Inventory of New Mexico Greenhouse Gas Emissions: 2000 - 2013

Prepared by the New Mexico Environment Department

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List of Acronyms and Key Terms

Ag	Agricultural
BBER	Bureau of Business and Economic Research
CaO	Calcium Oxide
$CaCO_3$	Calcium Carbonate
CAA	Clean Air Act
CBM	Coal Bed Methane
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalence
CPP	Clean Power Plan
DOE	Department of Energy
EAT	Emissions Analysis Tool
EE	Energy Efficiency
EI	Emissions Inventory
EIA	Energy Information Administration
EIIP	Emissions Inventory Improvement Project
EPA	US Environmental Protection Agency
FF	Fossil Fuel
GHG	Greenhouse Gases
GTE	Gas to Energy
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
IPCC	International Panel on Climate Change
LFGTE	Landfill Gas to Energy
MCF	Methane Conversion Factors
$MMtCO_2$	Million Metric Tonnes Carbon Dioxide
$MMtCO_2e$	Million Metric Tonnes Carbon Dioxide Equivalent
$MtCO_2e$	Metric Tonnes Carbon Dioxide Equivalent
MSW	Municipal Solid Waste
MW	Megawatt
MWh	Megawatt hour
N	Nitrogen
NASS	National Agricultural Statistics Service
NM	New Mexico
NMED	New Mexico Environment Department
N_2O	Nitrous Oxide
NOx	Nitrogen Oxides
O_2	Oxygen
ODS	Ozone Depleting Substances
PFCs	Perfluorocarbons
RCI	Residential Commercial Industrial
RPS	Renewable Portfolio Standard

SCR	Selective Catalytic Reduction
SEDS	State Energy Data System
SIT	State Inventory Tool
SF_6	Sulfur Hexafluoride
SWB	Solid Waste Bureau
US	United States
USDA	United States Department of Agriculture
USGS	United State Geological Survey

Executive Summary

This document, Inventory of New Mexico Greenhouse Gas (GHG) Emissions: 2000-2013 (hereafter referred to as 2013 Update), is a statewide compilation and analysis of GHG emissions data on a sector basis, providing information for decision makers to gain a broad perspective about the relative contribution of each sector as it relates to the state's GHG portfolio. This 2013 Update relies heavily on the Environmental Protection Agency (EPA) State Inventory Tool (SIT) and input data from the Energy Information Administration (EIA). The use of these data and the tool will ensure that future updates to the state inventory are compiled with similar methods so that trend analyses and comparisons are meaningful. This report will be periodically updated to evaluate statewide GHG emissions on a sector basis. It is important to recognize that changes from previous updates may, in part, reflect changes to the input data and emission calculation methods. The data, analysis and trends derived from this report may help inform future climate change planning and adaptation. This document was last updated in May 2016 to include emissions from 2000 - 2010.

This report discusses GHG emissions, significant issues, trends, and uncertainties from each of the following primary sectors of GHG emissions:

- Fossil fuel combustion
- Fossil fuel industry
- Electricity Generation
- Transportation
- Residential, commercial and industrial energy consumption
- Industrial processes
- Agriculture
- Waste management

Although the focus of this report is to provide a top-down inventory, bottom-up data are included. Top-down activity data (e.g., statewide fuel consumption) are used to estimate emissions from a broad cross section of GHG emitting sources, whereas bottom-up data are estimated from specific and larger emitting unit(s) (e.g., a facility with an air permit). NMED developed an Emissions Analysis Tool (EAT) that allows users to review and analyze criteria and GHG pollutant emissions inventory data primarily from Title V facilities starting with emissions year 2008. The tool includes map, list, trend and chart views. Additional features allow users to filter data by year, source, pollutant, industry, county, city and facility. The EAT can be found at the following link:

https://eatool.air.net.env.nm.gov/aqbeatool/

New Mexico's total GHG emissions are dominated by Electricity Generation and consumption, fossil fuel industry, and transportation sectors. Emissions from the residential, commercial, and (non-fossil fuel production) industrial sectors are also proportionally significant, with an increase in the use of Ozone Depleting Substitutes (ODS) and relatively steady production in the semi-conductor industry. The industrial, agricultural, and waste management sectors are relatively small contributors to total GHG emissions in New Mexico. The largest shift in emissions resulting from this update was the overall reduction of total emissions from prior years.

