Developing Mexico National Emissions Inventory Projections for the Future Years of 2008, 2012, and 2030

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ABSTRACT

The 1999 Mexico National Emissions Inventory (NEI) was the first comprehensive municipality-level emissions inventory of criteria air pollutants developed for the country of Mexico. However, more current and future year emissions inventory projections are essential to evaluate the future benefits of air quality control measures and to support various modeling analyses in Mexico. Therefore, the Western Governors’ Association (WGA) has supported Mexico’s National Institute of Ecology (INE – Instituto Nacional de Ecología) by sponsoring a project to develop future year emissions inventory projections. Also, support for the project was extended by the National Renewable Energy Laboratory (NREL) to evaluate the benefits of air quality control measures in Mexico at the national level.

This paper discusses the development of municipality-level emissions inventory projections for the years of 2008, 2012, and 2030 based upon the 1999 Mexico NEI. Adjustments made to the 1999 base year inventory due to municipality divisions are presented. The development of sector-specific point source growth factors for electricity generating units, refineries and other petroleum-related sources, primary metal facilities, manufacturing facilities, miscellaneous industrial facilities, and service facilities is described. The development of area source and nonroad mobile source growth factors based upon surrogate projections (e.g., population, fuel use, gross domestic product [GDP], etc.) is also presented. The results of a detailed analysis of the projected effects of Mexico’s future low-sulfur fuel standards and new vehicle emission standards on on-road motor vehicle emissions are also incorporated. This paper also discusses the interactions between the emissions projections and other projects related to greenhouse gases that are currently being conducted in Mexico.

INTRODUCTION

Background

Future year emission inventory projections are essential to evaluating the potential benefits of air quality control measures and supporting various modeling analyses. The Mexico NEI projections were developed for Mexico’s National Institute of Ecology (INE – Instituto Nacional de Ecología) in support of the fourth phase of the Integrated Environmental Strategies (IES) Program sponsored by the U.S. Environmental Protection Agency (U.S. EPA) and the National Renewable Energy Laboratory (NREL) to evaluate the benefits of air quality control measures in Mexico at the national level. Point, area, on-road motor vehicle, and nonroad mobile source emissions from the 1999 Mexico National Emissions Inventory (NEI) were projected to the years of 2008, 2012, and 2030 at the municipality-level. In
addition, emission impacts in Mexico due to three control scenarios were developed in consultation with INE.

**Projections Scope**

Since the emission inventory projections were based upon the 1999 Mexico NEI, the scope of the projections was similar to the Mexico NEI, and included the following characteristics:

- **Source types** – Point sources, area sources (excluding paved and unpaved road dust), on-road motor vehicles, and nonroad mobile sources. Natural sources (i.e., biogenic and volcanic sources), although part of the 1999 Mexico NEI, were not included in the scope of the projections.
- **Pollutants** – Nitrogen oxides (NO\textsubscript{x}), sulfur dioxide (SO\textsubscript{2}), volatile organic compounds (VOC), carbon monoxide (CO), particulate matter with an aerodynamic diameter of 10 micrometers (µm) or less (PM\textsubscript{10}), particulate matter with an aerodynamic diameter of 2.5 µm or less (PM\textsubscript{2.5}), and ammonia (NH\textsubscript{3}).
- **Spatial aggregation** – Municipality-level for all municipalities in Mexico.
- **Reported units** – Megagrams (Mg) per year (i.e., 1,000 kilograms [kg] or 1 metric ton).
- **Results** – Projected emission results were provided in spreadsheet, U.S. EPA Emissions Inventory Format (NIF) 3.0, and SMOKE/IDA modeling file formats.

**Adjustments for New Municipalities**

Prior to projecting the 1999 Mexico NEI to 2008, 2012, and 2030, it was necessary to adjust the baseline municipality-level emissions to account for municipality realignments since 1999. The 1999 Mexico NEI contained a total of 2,443 municipalities for the entire country. However, the national municipality-level population projections that were provided by the National Council on Population (CONAPO – Consejo Nacional de Población) indicated that there were a total of 2,454 municipalities as of 2005. The 11 new municipalities were formed in the states of Guerrero, México, Veracruz, and Zacatecas. Seven new municipalities were formed by the division of an existing municipality; four new municipalities were formed by the reorganization of multiple existing municipalities. Table 1 lists the new municipalities and their associated municipality codes.

Emissions from the existing municipalities included in the 1999 Mexico NEI (listed in Table 1) were allocated to the new municipalities. If this allocation had not been performed, then these 11 new municipalities would have zero emissions in the 1999 baseline inventory, as well as in the projected inventories. The emissions allocation for area sources, on-road motor vehicles, and nonroad mobile sources was based upon the ratio of 2005 population estimates. For example, Iliatenco (Guerrero) was formed from the municipalities of Malinaltepec and San Luis Acatlán. The 2005 populations of these municipalities were as follows: Malinaltepec – 27,231; San Luis Acatlán – 41,917; Iliatenco – 9,762; and three municipality total – 78,910. The calculated ratios for area sources, on-road motor vehicles, and nonroad mobile sources were then: Malinaltepec – 0.3451 (i.e., 27,231/78,910); San Luis Acatlán – 0.5312; and Iliatenco – 0.1237. For point source emissions, a Geographic Information System (GIS) was used to plot the point source locations to determine if any were located within the municipalities that were split to form new municipalities. It was confirmed that no reallocation of point source emissions was needed because none of the point sources are located within the 11 new municipalities.

**PROJECTIONS METHODOLOGY**

For the purposes of this study, baseline growth projections for 2008, 2012, and 2030 were initially developed assuming no future controls. Ideally, the development of growth factors would be conducted at the facility- or process-level. However, information concerning future year conditions was
typically limited by insufficient detailed data. As a result, facility- or process-level growth factors were not developed; instead, national- and regional-level growth factors were developed. After the baseline growth projections were developed, three control scenarios were developed in conjunction with INE staff. Then, the three control scenarios were applied to the baseline growth projections.

Point Sources

The 1999 Mexico NEI point source emissions were projected to 2008, 2012, and 2030 using sector-specific growth surrogates. The first step was to classify all of the 1999 Mexico NEI point sources into one of six groups based upon 3-digit North American Industry Classification System (NAICS) codes. The assignment of the 3-digit NAICS codes is presented in Table 2. The six groups were:

- Electricity generating units (EGUs)
- Refineries and other petroleum-related industries
- Primary metals manufacturing
- Manufacturing industries (all other)
- Miscellaneous industries (not elsewhere classified)
- Service industries (e.g., auto repair, dry cleaners, etc.)

The methodology used to develop growth factors for each of these point source groups is described below.

EGUs Growth Factors

The growth factors for EGUs were developed from historical fuel use statistics and fuel use projections. The actual fuel consumption by the EGU sector for 1999 was obtained from a fuel balance developed as part of the 1999 Mexico NEI. Fuel projections used for electricity generation for 2008, 2012, and 2030 were obtained from modeling conducted for Mexico greenhouse gas studies. The growth factors for each year were estimated by calculating the ratio of the projected year demand data relative to the actual 1999 fuel combustion. Fuel-specific growth factors were only developed for natural gas, combustóleo (i.e., residual fuel oil), and coal. The EGUs contained in the 1999 MNEI were assigned a fuel type based upon power plant information from the North American Commission for Environmental Cooperation (CEC). Based upon the CEC power plant information, fuel types were assigned to 41 of 73 EGUs contained in the 1999 Mexico NEI. For the remaining 32 EGUs, either natural gas or combustóleo was assigned based upon comparative SO2 emissions relative to NOx emissions at the facility level (i.e., EGUs with low SO2 emissions were assigned to natural gas, while EGUs with high SO2 emissions were assigned to combustóleo).

Refineries and Other Petroleum-Related Industries Growth Factors

The growth factors for refineries and other petroleum-related sources were developed from historical crude oil production statistics and production projections. The 1999 crude oil production was obtained from an analysis of the Department of Energy (DOE)/Energy Information Administration’s (EIA) International Energy Outlook; this study indicated a daily total crude production of 2.87 million barrels for Mexico in 1999. Crude production forecast data were obtained from the Organization of the Petroleum Exporting Countries’ (OPEC) World Oil Outlook. These data indicate a decrease in crude production for Mexico in future years (e.g., the crude production in 2030 is almost equal to that in 1999).
Primary Metals Manufacturing Growth Factors

The growth factors for primary metal manufacturing facilities were based upon historic copper, lead, and zinc production data in Mexico. Historic Mexican copper, lead, and zinc production data from 1990 to 2006 were obtained from the United States Geological Survey (USGS) Mineral Resources Program. Aggregated copper, lead, and zinc statistics for primary refined metal were used to develop a linear regression equation to predict annual primary metal production for the years 2008, 2012, and 2030. Growth factors were then developed by dividing the projected primary metal production by the actual 1999 primary metal production.

