza y Residuos

Lever Name in McKinsey 2009:

- L.6.2.1 Tillage and residue management practices

Agronomy Practices

Scenario name in LEAP: A2: Practicas de Agronomia

Lever Name in McKinsey 2009:

- L.6.2.2 Agronomy practices

Cropland nutrient management

Scenario name in LEAP: A3: Gestion de Nutrientes de Tierras Agricolas

Lever Name in McKinsey 2009:

- L.6.2.3 Cropland nutrient management

Rice management – Shallow Flooding

Scenario name in LEAP: A4: Gestion de Arroz – Inundaciones Superficiales

Lever Name in McKinsey 2009:

- L.6.2.4.1 Rice management – shallow flooding

Rice management – nutrient management

Scenario name in LEAP: A5: Gestion de Arroz – gestion de nutrientes

Lever Name in McKinsey 2009:

- L.6.2.4.2 Rice management – nutrient management

Grassland management

Scenario name in LEAP: A6: Gestion de Pastizales

Lever Name in McKinsey 2009:

- L.6.2.5 Grassland Management

Grassland Nutrient Management

Scenario name in LEAP: A7: Gestion de Nutrientes de Pastizales

Lever Name in McKinsey 2009:

- L.6.2.6 Grassland nutrient management

Degraded land restoration

Scenario name in LEAP: A8: Degraded land restoration

Lever Name in McKinsey 2009:

- L.6.2.8 Degraded land restoration

Livestock feed supplements

Scenario name in LEAP: A9: Suplementos Alimenticios para Ganado

Lever Name in McKinsey 2009:

- L.6.2.9 Livestock feed supplements

Livestock – Antimethanogen Vaccine

Scenario name in LEAP: A10: Ganaderia – Vacuna Antimethanogen

Lever Name in McKinsey 2009:

- L.6.2.10 Livestock – Antimethanogen Vaccine

Variables Affected:

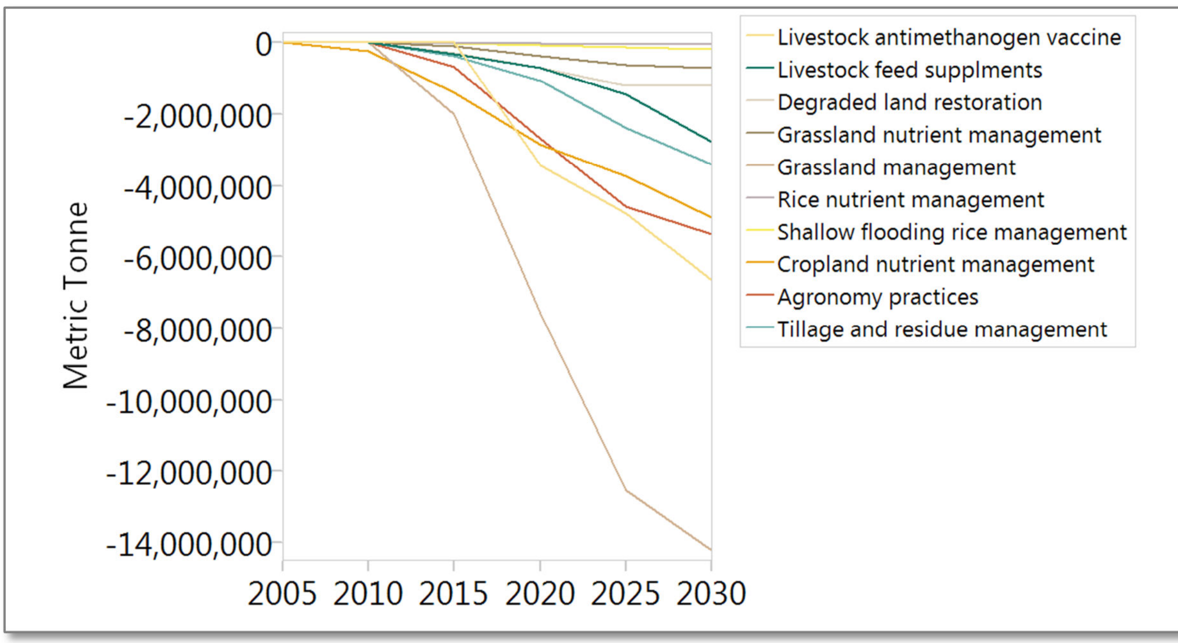
Non Energy/Agricultura/Mitigacion/

- Tillage and residue management: Effect Loading
- Agronomy Practices: Effect Loading
- Cropland nutrient management: Effect Loading
- Shallow flooding rice management: Effect Loading
- Rice nutrient management: Effect Loading
- Grassland management: Effect Loading
- Grassland nutrient management: Effect Loading
- Degraded land restoration: Effect Loading
- Livestock feed supplements: Effect Loading
- Livestock antimentanogen vaccine: Effect Loading

Assumptions:

	Assumption	Source
Effect Loading [$MtCO_2e$]		
- **Tillage and residue management**	- - Interp(2010,0, 2015, 0.365, 2020, 1.077, 2025, 2.384, 2030, 3.407)	McKinsey 2009
- **Agronomy Practices**	- -Interp(2010,0, 2015, 0.689, 2020, 2.692, 2025, 4.592, 2030, 5.37)	