Summary of New Mexico GHG Emissions Trends 2000 – 2013

- After a 3% annual GHG emissions growth rate experienced from 1990 to 2000, the total (gross) direct emissions in New Mexico decreased by 6 million metric tons from 2000 to 2013. Emissions decreased slightly despite a 14.7%[1] growth in New Mexico's population over that period.
- The largest sources of GHG emissions in 2013 were Electricity Generation (35%), the fossil fuel industry (26%), and transportation fuel use (17%).
- 2013 per capita emissions on a consumption basis were 34 metric tons of carbon dioxide equivalent ($MtCO_2e$) per person.
- Fossil fuel industry (production, processing and transportation of natural gas, oil, and coal) emissions in 2013 were 21.1 million metric tons of carbon dioxide equivalent ($MMtCO_2e$), the lowest they have been since 2000 and a sharp departure from 2010. Values from this sector for all years were updated using a methane global warming potential (GWP) of 25 instead of 21 which was used in the 2007 Update.[2] (The 2010 Update also used a GWP of 25 for methane.)
- For 2013, approximately 85% of Electricity Generation emissions are from coal-fired power plants; this percentage has been decreasing since 2000.
- The metric tons of carbon dioxide equivalent per megawatt hour ($MtCO_2e/MWh$) of production decreased by 17% from 2000 to 2013 reflecting increases in Electricity Generation from lower emitting renewable and natural gas electric generating sources.
- GHG emissions from the transportation sector increased 12%, peaking in 2007 before returning to 2000 levels in 2013.
- Both the waste management and agricultural sectors showed small total increases in GHG emissions (0.8 and 1.4 $MMtCO_2e$, respectively) since 2000.
- The total emissions from energy consumption in the commercial sector fluctuated, ending with 2013 emissions slightly below 2000 levels.
- The use of ODS substitutes is now the leading source of GHG emissions from the industrial sector having nearly doubled from 2000 to 2013.

[1] From the Bureau of Business & Economic Research at the University of New Mexico, Statistics at a glance 2014. http://bber.unm.edu/

[2] Based on reporting guidelines issued by the United National Framework Convention on Climate Change, http://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf#page=2.

1.0 Inventory of New Mexico Greenhouse Gas Emissions, 2000-2013

1.1 Introduction

This report presents estimates of historical New Mexico anthropogenic GHG emissions for the period from 2000 to 2013. This information has been compiled to support and inform efforts to address anthropogenic climate change. In some cases, reference to estimates of emissions from 1990 have been included for purposes of evaluating longer term trends. Emissions by sector are reported in Sections 2 through 8. Key findings and summaries of trends are reported in Sections 1.2 through 1.5. The emissions estimation approaches and variations from methods used in previous update(s) are discussed in Section 1.6 and throughout the report.

This analysis updates the Inventory of Greenhouse Gases 2000 - 2010 report released by the New Mexico Environment Department (NMED, or Department) on May 13, 2016. This report includes three additional years of now historical information. This report covers the six gases included in the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions of these greenhouse gases are presented using a common metric, CO_2 equivalence (CO_2e), which indicates the relative contribution of each gas to global average radiative forcing by weighting them using the Global Warming Potential (GWP) established for each gas. The GWPs for CH_4 and N_2O have been changed to their current values of 25 and 298 respectively.[3] Table 1 lists the GWPs used in this updated report.