Manufacturing Industries and Miscellaneous Industries Growth Factors

The growth factors for manufacturing industries, as well as miscellaneous industries were based upon Mexican gross domestic product (GDP). An annual GDP rate of 3.5 percent has been recently used for various environmental and economic studies; this annual growth rate was used for projecting emissions from the manufacturing industries and miscellaneous industries.

Service Industries Growth Factors

The growth factors for service sector point sources were based upon municipality-level population estimates for the time period from 2005 to 2030. As shown in Table 2, services industries include printing facilities, repair and maintenance shops, dry cleaners, and wastewater treatment plants. The growth of these types of point sources can largely be attributed to growth in population. Therefore, municipality-level population was used as a surrogate to project emissions from these sources.

Area Sources

The 1999 Mexico NEI area source emissions were projected to 2008, 2012, and 2030 using various growth surrogates, as shown in Table 3. A majority of the area source categories were projected to 2008, 2012, and 2030 using population and fuel use surrogates. The development of each growth surrogate is described below.

Population Growth Surrogate

A population surrogate was used to project emissions growth for 14 area source categories as shown in Table 3. Municipality-level population estimates for Mexico for the time period 2005-2030 were obtained from CONAPO; 1999 municipality-level population data were obtained from the 1999 Mexico NEI. Municipality-level population growth factors were calculated by dividing 2008, 2012, and 2030 population by 1999 population.

Fuel Use Growth Surrogates

Fuel use surrogates were used to project emissions growth for fuel combustion of six different fuels (i.e., distillate, residual, natural gas, LPG, kerosene, and wood), as well as commercial marine vessels and the distribution of gasoline and LPG. Fuel use projections for 2008, 2012, and 2030 were obtained from modeling conducted for Mexico greenhouse gas studies. The projection data consisted of actual energy demand data for the years 1999 through 2006 and forecasted energy demand data for the years 2007 through 2030. These data were available by sector (e.g., industrial, commercial, residential, agricultural, transportation, etc.) and by fuel type. Sector- and fuel-specific growth factors were calculated by dividing the energy demand projections (in petajoules [PJ]) by 1999 energy demand (in PJ).
LPG demand for all sectors was summed together to estimate the growth factors for the LPG distribution source category. Gasoline demand for the transportation sector was used to calculate growth factors for the gasoline distribution source category.

Gross Domestic Product (GDP) Growth Surrogates

Mexican GDP was used as a growth surrogate to project 1999 emissions to 2008, 2012, and 2030 for locomotives, industrial surface coatings, and degreasing. As discussed for point sources, a GDP rate of 3.5 percent has been recently used for various environmental and economic studies.9 This annual growth rate was used for projecting these three source categories. A slight modification was used for locomotives. The same annual growth rate of 3.5 percent was used to develop the 2008 and 2012 growth factors; however, no growth was assumed to occur after 2012 (i.e., the 2030 growth factor was assumed to be the same as the 2012 growth factor) due to expected minimal growth after 2012.10

Planted Acreage Growth Surrogates

Historical planted acreage by state was used as a surrogate to develop growth factors for the pesticide application, agricultural tilling, fertilizer application, and agricultural burning. State-level historical planted acreage from 1980 to 2006 was obtained from the Secretariat of Agriculture, Livestock, Rural Development, Fisheries, and Food Supply (SAGARPA – Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación).11 Using these data, a long-term annual average planted acreage was calculated for each state. Long-term annual average planted acreage was used rather than linear regressions because the state-level year-to-year statistics appeared to have some reporting gaps and tend to be very erratic. It was then assumed that the planted acreage in 2008, 2012, and 2030 will be equal to the long-term annual average planted acreage. Growth factors were developed by dividing the long-term annual average planted acreage by the state-level 1999 planted acreage. In some cases, the growth factor was less than 1.0 (i.e., the long-term annual average planted acreage was less than the 1999 planted acreage). For agricultural burning, only historical averages of wheat and sugarcane planted acreages were used to derive growth factors. Burning of sugarcane prior to harvest is a common agricultural practice throughout the world in order to remove leafy trash. Post-harvest burning of wheat is commonly practiced to eliminate wheat stubble; recent inventory efforts in San Luis Río Colorado, Sonora and Mexicali, Baja California indicate that the practice is fairly common in Mexico.12,13

Livestock Population Growth Surrogates

Historical livestock population by state was used as a surrogate to develop growth factors for the livestock ammonia and beef cattle feedlots. State-level livestock populations from 1996 to 2005 were obtained from SAGARPA for the following seven livestock categories: beef cows, dairy cows, pigs, sheep, horses, chickens, and turkeys.14 Using these data, historical average populations were calculated for each livestock category for each state. It was then assumed that the livestock populations in 2008, 2012, and 2030 would be equal to the historical average populations. Growth factors were developed by dividing the historical average populations by the state-level 1999 livestock populations. In some cases, the growth factor was less than 1.0 (i.e., the historical average populations were less than the 1999 livestock populations). The overall 1999 Mexico NEI emissions for livestock ammonia were split into emissions by livestock type, and growth factors were applied to each livestock type to project emissions to 2008, 2012, and 2030.

Burned Forest Acreage Growth Surrogates

Historical data on burned forest acreage by state were used as a surrogate to develop growth factors for wildfires. State-level burned forest acreage from 1970 to 2005 was obtained from the National Forest Commission (CONAFOR – Comisión Nacional Forestal).15 Historical burned forest
acreage was calculated at the state level and was assumed to be equal to the burned forest acreage in 2008, 2012, and 2030. Growth factors were developed by dividing the state-level historical burned forest acreage by the 1999 burned forest acreage.

Border Crossing Vehicle Traffic Growth Surrogates

Historical border crossing vehicle traffic data were used to develop growth factors for border crossings. Historical traffic data from 1995 to 2007 (including buses, trucks, and personal vehicles) were obtained from the U.S. Bureau of Transportation Statistics (BTS). These data were used to develop a linear regression equation to predict the total vehicular traffic at border crossings in 2008, 2012, and 2030. After predicting the annual traffic counts for 2008, 2012, and 2030, growth factors were developed by dividing the projection year vehicular traffic by 1999 vehicular traffic. Traffic data were limited to border crossing traffic for vehicles crossing from Mexico into the U.S. Emission estimates for vehicles crossing from the U.S. into Mexico were not estimated as part of the 1999 Mexico NEI because of insignificant wait times. Also, the 1999 Mexico NEI did not include emissions for border crossings at Mexico’s borders with Guatemala and Belize because of data unavailability.

Aircraft Passenger Volume

Annual air passenger traffic data were used to develop growth factors for aircraft emissions. Total passenger volume data (both domestic and international) from January 2001 through August 2008 for 13 airports in north and central Mexico. Although there are more than 13 airports located in Mexico, it was assumed that these 13 airports reasonably approximated the national level of aircraft activity. For the year 2008, the eight months of data from January to August were extrapolated to obtain an annual estimate for 2008. After completing the extrapolation of the 2008 annual estimate, the data from 2001 to 2008 were used to develop a linear regression equation to predict annual total passenger volume for 2012 and 2020. Once the annual air passenger volumes for the years 2008, 2012, and 2030 was obtained, growth factors were developed by dividing the projection year air passenger volume by 1999 air passenger volume.

Public Wastewater Treatment Growth Surrogates

Historical public treated wastewater quantities were used to develop growth factors for wastewater treatment. Annual treated wastewater quantities from 1999 to 2006, as well as planned treatment rate increases until 2012, were obtained from the National Water Commission (CNA – Comisión Nacional del Agua). Due to the unavailability of data, it was assumed that 2030 treatment quantities would be equal to 2012. The 2008 and 2012 planning values were divided by the 1999 actual treated quantities to obtain the growth factors.