- **Cropland nutrient management**	- -Interp(2010, 0.249, 2015, 1.393, 2020, 2.858, 2025, 3.725, 2030, 4.903)
- **Shallow flooding rice management**	- -Interp(2010,0, 2015, 0.021, 2020, 0.064, 2025, 0.128, 2030, 0.171)
- **Rice nutrient management**	- -Interp(2010,0, 2015, 0.006, 2020, 0.019, 2025, 0.039, 2030, 0.052)
- **Grassland management**	- -Interp(2010,0, 2015, 1.998, 2020, 7.573, 2025, 12.528, 2030, 14.21)
- **Grassland nutrient management**	- -Interp(2010,0, 2015, 0.098, 2020, 0.372, 2025, 0.615, 2030, 0.698)
- **Degraded land restoration**	- -Interp(2010,0, 2015, 0.288, 2020, 0.702, 2025, 1.206, 2030, 1.17)
- **Livestock feed supplements**	- -Interp(2010,0, 2015, 0.323, 2020, 0.72, 2025, 1.457, 2030, 2.78)
- **Livestock antimentanogen vaccine**	- -Interp(2015,0, 2020, 3.434, 2025, 4.773, 2030, 6.649)



McKinsey Measures not Included

All measures from McKinsey 2009 were included.

Waste

Sector Overview

All non-energy sectors were modeled very closely on the McKinsey 2009 analysis, much like the baseline. With the limited time to consult with INECC staff and local sectoral experts, we used McKinseys assumptions for all McKinsey levers. We used a top-down approach and included only total emissions from 2010 to 2030 as calculated by McKinsey.

Mitigation Measures

Landfill gas flaring

Scenario name in LEAP: D1: Gas de Vertedero - Quema

Lever Name in McKinsey 2009:

- L.6.1.1 Waste – landfill gas flaring

Landfill gas direct use

Scenario name in LEAP: D2: Gas de Vertedero – Uso Directo

Lever Name in McKinsey 2009:

- L.6.1.2 Waste – Landfill gas direct use

Recycling New Waste

Scenario name in LEAP: D3: Reciclaje de Residuos Nuevos

Lever Name in McKinsey 2009:

- L.6.1.4 Recycling New Waste

Composting New Waste

Scenario name in LEAP: D4: Compostaje de Residuos Nuevos

Lever Name in McKinsey 2009:

- L.6.1.5 Composting new waste

Wastewater treatment

Scenario name in LEAP: D5: Tratamiento de Aguas Residuales

Lever Name in McKinsey 2009:

- Wastewater treatment (External)

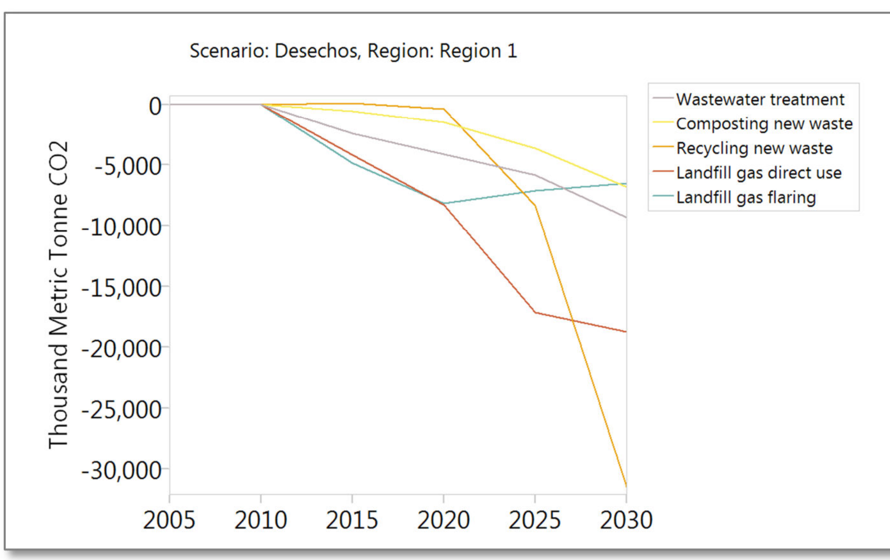
Variables Affected:

Non Energy/Desechos/Mitigacion/

- Landfill gas flaring: Effect Loading
- Landfill gas direct use: Effect Loading
- Recycling new waste: Effect Loading
- Composting new waste: Effect Loading
- Wastewater treatment: Effect Loading

Assumptions:

	Assumption	Source
Effect Loading [$MtCO_2e$]		
- **Landfill gas flaring**	- -Interp(2010,0, 2015, 4.868, 2020, 8.151, 2025, 7.121, 2030, 6.497)	McKinsey 2009
- **Landfill gas direct use**	- -Interp(2010,0, 2015, 4.167, 2020, 8.288, 2025, 17.155, 2030, 18.696)	
- **Recycling**	- -Interp(2010,0,2015,-0.076, 2020, 0.394, 2025, 8.344,2030,31.475)	
- **Composting**	- -Interp(2010,0, 2015, 0.562, 2020, 1.491, 2025, 3.604, 2030, 6.797)	
- **Wastewater treatment**	- -Interp(2010,0, 2015, 2.413, 2020, 4.144, 2025, 5.852, 2030, 9.326)	



McKinsey Measures not Included

Measure L.6.1.3, electricity generation from landfill gas, was not included in the INECC 2013 mitigation model. This was due to the fact that it would be inconsistent to include that modeling in the non-energy sector and that there was not enough information to properly model it in the electricity generation module. We recommend discussing with CFE and waste experts to confirm whether this mitigation option should be considered in future iterations of the model.

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