Table 1: Global Warming Potentials Used in this Report

Gas	GWP
Carbon dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous oxide (N_2O)	298
HFC-23	14,800
HFC-125	3,500
HFC-134a	1,430
HFC-143a	4,470
HFC-152a	124
HFC-227ea	3,220
HFC-236fa	9,810
HFC-4310mee	1,640
CF_4	7,390
C_2F_6	12,200
C_4F_{10}	8,860
C_6F_{14}	9,300
SF_6	22,800

This estimate does not include emissions sinks and projections. Carbon sinks are primarily vegetative material that absorbs carbon dioxide from the atmosphere. Projections are developed based on a range of assumptions, which assume that past trends can predict future activities. In some cases, these predictions are met. However, current uncertainties regarding the impacts of

[3] https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

federal GHG emission reduction programs and instability of fuel prices and the economy do not allow the Department to develop valid projections regarding future GHG emissions.

Readers of this report may be interested in the US Environmental Protection Agency's annual Inventory of US Greenhouse Gas Emissions.[4] In addition to GHG emissions inventories developed by local, state and federal agencies to estimate regional emissions, a growing number of companies are developing GHG emissions inventories either voluntarily[5] or to meet regulatory reporting requirements.[6] In New Mexico (exclusive of Indian Lands and Bernalillo County), larger emissions sources have reported GHG emissions since 2008 to the New Mexico Environment Department. NMED developed the EAT which provides users with annual criteria, hazardous and GHG pollutant data. The EPA has also required GHG emissions reporting pursuant to 40 CFR Part 98 since 2010.[7] Detailed analyses of GHG emissions reported to the EPA can be conducted by reviewing EPA's FLIGHT[8] database.

1.2 Summary of Key Findings and Trends

Similar to previous updates, this report utilizes several approaches to evaluate emissions of greenhouse gases in New Mexico. As discussed in Sections 1.3 through 1.5, emissions can be evaluated on a production basis, consumption basis, or per capita basis. Each approach can offer insights regarding emissions patterns and trends in the state. In addition, sector-specific information may be found in Sections 2 through 8.

In summary, for the period 2000 – 2013:

- The largest sources of GHG emissions in 2013 were Electricity Generation (35%), the fossil fuel industry (26%), and transportation fuel use (17%). This ranking is consistent with emissions estimations for the years 2000, 2007 and 2010 though the percentages for these categories went down except for the transportation sector which went up one percent from 2010 – 2013.
- The total (gross) direct emissions in New Mexico decreased by approximately seven percent from 2000 to 2013. The decrease can be attributed in part to lower electricity and fossil fuel sector emissions, and partly to a sluggish economy. Direct emissions peaked in 2007 which was prior to the economic downturn. The decreased emissions occurred despite a 14.7% growth in New Mexico's population over that period.
- This report estimates the per capita emissions for the state on a consumption basis (Section 1.4). For 2013, the per capita emissions for New Mexico were 34 $MtCO_2e$ per person (see Section 1.5). This value is unchanged from the 2010 Update.
- Estimations for emissions from the fossil fuel industry (production, processing, and transportation of natural gas, oil, and coal) were recalculated using updated emission factors and a revised methane GWP and showed a decrease from the 2010 Update. These values will likely change as EPA continues to receive emissions data from this sector via

[4] http://www.epa.gov/climatechange/emissions/index.html#inv
[5] Voluntary reporting may be accomplished under a number of programs. The most comprehensive is The Climate Registry (http://www.theclimateregistry.org/).
[6] NMED's GHG emissions reporting requirements (https://www.env.nm.gov/aqb/GHG/ghgrr_index.html)
[7] US EPA's GHG emissions reporting requirements (http://www.epa.gov/ghgreporting/)
[8] Ibid.

40 CFR Part 98 Subpart W. Despite this decrease, it is clear that emissions from this sector are greater than what was previously estimated. One trend noted is a ten-fold increase in methane emissions from coal mining, which now comprise about 7% of the estimated emissions from the fossil fuel industry sector.