On-Road Motor Vehicles

The 1999 on-road motor vehicle emissions were projected to 2008, 2012, and 2030 using two different growth factors. The first growth factor accounted for the increased demand of motor vehicle fuels projected between 1999 and 2030. As with many of the area source categories, gasoline use projections were obtained from modeling conducted for Mexico greenhouse gas studies. The second growth factor addressed the changes in vehicle technologies and emissions due to the turnover of the Mexican fleet. Over time, newer vehicles with improved technologies (e.g., improved catalysts, etc.) and lower emissions will enter the vehicle fleet and gradually replace older vehicles with limited or no technology. The effects of vehicle turnover were estimated using the MOBILE6-Mexico on-road motor vehicle emission factor model. The MOBILE6-Mexico model was run for all years (i.e., 1999 base and 2008, 2012, and 2030 projected years) and fleet average emission rates were generated. The ratio of fleet average emission rates for each future year relative to the 1999 base year was calculated; this ratio was the “turnover” factor. The overall growth factor for each of the projection years was estimated by
multiplying the fuel growth factor by the fleet turnover factor. A more detailed explanation of the MOBILE6-Mexico modeling process is provided below.

Fuel Regulations

The MOBILE6-Mexico model was modified to reflect new gasoline and diesel fuel standards regulations that would be in effect in Mexico in the future. Mexican fuel standards are split into three regions (i.e., Metropolitan Zone [ZM], Frontier Zone [ZF], and the remainder of the country [RP]) with each region having an applicable gasoline and diesel sulfur standard. Table 4 lists the Mexican fuel sulfur standards by fuel type and region for the 1999 base year and the three projected years. These fuel sulfur standards were obtained from the fuel standard implementation schedule provided by PEMEX. It should be noted that individual values in Table 4 represent maximum standards, while split values (e.g., 30/80) represent average/maximum standards, respectively. Also, for Magna gasoline, the Frontier Zone (ZF) is considered to be part of the remainder of the country (RP). Although both Magna and Premium gasoline are used in Mexico, only Magna gasoline (i.e., the predominant motor vehicle fuel) was used in the modeling runs in order to simplify the analysis.

Other MOBILE6-Mexico Model Parameters

The average temperature range for Mexico was assumed to be a minimum of 55.6 °F and a maximum of 82.9 °F for all the model runs. The fuel Reid Vapor Pressure (RVP) was assumed to be 7.5 psi and the average vehicle speed was assumed to be 18.5 kilometers per hour for all the model runs.

Emission Standards

Mexico has motor vehicle emission limits standards that are equivalent to a combination of U.S. Tier 1 and Tier 2 standards and European EURO 3 and EURO 4 standards. The equivalency of Mexican motor vehicle emission standards to EURO standards and U.S. standards is shown in Table 5. Because the MOBILE6-model is based on an 80,000 km (i.e., 50,000 miles) certification rather than a 100,000 km certification, the U.S. Tier 1 and Tier 2 standards were used for the modeling runs and the EURO 3 and EURO 4 standards were not investigated further. The 1999 base year model runs in Mexico were assumed to be equivalent to U.S. EPA’s Tier 0 standards. For the future years of 2008, 2012, and 2030, the Mexican A, B, and C standards were incorporated into the MOBILE6-Mexico model runs. Mexican Standard A is similar to the U.S EPA’s Tier 1 standard for VOC, CO, and NOx. Standards B and C are a combination of U.S. EPA’s Tier 1 and Tier 2 standards for VOC, CO, and NOx. For particulate emissions, Mexican Standards A, B, and C were all the same as U.S EPA’s Tier 1 standard. In addition, there are no emissions standards in Mexico for heavy-duty gasoline trucks and vehicles (HDGV and HDGT). Mexican Standards A, B, and C are presented in Table 6. The vehicle types used in the Mexican standards are defined below:

- PV – Passenger vehicle (light-duty) with a maximum gross vehicle weight rating (GVWR) of 8,500 lbs or less
- LDT1 – Light-duty truck with a maximum loaded vehicle weight (LVW) of 3,750 lbs and GVWR not to exceed 6,000 lbs
- LDT2 – Light-duty truck with a minimum LVW of 3,750 lbs and GVWR not to exceed 6,000 lbs
- LDT3 – Light-duty truck with a maximum adjusted loaded vehicle weight (ALVW) of 5,750 lbs and GVWR greater than 6,000 lbs
- LDT4 – Light-duty truck with a minimum ALVW of 5,750 lbs and GVWR not to exceed 6,000 lbs.
The phase-in schedule of Mexican Standards A, B, and C as a percentage of vehicles within each model year are presented in Table 7. As shown in Table 7, the 2008 phase-in schedule indicates a 50 percent allocation for Standard A and 50 percent allocation for Standard B. The schedule for 2012 consists of a 75 percent allocation for Standard B and a 25 percent allocation for Standard C. By 2015, Standard C will be entirely phased in. Lacking information regarding additional future standards beyond Standard C, it was assumed that the Standard C would still be in effect in 2030.

Implementation Schedule Input File

The MOBILE6-Mexico external input file that contains information relevant to the emission standard implementation schedule is called the Mex_P94_Imp.dat. This file contains the implementation schedule from model year 1994 thru model year 2025 (inclusive). The file contains the fraction of implementation for different standards for each of the above mentioned years by vehicle type (e.g., Tier 0, Tier 1 [interim], Tier 1, Tier 2, Tier LEV [interim], Tier LEV, etc.). For purposes of this projection analysis, only Tier 1 and Tier 2 standards are analyzed for future year scenarios. The implementation schedule input file (i.e., Mex_P94_Imp.dat) was modified to represent the implementation schedule for Mexican Standards A, B, and C.

Certification Standards Input File

The MOBILE6-Mexico external input file that contains information regarding vehicle manufacturer certification standards is called Mex_T2CERT.dat. The Mex_T2CERT.dat file contains the 50,000 mile certification standards by certification bin by pollutant (HC, CO, and NOx). The same modified Mex_T2CERT file was used for all MOBILE6-Mexico runs (i.e., 1999, 2008, 2012, and 2030).

Exhaust Emission Standards Input File

The MOBILE6-Mexico external input file that contains information regarding the phase-in schedule for the Tier 2 exhaust emission standards is called Mex_T2EXH.dat. Since this file only contains the phase-in schedule until 2015, it was assumed that 2030 standards will be the same as those in 2015. This external file is applicable only for HC, CO, and NOx emissions and is same for all runs (i.e., 1999, 2008, 1012, and 2030).

Emission Factors

After making modifications to the three external input files (i.e., Mex_P94_Imp.dat, Mex_T2CERT.dat, and Mex_T2EXH.dat), the MOBILE6-Mexico model was then run to generate fleet average emission factors for the base year 1999, as well as for the future projection years of 2008, 2012, and 2030. These model runs accounted for both Mexican fuel standards and emission standards. After the fleet average emission factors were generated, turnover factors were calculated by dividing the future year emission factors by the base year 1999 emission factors. These future year turnover factors were then multiplied by the future year gasoline growth factors to develop a set of composite projection factors that were used to project 1999 base year on-road emissions to 2008, 2012, and 2030. The composite projection factors by pollutant and region are presented in Table 8.

As can be seen in Table 8, there are projected to be significant reductions in NOx, SO2, VOC, and CO emission factors by 2030, in spite of increased motor vehicle fuel use. The reductions in NOx, VOC, and CO are due to fleet turnover, which gradually incorporates cleaner vehicles into the overall fleet over time. The reductions in SO2 are attributable to the lower sulfur contents in the future Mexican fuel standards. Increased PM10 and PM2.5 emissions are the result of increased fuel use without any future PM standards, while increased NH3 emissions are likely due to fleet turnover (i.e., new vehicle technologies, such as advanced catalytic converters tend to reduce NOx, but increase NH3).
Nonroad Mobile Sources

The 1999 nonroad mobile source categories were limited to diesel-powered agricultural equipment and diesel-powered construction equipment, only, due to the lack of Mexico-specific activity data for other types of nonroad equipment (e.g., recreational vehicles, lawn and garden equipment, etc.). These were projected to 2008, 2012, and 2030 using energy demand projections. Projected fuel use was obtained from modeling conducted for Mexico greenhouse gas studies; these projections included disaggregated demand data for the transportation, industrial, commercial, and agricultural sectors.

Diesel energy demand in the agricultural sector was used as a surrogate to project nonroad emissions from the agricultural equipment source category. The data indicated an increase of approximately 75 percent in diesel usage for agricultural equipment in 2030 compared to 1999 usage. Diesel energy demand in the commercial sector was used as a surrogate to project 1999 nonroad emissions for construction equipment. The data indicated an increase of approximately 57 percent in diesel usage for construction equipment in 2030 compared to 1999 usage.