- Emissions from electricity generation are predominantly attributed to coal-fired power plants, which contribute approximately 85% of the total GHG emissions for this sector (see Section 3) in 2013. However, the emissions per megawatt-hour of electricity produced have decreased by almost 17% since 2000, due to increases in the use of natural gas, wind, and solar energy to generate electricity.
- GHG emissions from the transportation sector increased to a peak in 2007 before retreating to 2000 levels by 2013 (see Section 4). Emissions from diesel fuel use increased by 34% during this period, and the estimated emissions from gasoline consumption decreased by 8%.
- Although the state population grew 14.7% from 2000 – 2013 (see Sections 1.4 and 1.5), New Mexicans reduced their average (per capita) emissions from transportation gasoline use by 20% and increased their consumption of energy in heating, cooling, and powering residential buildings by 1%. Over time, energy use in residential and commercial buildings has shifted away from fossil fuel combustion (predominantly natural gas) in favor of electricity use. The increase in electricity use may be the result of a greater use of air conditioning, electric heat, and appliances.
- The total emissions from energy consumption in the commercial sector fluctuated, ending with 2013 emissions slightly greater than 2000 levels.
- The total emissions from industrial processes (i.e., emissions not associated with combustion) decreased slightly from 1.5 $MMtCO_2e$ in 2000 to 1.4 $MMtCO_2e$ in 2013. The use of ODS substitutes is now the leading source of GHG emissions from the industrial sector, replacing GHG emissions from semiconductor manufacturing. The contribution from the various sub-categories is reported in Section 6.
- Both the waste management and agricultural sectors showed small total increases in 2013 GHG emissions (0.8 and 1.4 $MMtCO_2e$, respectively) compared to 2000 emissions. These estimates do not include emissions from consumption of fossil fuels (e.g., transportation, equipment operation, heaters, etc.).

1.3 Evaluating Emissions on a Production Basis

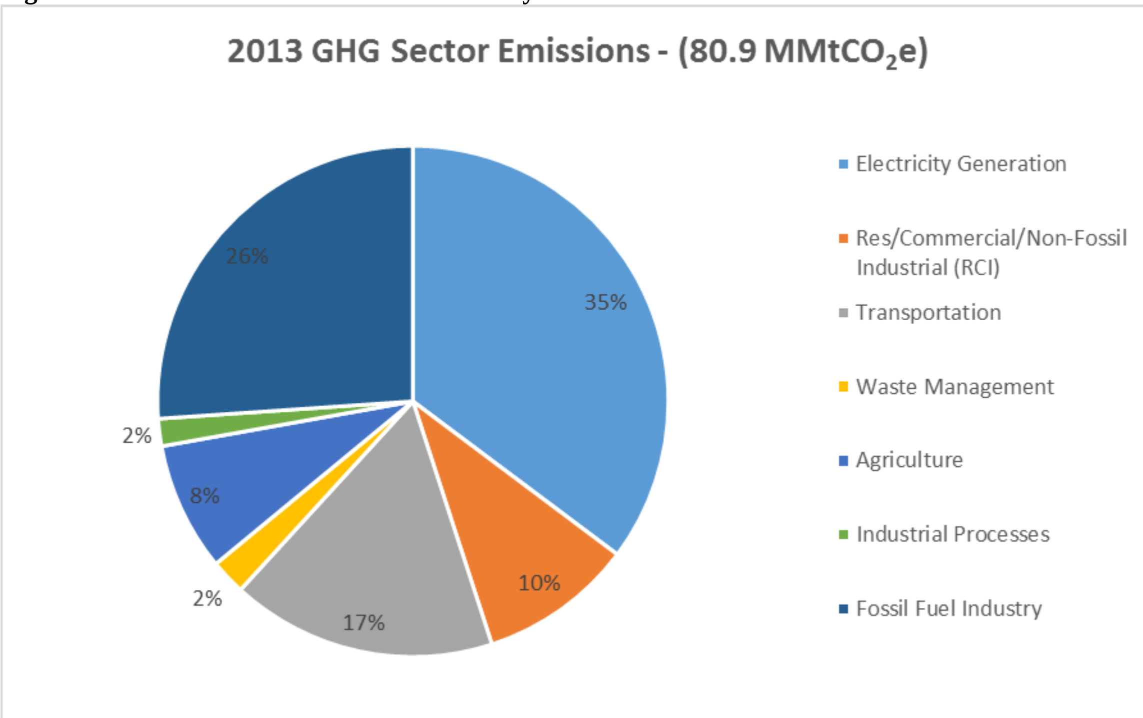
To evaluate emissions on a production basis one must consider the total (gross) direct emissions from the activities of all sources in the state. A production-based analysis does not take into consideration the GHG emissions produced during the manufacture and transportation of products to the state, or adjust for the GHG emissions associated with electricity imported or exported across state lines. Table 2 summarizes the total direct emissions for 2000, 2007, 2010 and 2013 estimated in Sections 2 through 8 for each sector.