BASELINE RESULTS

The baseline growth projections for 2008, 2012, and 2030 were developed through the implementation of the methodologies described above. These projection results for point sources, area source, on-road motor vehicles, and nonroad mobile sources are presented below.

Point Sources

The overall projected baseline point source emission totals are presented in Table 9; the baseline point source emission totals are also disaggregated by group in Table 10.

Table 9 indicates an approximately threefold increase in baseline NOx emissions from 1999 to 2030. Most of this increase can be attributed to the EGU sources, where the baseline NOx emissions in 2030 increased by 279 percent from the 1999 levels. Similarly, the manufacturing sector is expected to have a threefold increase in 2030 NOx emissions compared to the 1999 levels. However, the 2030 NOx emissions in the refineries sector was nearly unchanged relative to the 1999 NOx emissions.

According to Table 9, baseline SO2 emissions in the year 2030 are expected to increase slightly more than 25 percent from 1999. Of the total SO2 emissions from the EGU sector in 1999, power plants fired with combustóleo (residual fuel oil) contribute approximately 75 percent of the emissions. As Mexico is moving away from use of residual fuel oil in power plants, SO2 emissions in 2030 from residual fuel-fired power plants are expected to drop by almost 87 percent. On the other hand, SO2 emissions from natural gas-fired power plants should increase 30 percent and those from coal-fired power plants should increase by approximately 279 percent. Also, SO2 emissions in the year 2030 from the manufacturing sector increased almost three-fold from the 1999 levels.

Over 50 percent of the VOC emissions from point sources in 1999 were from refineries. The 2030 emissions are expected to remain relatively unchanged compared to the 1999 emissions. The increase in VOC emissions from 1999 levels to 2030 levels can be attributed to manufacturing industries with 2030 VOC emissions increasing by almost 200 percent from their 1999 levels.

Approximately 72 percent of the total point source CO emissions in 1999 originate from refineries and manufacturing. While the emissions from refineries are expected to remain constant, emissions from manufacturing are projected to increase by approximately 200 percent in the year 2030. Manufacturing contributes slightly less than half of the total CO increase from 1999 to the year 2030. EGUs are responsible for a similar increase in CO emissions.
A significant portion majority of PM$_{10}$ emissions (i.e., 44 percent) and PM$_{2.5}$ emissions (i.e., 41 percent) in 1999 are from manufacturing. By 2030, particulate emissions from these sources are projected to increase by approximately 190 percent compared to 1999 levels. Out of the total increase in particulate emissions, manufacturing sources are expected to contribute approximately 73 percent of the PM$_{10}$ increase and 70 percent of the PM$_{2.5}$ emissions increase. In addition, EGU$s$ contribute approximately 11 percent of the PM$_{10}$ increase and 26 percent of the PM$_{2.5}$ increase. Particulate emissions in the year 2030 from refineries should remain the same as 1999 levels.

**Area Sources**

The projected baseline area source emission totals are summarized in Table 11, along with the initial 1999 area source emission totals. Baseline area source emissions for 1999 and 2030 by Source Classification Code (SCC) are presented in Tables 12 and 13. (Due to length considerations, baseline area source emissions for 2008 and 2012 are not shown.)

As can be seen from the tables, SO$_2$ emissions in 2030 are projected to decrease by almost 88 percent compared to the 1999 base year emissions. This decrease in SO$_2$ emissions can primarily be attributed to changes in the industrial and commercial residual combustion category. SO$_2$ emissions from residual fuel combustion in 1999 were approximately 56,000 Mg/year. The energy demand projections from LEAP$^4$ indicated that there will be no residual fuel combustion in the commercial sector after 2002; therefore, SO$_2$ emissions from commercial residual fuel combustion in 2008, 2012, and 2030 were set to zero. Similarly, the energy demand data also indicate that emissions from industrial residual fuel combustion are projected to drop to 10 percent of 1999 levels.

The 2030 NO$_x$ emissions, on the other hand, are projected to increase to nearly 200 percent of 1999 levels. Most of this increase can be attributed to the commercial marine vessel and LPG combustion source categories. The NO$_x$ emissions from commercial marine vessels are projected to increase from approximately 76,000 Mg/yr in 1999 to almost 282,000 Mg/yr in 2030. The energy demand projections from LEAP$^4$ indicate a threefold increase in commercial marine diesel use in 2030 compared to 1999 levels. Also, NO$_x$ emissions for all the LPG combustion categories (i.e., industrial, commercial, residential, transportation, and agriculture) are projected to grow from 72,750 Mg/yr in 1999 to 384,230 Mg/yr in 2030.

VOC emissions show a steady increase from 1999 to 2030. In 1999, approximately half the VOC emissions are from the solvent evaporation categories (e.g., industrial surface coatings, architectural surface coatings, degreasing, consumer solvent usage, etc.). The growth factors for these categories were based upon either population or GDP and the VOC growth tends to mirror these two growth factors.

Like VOC, the CO emission estimates also indicate a steady increase from the 1999 levels. However, it should be noted that almost all of the CO increase can be attributed to growth in transportation LPG combustion. The 1999 CO emissions from transportation LPG combustion are approximately 279,000 Mg/yr, corresponding to 11 percent of the total area source CO emissions. In 2030, the CO emissions for the same category projected to be 2,167,194 Mg/yr (i.e., an emissions increase of a factor of 8). This is due to an expected major increase in LPG usage by transportation sources, from 35.3 PJ in 1999 to 274.7 PJ in 2030.$^4$ Other significant area source contributors of CO emissions in 1999 (e.g., wildfires, agricultural burning, and residential wood combustion) are projected to decrease by 2030.

Residential wood combustion accounts for 51 percent of PM$_{10}$ emissions and 68 percent of PM$_{2.5}$ emissions in the 1999 Mexico NEI. However, energy demand data indicate a drop in residual wood combustion of almost 30 percent by 2030.$^4$ This decrease in residential wood combustion demand
creates a drop in PM\textsubscript{10} and PM\textsubscript{2.5} emissions in 2030 relative to 1999 levels. As a result of this decrease, the agricultural tilling category increases in relative importance.

The 2030 NH\textsubscript{3} emissions are projected to decrease by approximately 35 percent compared to the 1999 inventory. Most of this decrease can be attributed to reductions in livestock ammonia as a result of projecting historical average livestock statistics.

**On-Road Motor Vehicles**

The projected baseline on-road motor vehicle emission totals are summarized in Table 14, along with the initial 1999 on-road motor vehicle emission totals. Baseline on-road motor vehicle emissions by vehicle classification are presented in Table 15. As shown in these two tables, NO\textsubscript{x}, SO\textsubscript{2}, VOC, and CO emissions are expected to significantly decrease by 2030, in spite of increased motor vehicle fuel use. The reductions in NO\textsubscript{x}, VOC, and CO are due to fleet turnover, while the SO\textsubscript{2} reductions are attributable to the lower sulfur contents in the future Mexican fuel standards. Increased PM\textsubscript{10} and PM\textsubscript{2.5} emissions are the result of increased fuel use without any future PM standards, while increased NH\textsubscript{3} emissions are likely due to fleet turnover (i.e., new vehicle technologies, such as advanced catalytic converters tend to reduce NO\textsubscript{x}, but increase NH\textsubscript{3}).

**Nonroad Mobile Sources**

The projected baseline nonroad mobile source emission totals are summarized in Table 16, along with the initial 1999 nonroad mobile source emission totals. Emission totals for all pollutants are expected to rise due to the expected increase in diesel usage for agricultural equipment and construction equipment (i.e., 75 percent and 57 percent, respectively).

**Overall Baseline Inventory**

The entire projected baseline Mexico NEI emissions (i.e., 2008, 2012, and 2030) are summarized in Table 17 by emission type, along with the initial 1999 inventory. The overall inventory is projected to increase in the future.

In general, emissions from point sources, area sources, and nonroad mobile sources are projected to increase in future years relative to the 1999 base year. The projection factors for these source types are primarily driven by population growth, GDP growth, and fuel growth. There are also a few source categories with decreasing emissions (i.e., area source SO\textsubscript{2}, PM\textsubscript{10}, and PM\textsubscript{2.5}); these are due to projected decreases in certain fuel types (i.e., commercial combustion of residual fuel oil and residential wood combustion). The relative decrease of area source and on-road motor vehicle SO\textsubscript{2} is shown in Figures 1 and 2.

Although point source, area source, and nonroad mobile source emissions are projected to increase, projected increases to the overall inventory are dampened by projected decreases in some on-road motor vehicle emissions. This trend is shown in Figure 3. As described above, on-road motor vehicle NO\textsubscript{x}, SO\textsubscript{2}, VOC, and CO emissions are projected to decrease in future years relative to the 1999 base year, while PM\textsubscript{10}, PM\textsubscript{2.5}, and NH\textsubscript{3} emissions increase. Although the demand for motor vehicle fuel will increase significantly in the future, the decreases in NO\textsubscript{x}, SO\textsubscript{2}, VOC, and CO emissions will also be significant due to the effects of new control technologies that will gradually be incorporated into the overall vehicle fleet due to turnover, as well as low sulfur fuels. Because new motor vehicle standards are not being implemented for PM\textsubscript{10}, PM\textsubscript{2.5}, and NH\textsubscript{3}, emissions are projected to increase in the future for these pollutants.
CONTROL SCENARIO RESULTS

Following the development of base year emission projections for 2008, 2012, and 2030, additional analysis was conducted involving three control scenarios and their effect on future emissions. All three control scenarios focused only on on-road motor vehicles and do not affect point, area, or nonroad mobile sources. Details of the control scenarios and the associated control levels were developed by INE staff and are described in the following subsections.22

Control Scenario 1 – Increased Fuel Economy

The first control scenario considers an increase in fuel economy for new light-duty gasoline vehicles and trucks; the fuel economy for all other vehicle types is assumed to be unchanged. The baseline fuel economy for new vehicles is assumed to be 10.82 kilometers per liter (km/l), and will begin increasing by 1 km/l annual in 2011 until reaching a value of 15.82 km/l in 2015 and all subsequent years. The pollutant specific reductions are presented in Table 18. No emission reductions were projected for 2008; reductions will only occur in 2012 and 2030. In addition, no emission reductions were quantified for SO₂ or NH₃ for any of the years, because none of the control scenarios were applicable to these pollutants.

Control Scenario 2 – Use of Ethanol in Oxygenated Fuel

Oxygenated fuels have been used in the major metropolitan zones of Mexico since 1990 in order to reduce ozone levels. The oxygenated gasoline supplied by PEMEX (Petróleos Mexicanos – Mexico’s state-owned petroleum company) contains methyl tert-butyl ether (MTBE) and/or tertiary amyl methyl ether (TAME). PEMEX is currently contemplating switching from MTBE/TAME to ethanol. The second control scenario involves the switch from MTBE/TAME oxygenates to ethanol while maintaining an oxygenate level of 2 percent by weight. The switch is assumed to begin in Guadalajara in 2010, follow in Monterrey in 2011, and finish in Mexico City in 2012. All other fuel characteristics (e.g., Reid vapor pressure [RVP], etc.) are assumed to remain unchanged. The switch to oxygenated fuel with ethanol was assumed to only affect gasoline-fueled vehicles (i.e., light-duty gasoline vehicles, light-duty gasoline trucks, heavy-duty gasoline vehicles, and motorcycles). The reductions for Guadalajara, Monterrey, and Mexico City are presented in Table 19. No emission reductions were projected for 2008; reductions will only occur in 2012 and 2030. The emission reductions were applied for all inventoried pollutants.

Control Scenario 3 – Combined Increased Fuel Economy and Use of Ethanol in Oxygenated Fuel

The third control scenario is the combined implementation of Control Scenario 1 and Control Scenario 2 and does not include any new control strategies. The effects of Control Scenarios 1 and 2 are applied by calculating the reduced emissions due to Control Scenario 1 and then applying the controls from Control Scenario 2. The effect of Control Scenario 3 is dependent on the vehicle classification, pollutant, or geographically location to which it is applied. For example, Control Scenario 3 for light-duty gasoline vehicle NOₓ emissions in Guadalajara would include the control effects from both Control Scenario 1 and Control Scenario 2, while Control Scenario 3 for heavy-duty diesel vehicle emissions in the state of Sonora would have no control effects from Control Scenario 1 or Control Scenario 2.

Results with Controls

The projected on-road motor vehicle emission totals, including the effects of Control Scenarios 1, 2, and 3 are summarized in Table 20. Control Scenarios 1, 2, and 3 are identified with the abbreviations CS1, CS2, and CS3, respectively. For reference purposes, the baseline projected emission totals for 1999, 2008, 2012, and 2020 have also been included. Because Control Scenarios 1, 2, and 3 are based upon on-road motor vehicle control strategies, only on-road motor vehicle emissions are
presented in Table 19. Point source, area source, and nonroad mobile source emissions are not impacted by Control Scenarios 1, 2, and 3.

The emission reductions due to Control Scenario 1 vary from 0.1 percent to 0.6 percent for 2012 and from 1.1 percent to 5.0 percent for 2030; Control Scenario 1 does not affect SO2 and NH3, so these are not included in these reduction values. The percentage reductions due to Control Scenario 1 relative to baseline emissions increase over time because new vehicles with improved fuel economy gradually penetrate the overall vehicle fleet over time, thereby raising the fleet average fuel economy and decreasing emissions from the fleet.

The percentage reductions due to Control Scenario 2 vary from 0.6 percent to 1.3 percent for 2012 and from 0.5 percent to 1.3 percent for 2030. The emission reductions due to Control Scenario 2 relative to baseline emissions are fairly constant from 2012 to 2030 because the switch from MTBE/TAME-based oxygenated fuels to ethanol-based oxygenated fuels is a one-time event that does not have increasing penetration over time.

As expected, emission reductions due to Control Scenario 3 are greater than those of Control Scenarios 1 or 2 applied individually, and range from 0.7 percent to 1.5 percent for 2012, and from 1.0 percent to 5.7 percent for 2030. The expected VOC emission reductions due to Control Scenarios 1, 2, and 3 are shown in Figure 4.

HARMONIZATION WITH GREENHOUSE GAS EMISSIONS INVENTORIES

Another objective accomplished as part of the development of emissions projections was to “harmonize” the criteria pollutant emission projections with current and future year greenhouse gas emissions inventories in Mexico. The term “harmonize” refers to standardizing or increasing comparability and/or convergence between inventories.

Because of methodological differences between criteria pollutant and greenhouse gas inventories, there are inherent differing aspects between the two types of inventories. For example, VOC emissions from consumer solvents are typically estimated with an annual per capita emission factor combined with population counts; however, consumer solvents do not generate greenhouse gas emissions. In contrast, fuel combustion is a source of both criteria pollutants (i.e., NOx, SO2, CO, and VOC) and greenhouse gases (i.e., carbon dioxide[CO2], methane[CH4], and nitrous oxide[N2O]).

In order to ensure harmony between criteria pollutant and greenhouse gas emission inventories, INE provided important data and assumptions used in the development of Mexico’s greenhouse gas emissions inventories. For example, future year fuel use projections from LEAP were developed to estimate greenhouse gas emissions in Mexico. These future fuel use projections were then used in this project to generate criteria pollutant growth factors for a wide number of sources categories, including: point source electric generating units (EGUs), area source fuel combustion (i.e., industrial, commercial/institutional, residential, and agricultural), area source fuel distribution (i.e., gasoline and LPG), on-road motor vehicles (in conjunction with the MOBILE6-Mexico analysis), and nonroad mobile sources. In addition, underlying economic assumptions, such as annual Gross Domestic Product (GDP) growth rates, were used to develop projection factors for some point sources (i.e., manufacturing industries and miscellaneous industries) and some area source categories (i.e., locomotives, industrial surface coating, and degreasing) in this project.