Figure 1 illustrates the GHG emissions percentage by sector. Note that while the estimates are rounded to one decimal point, the sums are based on the estimates prior to rounding and so might not reflect the sum of the rounded estimates. Table 2 provides the updated estimates for 2000, 2007, 2010, and 2013 using the methods described in this report.

Table 2: GHG Emissions for New Mexico Production Basis

GHG Emissions for New Mexico - Production Basis (Million Metric Tons CO_2e)	2000	2007	2010	2013
Electricity Generation	32.5	31.9	28.8	28.5
Coal	29.5	28.6	25.5	24.4
Natural Gas	3.0	3.3	3.3	4.1
Petroleum	0.0	0.0	0.0	0.0
Residential/Commercial /Non-Fossil Industrial (RCI)	7.4	7.7	6.3	7.9
Coal	0.2	0.2	0.1	0.1
Natural Gas	4.4	3.9	3.2	3.3
Petroleum	2.8	3.6	3.0	4.5
Transportation	13.6	15.1	13.0	13.6
Fossil Fuel Industry	25.7	27.4	25.6	21.1
Natural Gas Industry	22.7	24.0	21.3	16.7
Production	11.3	14.1	14.7	9.7
Processing	7.3	6.7	3.5	3.9
Transmission	3.7	2.8	2.5	2.5
Distribution	0.4	0.5	0.6	0.6
Oil Industry	2.8	2.1	2.4	3.0
Production	1.2	1.1	1.2	1.8
Refineries	1.6	1.0	1.2	1.2
Coal Mining (Methane)	0.2	1.3	1.9	1.4
Industrial Processes	1.5	1.4	1.1	1.4
ODS Substitutes	0.5	0.7	0.8	1.1
PFCs in Semi-conductor Ind.	0.5	0.2	0.1	0.1
SF6 from Electric Utilities	0.1	0.1	0.1	0.1
Cement & Other Industry	0.4	0.4	0.1	0.1
Waste Management	1.0	1.3	1.7	1.8
Solid Waste Management	0.8	1.1	1.5	1.6
Wastewater Management	0.2	0.2	0.2	0.2
Agriculture	5.2	6.1	6.0	6.6
Manure Management Mgmt & Enteric Fermentation (CH4)	3.9	4.7	4.9	5.2
Agricultural Soils (N2O)	1.3	1.4	1.1	1.4
Total Gross Emissions	86.8	90.9	83.3	80.9

Figure 1: 2013 New Mexico GHG Emissions by Sector



1.4 Evaluating Emissions on a Consumption Basis

The majority of GHG emissions in New Mexico are the result of the coal-based electricity generation and fossil fuel industries, a significant fraction of which meets the needs in other states. This situation raises an important question with respect to how these emissions should be addressed from an accounting and policy basis. Section 1.3 presents New Mexico emissions on a production basis, which is to say the total gross emissions of GHG from New Mexico. Another approach is to evaluate New Mexico emissions on a consumption basis, which would reflect the emissions resulting from the consumption of energy (both fossil fuels and electricity) in each sector.