A certain level of harmony was obtained by using this information from Mexico greenhouse gas inventories to develop projection factors for the future year criteria pollutant projections. In some cases, momentary pauses in the project schedule occurred to ensure that the most up-to-date greenhouse gas inventory information was obtained, rather than using outdated information or information unrelated to greenhouse gas inventories.
REFERENCES


### Table 1. New municipalities in Mexico.

<table>
<thead>
<tr>
<th>State</th>
<th>New Municipality</th>
<th>Already Existing Municipalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guerrero</td>
<td>Marquelia (077)</td>
<td>Azoyú (013); Cuajinicuilapa (023)</td>
</tr>
<tr>
<td>Guerrero</td>
<td>Cochoapa el Grande (078)</td>
<td>Metlatónoc (043)</td>
</tr>
<tr>
<td>Guerrero</td>
<td>José Joaquín de Herrera (079)</td>
<td>Atlixtec (010); Chilapa de Alvarez (028)</td>
</tr>
<tr>
<td>Guerrero</td>
<td>Juchitán (080)</td>
<td>Azoyú (013)</td>
</tr>
<tr>
<td>Guerrero</td>
<td>Iliatenco (081)</td>
<td>Malinaltepec (041); San Luis Acatlán (052)</td>
</tr>
<tr>
<td>México</td>
<td>Luvianos (123)</td>
<td>Tejupilco (082)</td>
</tr>
<tr>
<td>México</td>
<td>San José del Rincón (124)</td>
<td>San Felipe del Progreso (074)</td>
</tr>
<tr>
<td>México</td>
<td>Tonaltila (125)</td>
<td>Jaltenco (044)</td>
</tr>
<tr>
<td>Veracruz</td>
<td>San Rafael (211)</td>
<td>Martínez de la Torre (102)</td>
</tr>
<tr>
<td>Veracruz</td>
<td>Santiago Sochiapan (212)</td>
<td>Playa Vicente (130)</td>
</tr>
<tr>
<td>Zacatecas</td>
<td>Santa María de la Paz (058)</td>
<td>Apozol (001); Atolinga (003); Benito Juárez (004); Jalpa (019); Juchipila (023); Tepechiltlán (045); Teul de González Ortega (047)</td>
</tr>
</tbody>
</table>

Note: Parenthetical numbers are municipality codes.

### Table 2. Point source groups and applicable NAICS codes.

<table>
<thead>
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<th>Point Source Group</th>
<th>3-Digit NAICS</th>
<th>NAICS Description</th>
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<td>EGUs</td>
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<td>Utilities</td>
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<td></td>
<td>211</td>
<td>Oil &amp; Gas Extraction</td>
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<tr>
<td></td>
<td>324</td>
<td>Petroleum &amp; Coal Products Manufacturing</td>
</tr>
<tr>
<td></td>
<td>325</td>
<td>Chemical Manufacturing</td>
</tr>
<tr>
<td></td>
<td>424</td>
<td>Merchant Wholesalers, Nondurable Goods</td>
</tr>
<tr>
<td>Refineries</td>
<td>331</td>
<td>Primary Metal Manufacturing</td>
</tr>
<tr>
<td></td>
<td>311</td>
<td>Food Manufacturing</td>
</tr>
<tr>
<td></td>
<td>312</td>
<td>Beverage &amp; Tobacco Product Manufacturing</td>
</tr>
<tr>
<td></td>
<td>313</td>
<td>Textile Mills</td>
</tr>
<tr>
<td></td>
<td>314</td>
<td>Textile Product Mills</td>
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<tr>
<td></td>
<td>315</td>
<td>Apparel Manufacturing</td>
</tr>
<tr>
<td></td>
<td>316</td>
<td>Leather &amp; Allied Product Manufacturing</td>
</tr>
<tr>
<td></td>
<td>321</td>
<td>Wood Product Manufacturing</td>
</tr>
<tr>
<td></td>
<td>322</td>
<td>Paper Manufacturing</td>
</tr>
<tr>
<td></td>
<td>324</td>
<td>Petroleum &amp; Coal Product Manufacturing</td>
</tr>
<tr>
<td></td>
<td>325</td>
<td>Chemical Manufacturing</td>
</tr>
<tr>
<td></td>
<td>326</td>
<td>Plastics &amp; Rubber Products Manufacturing</td>
</tr>
<tr>
<td></td>
<td>327</td>
<td>Nonmetallic Mineral Product Manufacturing</td>
</tr>
<tr>
<td></td>
<td>331</td>
<td>Fabricated Metal Product Manufacturing</td>
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<tr>
<td></td>
<td>333</td>
<td>Machinery Manufacturing</td>
</tr>
<tr>
<td></td>
<td>334</td>
<td>Computer &amp; Electronic product Manufacturing</td>
</tr>
<tr>
<td></td>
<td>335</td>
<td>Electrical Equipment, Appliance, and Component Manufacturing</td>
</tr>
<tr>
<td></td>
<td>336</td>
<td>Transportation Equipment Manufacturing</td>
</tr>
<tr>
<td></td>
<td>337</td>
<td>Furniture and Related Product Manufacturing</td>
</tr>
<tr>
<td></td>
<td>339</td>
<td>Miscellaneous Manufacturing</td>
</tr>
<tr>
<td></td>
<td>999</td>
<td>Undisclosed</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>212</td>
<td>Mining (except Oil and Gas)</td>
</tr>
<tr>
<td>Industries</td>
<td>424</td>
<td>Merchant Wholesalers, Nondurable Goods</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>231</td>
<td>Printing and Related Support Activities</td>
</tr>
<tr>
<td>Industries</td>
<td>562</td>
<td>Waste Management and Remediation Services</td>
</tr>
<tr>
<td></td>
<td>811</td>
<td>Repair and Maintenance</td>
</tr>
<tr>
<td>Services</td>
<td>812</td>
<td>Personal and Laundry Services</td>
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Note: In the 1999 Mexico NEI, state jurisdiction point sources that belonged to a particular NAICS group and numbered fewer than three facilities in any given municipality were assigned NAICS 999 to maintain confidentiality.
Table 3. Area source growth surrogates.

<table>
<thead>
<tr>
<th>Surrogate</th>
<th>Area Source Categories</th>
</tr>
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<tbody>
<tr>
<td>Population</td>
<td>• Charbroiling/street vendors</td>
</tr>
<tr>
<td></td>
<td>• Bakeries</td>
</tr>
<tr>
<td></td>
<td>• Construction activities</td>
</tr>
<tr>
<td></td>
<td>• Architectural surface coatings</td>
</tr>
<tr>
<td></td>
<td>• Autobody refinishing</td>
</tr>
<tr>
<td></td>
<td>• Traffic markings</td>
</tr>
<tr>
<td></td>
<td>• Dry cleaning</td>
</tr>
<tr>
<td></td>
<td>• Graphic arts</td>
</tr>
<tr>
<td></td>
<td>• Consumer solvent usage</td>
</tr>
<tr>
<td></td>
<td>• Asphalt application</td>
</tr>
<tr>
<td></td>
<td>• Open burning</td>
</tr>
<tr>
<td></td>
<td>• Structure fires</td>
</tr>
<tr>
<td></td>
<td>• Brick kilns</td>
</tr>
<tr>
<td></td>
<td>• Domestic ammonia</td>
</tr>
<tr>
<td>Fuel use</td>
<td>• Distillate fuel combustion (industrial and commercial)</td>
</tr>
<tr>
<td></td>
<td>• Residual fuel combustion (industrial and commercial)</td>
</tr>
<tr>
<td></td>
<td>• Natural gas fuel combustion (industrial, commercial, and residential)</td>
</tr>
<tr>
<td></td>
<td>• LPG fuel combustion (industrial, commercial, residential, transportation, and agriculture)</td>
</tr>
<tr>
<td></td>
<td>• Kerosene fuel combustion (industrial, residential, and agriculture)</td>
</tr>
<tr>
<td></td>
<td>• Residential wood combustion</td>
</tr>
<tr>
<td></td>
<td>• Commercial marine vessels</td>
</tr>
<tr>
<td></td>
<td>• Gasoline distribution</td>
</tr>
<tr>
<td></td>
<td>• LPG distribution</td>
</tr>
<tr>
<td>Gross Domestic Product (GDP)</td>
<td>• Locomotives</td>
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<tr>
<td></td>
<td>• Industrial surface coating</td>
</tr>
<tr>
<td></td>
<td>• Degreasing</td>
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<tr>
<td>Planted acreage by state</td>
<td>• Pesticide application</td>
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<td></td>
<td>• Agricultural tilling</td>
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<td></td>
<td>• Fertilizer application</td>
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<tr>
<td></td>
<td>• Agricultural burning</td>
</tr>
<tr>
<td>Livestock population</td>
<td>• Livestock ammonia</td>
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<td></td>
<td>• Beef cattle feedlots</td>
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<td>Forest acreage burnt by state</td>
<td>• Wildfires</td>
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<td>Vehicular traffic at border</td>
<td>• Border crossings</td>
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<td>crossings</td>
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<td>Airline passenger volume</td>
<td>• Aircraft</td>
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<td>Residential wastewater</td>
<td>• Wastewater treatment</td>
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<td>treated quantities</td>
<td></td>
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### Table 4. Mexican fuel sulfur standards by fuel type and region (in ppm).