Reporting on a consumption basis has the advantage of showing the extent to which GHG reduction initiatives and other influences have changed energy consumption patterns in the state, to better inform policy makers who may be evaluating future initiatives. In addition, the 'carbon footprint' of each sector is more accurately presented by including the emissions that occurred as a result of the electricity consumption by that sector,[9] along with each sector's direct emissions from combustion and process emissions. In a consumption-based evaluation of emissions, the emissions from electricity generation are attributed to the sectors within the state that consume the electricity, with the emissions that occurred during generation of exported electricity reported

[9] The 'carbon content' of electricity used in New Mexico is estimated in this report as the total emissions from electricity generation in the state in a given year, divided by the total electricity generated in the state during that year. While the carbon content of imported electricity may be different, data are not available for estimating imported electricity. However, imported electricity accounts for only a small portion of electricity use in New Mexico.

as a separate category within the industrial sector. Thus the total emissions reported in Section 1.3 are included in this evaluation, although the attribution shifts.

Figure 2 illustrates the consumption based emissions in New Mexico for the years 2000, 2007, 2010, and 2013. This figure divides emissions into (1) transportation emissions (which include emissions from fleets, farm equipment, and personal transport), (2) emissions from energy use in buildings, and (3) emissions from the industrial sector (not including fleets). These represent the three general areas of activity that result in GHG emissions.

Figure 2: Consumption Based GHG Emissions

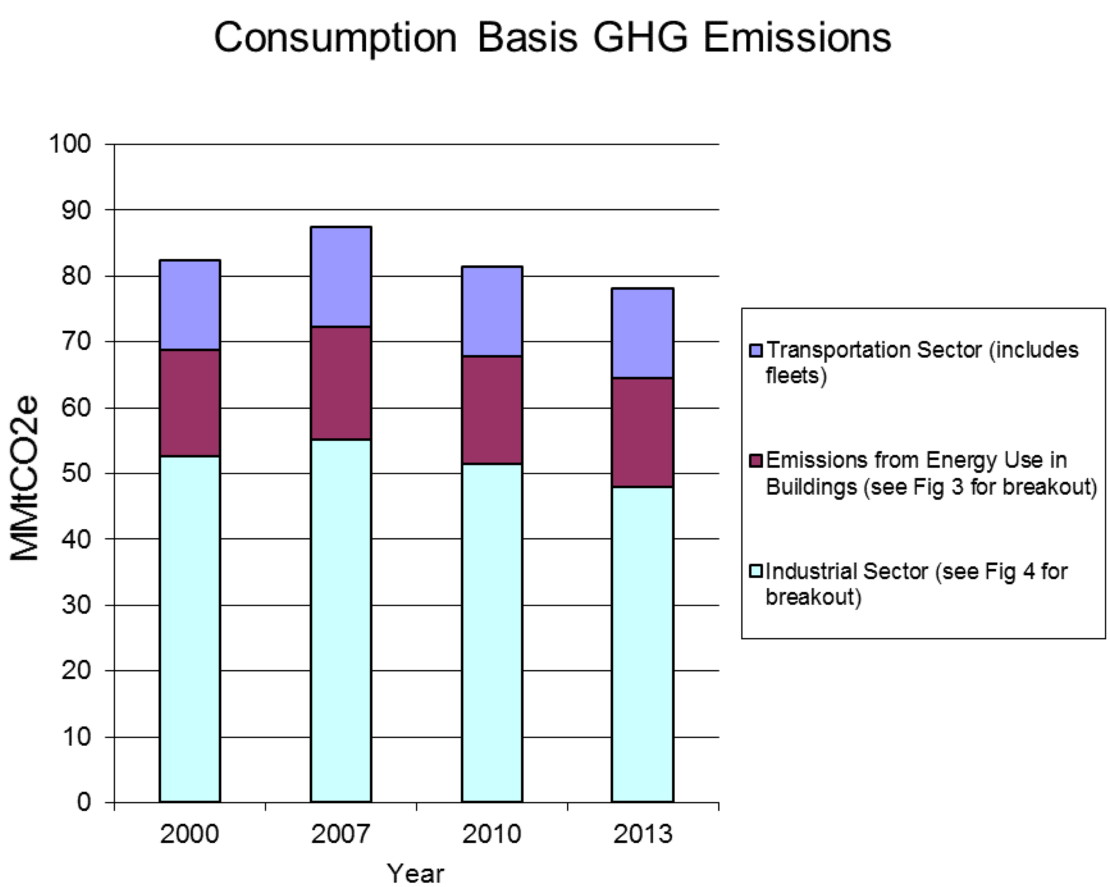


Figure 20 (in Section 4, which further discusses the transportation sector) compares emissions from diesel, gasoline and aviation fuels from 2000 to 2013. During the period 2000 through 2013, the estimated emissions from gasoline consumption decreased by 12.2% despite the state population growing by 14.7%.[10] Several factors may have contributed to this drop of average gasoline usage per person. As newer vehicles are purchased, the average gas mileage rate for vehicles in the state may have improved, and increases in gasoline prices and use of public

[10] From the Bureau of Business & Economic Research at the University of New Mexico, Statistics at a glance 2014. http://bber.unm.edu/

transportation may have resulted in less driving. However, data that would support or quantify such trends is not available at the time of this report.

Emissions from diesel fuel use rose by 34% between 2000 and 2013. This rise reflects the increase in freight traffic anticipated in the New Mexico 2025 Statewide Multimodal Transportation Plan (released in 2005). The Transportation Plan estimated that 85% of commercial traffic on I-10 and I-40 was simply crossing the state, without delivering or picking up any freight, and anticipated that such freight traffic would increase over time because these interstate highways connect to Southern California.

Figure 3 provides greater detail regarding emissions that result from energy use in buildings. These emissions are attributed to the residential and commercial sectors, which consume energy to heat and cool buildings and to power lights and appliances. As shown in Figure 3, electricity use accounts for a larger share of GHG emissions in these sectors than the direct combustion of fossil fuels. Between 2000 and 2013, the indirect emissions from the consumption of electricity in the residential and industrial sectors increased by 27% and 22%, respectively, and decreased by 1% in the commercial sector. Taking electricity consumption into account, the residential sector increased emissions from energy use by a total of 18%. Considering the state's population increase during this time period (2000 – 2013), the per capita residential sector emissions rose slightly to approximately 3.9 metric tons. During the same period, the total emissions from energy consumption in the commercial sector decreased by 1.3%. The RCI sector is further discussed in Section 5.