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>1999</th>
<th>2008</th>
<th>2012</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premium</td>
<td>500</td>
<td>30/80 (avg/max)</td>
<td>30/80 (avg/max)</td>
<td>30/80 (avg/max)</td>
</tr>
<tr>
<td>Magna (ZM)</td>
<td>500</td>
<td>421/500 (avg/max)</td>
<td>30/80 (avg/max)</td>
<td>30/80 (avg/max)</td>
</tr>
<tr>
<td>Magna (RP)</td>
<td>500</td>
<td>421/500 (avg/max)</td>
<td>30/80 (avg/max)</td>
<td>30/80 (avg/max)</td>
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<tr>
<td>Diesel (ZM)</td>
<td>500</td>
<td>300</td>
<td>300</td>
<td>15</td>
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<tr>
<td>Diesel (ZF)</td>
<td>500</td>
<td>15</td>
<td>15</td>
<td>15</td>
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<tr>
<td>Diesel (RP)</td>
<td>420/500 (avg/max)</td>
<td>420/500 (avg/max)</td>
<td>420/500 (avg/max)</td>
<td>15</td>
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### Table 5. Equivalency of Mexican standards to EURO and U.S. standards.

<table>
<thead>
<tr>
<th>Mexican Standard</th>
<th>Equivalent Standard</th>
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<tbody>
<tr>
<td>A</td>
<td>U.S. EPA’s Tier 1</td>
</tr>
<tr>
<td>B</td>
<td>Combination of U.S. EPA’s Tier 1 and Tier 2 for 80,000 km certification or EURO 3 for 100,000 km certification</td>
</tr>
<tr>
<td>C</td>
<td>Combination of U.S. EPA’s Tier 1 and Tier 2 for 80,000 km certification or EURO 4 for 100,000 km certification</td>
</tr>
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</table>

### Table 6. Mexican motor vehicle emission standards (g/km).

<table>
<thead>
<tr>
<th>Standard</th>
<th>CO (g/km)</th>
<th>NMHC (g/km)</th>
<th>NOx (g/km)</th>
<th>PM (g/km)</th>
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<tr>
<td></td>
<td>Gas, LPG, NG</td>
<td>Diesel</td>
<td>Gas, LPG, NG</td>
<td>Diesel</td>
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<tr>
<td>A</td>
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<td></td>
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<td></td>
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<tr>
<td>PV</td>
<td>2.11</td>
<td>0.156</td>
<td>0.25</td>
<td>0.62</td>
</tr>
<tr>
<td>LDT1</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>LDT2</td>
<td>2.74</td>
<td>0.200</td>
<td>0.44</td>
<td>0.62</td>
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<tr>
<td>LDT3</td>
<td></td>
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<tr>
<td>LDT4</td>
<td>3.11</td>
<td>0.240</td>
<td>0.68</td>
<td>0.95</td>
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<tr>
<td>B</td>
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</tr>
<tr>
<td>PV</td>
<td>2.11</td>
<td>0.099</td>
<td></td>
<td>0.249</td>
</tr>
<tr>
<td>LDT1</td>
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</tr>
<tr>
<td>LDT2</td>
<td>2.74</td>
<td>0.121</td>
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<tr>
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<td>C</td>
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<tr>
<td>PV</td>
<td>2.11</td>
<td>0.047</td>
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<tr>
<td>LDT1</td>
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<td>LDT2</td>
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<tr>
<td>LDT3</td>
<td>0.087</td>
<td>0.124</td>
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<td>LDT4</td>
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### Table 7. Phase-in schedule for Mexican motor vehicle emission standards (% of model year vehicles).

<table>
<thead>
<tr>
<th>Model Year</th>
<th>Standard A %</th>
<th>Standard B %</th>
<th>Standard C %</th>
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</thead>
<tbody>
<tr>
<td>2004</td>
<td>100%</td>
<td>-</td>
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<tr>
<td>2005</td>
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<tr>
<td>2006</td>
<td>100%</td>
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<tr>
<td>2007</td>
<td>75%</td>
<td>25%</td>
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<tr>
<td>2008</td>
<td>50%</td>
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<tr>
<td>2009</td>
<td>30%</td>
<td>70%</td>
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<td>2010</td>
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<td>100%</td>
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<td>2011</td>
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<td>100%</td>
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</tr>
<tr>
<td>2012</td>
<td>-</td>
<td>75%</td>
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<tr>
<td>2013</td>
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<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>2014</td>
<td>-</td>
<td>30%</td>
<td>70%</td>
</tr>
<tr>
<td>2015</td>
<td>-</td>
<td>-</td>
<td>100%</td>
</tr>
<tr>
<td>2030</td>
<td>-</td>
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Table 8. Composite projection factors for on-road motor vehicles by region.

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<th>CO</th>
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<th>CO</th>
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<td>247,878</td>
<td>167,648</td>
<td>297,264</td>
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<td>394,071</td>
<td>261,330</td>
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Table 10. Projected baseline point source emissions by group (Mg/yr).

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<td>297,264</td>
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Table 11. 1999, 2008, 2012, and 2030 baseline area source emissions (Mg/yr).

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<th>CO</th>
<th>PM₁₀</th>
<th>PM₂.₅</th>
<th>NH₃</th>
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Note: Blanks indicate the emissions were not estimated. A zero indicates emissions <0.5 Mg/yr.
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<th>CO</th>
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Note: Blanks indicate the emissions were not estimated. A zero indicates emissions <0.5 Mg/yr.
Table 14. 1999, 2008, 2012, and 2030 baseline on-road motor vehicle emissions (Mg/yr).

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<th>CO</th>
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<th>PM2.5</th>
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Table 15. Baseline on-road motor vehicle emissions by vehicle classification (Mg/yr).

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</tr>
<tr>
<td>2012 LDGT</td>
<td>50,094</td>
<td>4,584</td>
<td>108,357</td>
<td>718,517</td>
<td>8,878</td>
<td>8,132</td>
<td>4,952</td>
</tr>
<tr>
<td>2012 HDGV</td>
<td>10,422</td>
<td>761</td>
<td>16,190</td>
<td>135,641</td>
<td>391</td>
<td>332</td>
<td>407</td>
</tr>
<tr>
<td>2012 MC</td>
<td>863</td>
<td>64</td>
<td>2,354</td>
<td>13,517</td>
<td>21</td>
<td>15</td>
<td>195</td>
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<tr>
<td>2012 LDDV</td>
<td>487</td>
<td>14</td>
<td>392</td>
<td>554</td>
<td>202</td>
<td>187</td>
<td>49</td>
</tr>
<tr>
<td>2012 LDDT</td>
<td>247</td>
<td>9</td>
<td>207</td>
<td>303</td>
<td>99</td>
<td>92</td>
<td>23</td>
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<tr>
<td>2012 HDDV</td>
<td>197,240</td>
<td>1,873</td>
<td>19,704</td>
<td>89,620</td>
<td>14,358</td>
<td>13,283</td>
<td>1,743</td>
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<td>Total 2012</td>
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<td>340,519</td>
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<td>34,019</td>
<td>31,258</td>
<td>14,533</td>
</tr>
<tr>
<td>2030 LDGV</td>
<td>27,257</td>
<td>2,232</td>
<td>180,128</td>
<td>1,466,991</td>
<td>21,265</td>
<td>19,230</td>
<td>18,041</td>
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<tr>
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<td>1,973</td>
<td>100,997</td>
<td>951,772</td>
<td>18,748</td>
<td>16,965</td>
<td>12,468</td>
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<tr>
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<td>328</td>
<td>15,115</td>
<td>178,241</td>
<td>825</td>
<td>693</td>
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<tr>
<td>2030 MC</td>
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<td>44</td>
<td>32</td>
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<td>421</td>
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<tr>
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<td>4</td>
<td>191</td>
<td>394</td>
<td>207</td>
<td>189</td>
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<tr>
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<td>795</td>
<td>18,178</td>
<td>115,978</td>
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<td>4,327</td>
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<td>Total 2030</td>
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<td>5,366</td>
<td>317,164</td>
<td>2,731,909</td>
<td>71,402</td>
<td>64,816</td>
<td>36,529</td>
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</table>
Table 16. 1999, 2008, 2012, and 2030 baseline nonroad mobile source emissions (Mg/year).

<table>
<thead>
<tr>
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<th>VOC</th>
<th>CO</th>
<th>PM10</th>
<th>PM2.5</th>
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<tbody>
<tr>
<td>1999</td>
<td>263,768</td>
<td>3,486</td>
<td>35,169</td>
<td>153,604</td>
<td>37,240</td>
<td>36,123</td>
</tr>
<tr>
<td>2008</td>
<td>281,006</td>
<td>3,709</td>
<td>38,290</td>
<td>165,890</td>
<td>40,447</td>
<td>39,234</td>
</tr>
<tr>
<td>2012</td>
<td>296,402</td>
<td>3,911</td>
<td>40,463</td>
<td>175,197</td>
<td>42,734</td>
<td>41,452</td>
</tr>
<tr>
<td>2030</td>
<td>437,465</td>
<td>5,777</td>
<td>59,058</td>
<td>256,756</td>
<td>62,449</td>
<td>60,576</td>
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</table>

Table 17. Baseline Mexico emissions by source type (Mg/yr).

<table>
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<th>VOC</th>
<th>CO</th>
<th>PM10</th>
<th>PM2.5</th>
<th>NH3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td>297,264</td>
<td>198,917</td>
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<td>2,500,852</td>
<td>439,253</td>
<td>320,369</td>
<td>1,130,400</td>
</tr>
<tr>
<td>On-Road</td>
<td>435,665</td>
<td>24,453</td>
<td>573,042</td>
<td>4,671,842</td>
<td>20,567</td>
<td>18,845</td>
<td>7,609</td>
</tr>
<tr>
<td>Nonroad</td>
<td>263,768</td>
<td>3,486</td>
<td>35,169</td>
<td>153,604</td>
<td>37,240</td>
<td>36,123</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,424,580</td>
<td>2,856,380</td>
<td>2,599,676</td>
<td>7,493,946</td>
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<td>574,254</td>
<td>1,138,009</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point</td>
<td>606,053</td>
<td>2,575,537</td>
<td>328,096</td>
<td>237,926</td>
<td>359,919</td>
<td>239,274</td>
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</tr>
<tr>
<td>Area</td>
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<td>119,763</td>
<td>2,106,842</td>
<td>3,068,145</td>
<td>483,735</td>
<td>355,488</td>
<td>724,092</td>
</tr>
<tr>
<td>On-Road</td>
<td>370,177</td>
<td>27,765</td>
<td>399,936</td>
<td>2,872,420</td>
<td>31,890</td>
<td>29,551</td>
<td>11,931</td>
</tr>
<tr>
<td>Nonroad</td>
<td>281,006</td>
<td>3,709</td>
<td>38,290</td>
<td>165,890</td>
<td>40,447</td>
<td>39,234</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,621,199</td>
<td>2,726,774</td>
<td>2,873,164</td>
<td>6,344,381</td>
<td>915,991</td>
<td>663,547</td>
<td>736,023</td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point</td>
<td>686,509</td>
<td>2,615,816</td>
<td>348,004</td>
<td>262,449</td>
<td>388,825</td>
<td>256,861</td>
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<td>415,907</td>
<td>60,094</td>
<td>2,202,932</td>
<td>2,939,976</td>
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<td>727,417</td>
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<td>12,490</td>
<td>340,519</td>
<td>2,065,988</td>
<td>34,019</td>
<td>31,258</td>
<td>14,533</td>
</tr>
<tr>
<td>Nonroad</td>
<td>296,402</td>
<td>3,911</td>
<td>40,463</td>
<td>175,197</td>
<td>42,734</td>
<td>41,452</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,735,337</td>
<td>2,692,311</td>
<td>2,931,918</td>
<td>5,443,610</td>
<td>909,378</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point</td>
<td>1,239,873</td>
<td>3,359,643</td>
<td>455,901</td>
<td>436,116</td>
<td>638,533</td>
<td>420,929</td>
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</tr>
<tr>
<td>Area</td>
<td>854,999</td>
<td>23,223</td>
<td>3,170,187</td>
<td>4,167,536</td>
<td>412,043</td>
<td>286,518</td>
<td>738,330</td>
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<tr>
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<td>117,883</td>
<td>5,366</td>
<td>317,164</td>
<td>2,731,909</td>
<td>71,402</td>
<td>64,816</td>
<td>36,529</td>
</tr>
<tr>
<td>Nonroad</td>
<td>437,465</td>
<td>5,777</td>
<td>59,058</td>
<td>256,756</td>
<td>62,449</td>
<td>60,576</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2,650,220</td>
<td>3,394,009</td>
<td>4,002,310</td>
<td>7,592,317</td>
<td>1,184,427</td>
<td>832,839</td>
<td>774,859</td>
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</table>

Table 18. Control Scenario 1 emission reductions (increased fuel economy for light-duty gasoline vehicles and trucks) (%).

<table>
<thead>
<tr>
<th>Year</th>
<th>NOx</th>
<th>SO2</th>
<th>VOC</th>
<th>CO</th>
<th>PM10</th>
<th>PM2.5</th>
<th>NH3</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>0.000</td>
<td>NE</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>NE</td>
</tr>
<tr>
<td>2012</td>
<td>0.439</td>
<td>NE</td>
<td>0.204</td>
<td>1.028</td>
<td>0.986</td>
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<tr>
<td>2030</td>
<td>3.837</td>
<td>NE</td>
<td>1.785</td>
<td>1.222</td>
<td>8.973</td>
<td>8.610</td>
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NE = Not estimated

Table 19. Control Scenario 2 emission reductions (switching to ethanol) (%).

<table>
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<th>Guadalajara</th>
<th>Monterrey</th>
<th>Mexico City</th>
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<tr>
<td>2008</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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<td>2012</td>
<td>2.397</td>
<td>4.573</td>
<td>2.782</td>
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<td>2030</td>
<td>2.182</td>
<td>3.934</td>
<td>2.709</td>
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Table 20. 1999, 2008, 2012, and 2030 on-road motor vehicle emissions with Control Scenarios 1, 2, and 3 (Mg/yr).

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<tr>
<th>Year</th>
<th>NOx</th>
<th>SO2</th>
<th>VOC</th>
<th>CO</th>
<th>PM10</th>
<th>PM2.5</th>
<th>NH3</th>
</tr>
</thead>
<tbody>
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<td>1999</td>
<td>435,665</td>
<td>24,453</td>
<td>573,042</td>
<td>4,671,842</td>
<td>20,567</td>
<td>18,845</td>
<td>7,609</td>
</tr>
<tr>
<td>2008</td>
<td>370,177</td>
<td>27,765</td>
<td>399,936</td>
<td>2,872,420</td>
<td>31,890</td>
<td>29,551</td>
<td>11,931</td>
</tr>
<tr>
<td>2012</td>
<td>336,519</td>
<td>12,490</td>
<td>340,519</td>
<td>2,065,988</td>
<td>34,019</td>
<td>31,258</td>
<td>14,533</td>
</tr>
<tr>
<td>2030</td>
<td>117,883</td>
<td>5,366</td>
<td>317,164</td>
<td>2,731,909</td>
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<td>64,816</td>
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</table>

2012–CS1
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<th>VOC</th>
<th>CO</th>
<th>PM10</th>
<th>PM2.5</th>
<th>NH3</th>
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</thead>
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<tr>
<td>2012</td>
<td>335,960</td>
<td>12,490</td>
<td>339,902</td>
<td>2,063,431</td>
<td>33,824</td>
<td>31,087</td>
<td>14,533</td>
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<tr>
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<td>116,159</td>
<td>5,366</td>
<td>312,147</td>
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2012–CS2
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<th>PM10</th>
<th>PM2.5</th>
<th>NH3</th>
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</thead>
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<td>313,197</td>
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2012–CS3
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<th>VOC</th>
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<th>PM10</th>
<th>PM2.5</th>
<th>NH3</th>
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</table>

CS1 = Control Scenario 1, CS2 = Control Scenario 2, CS3 = Control Scenario 3

Figure 1. 1999 Mexico SO2 emissions by source type (Mg/yr).
Figure 2. 2030 Mexico SO₂ emissions by source type (Mg/yr).

Figure 3. Mexico NOₓ emissions by source type (Mg/yr).
Figure 4. Mexico on-road motor vehicle VOC emissions by control scenario (Mg/yr).