Figure 3: Consumption Basis Emissions from Energy Use in Buildings

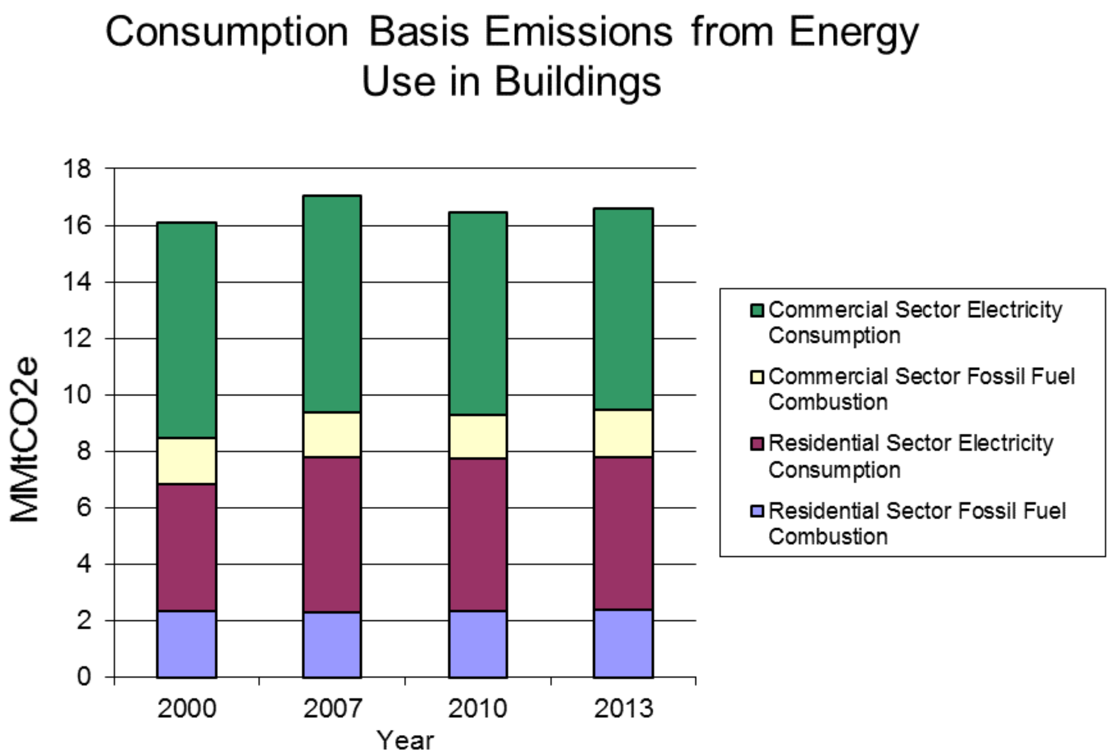
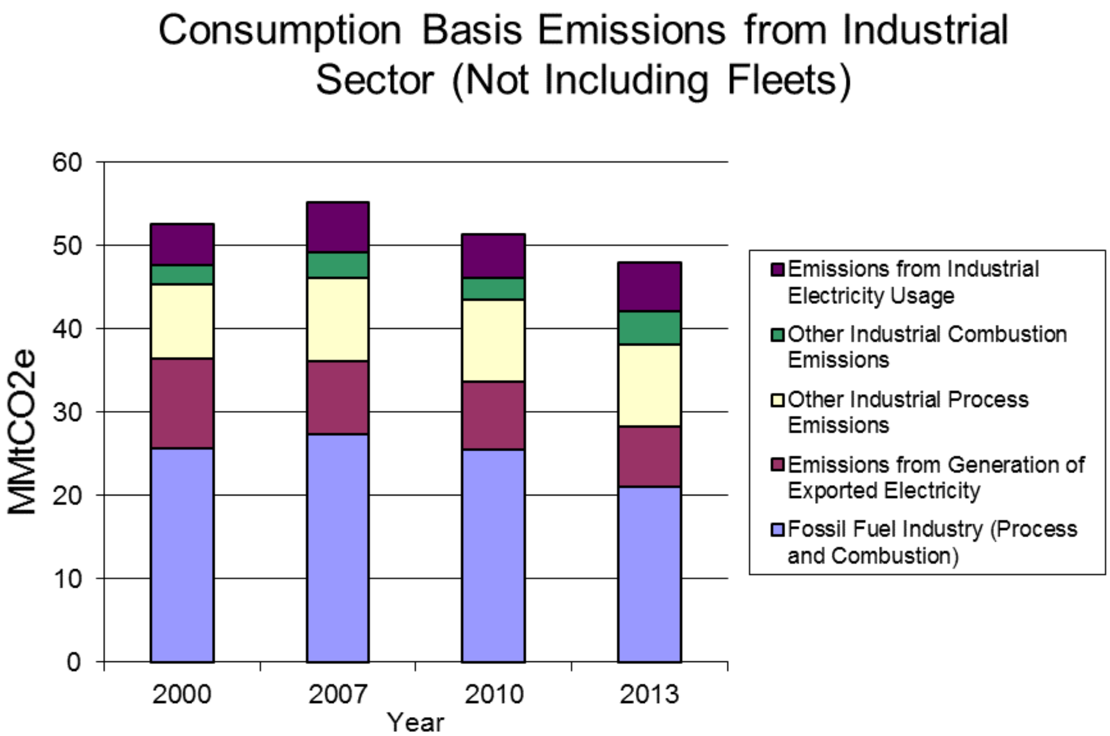


Figure 4 provides greater detail regarding emissions that result from activities in the industrial sector. These activities are further discussed in Section 2 (Fossil fuel Industry), Section 5 [Emissions from Fossil Fuel Combustion in the Residential, Commercial, and (Non-Fossil Fuel Industry) Industrial Sectors] and Sections 6 through 8 (which estimate process emissions). Emissions from the generation of electricity are addressed in Section 3.

Figure 4: Consumption Basis Emissions from Industrial Sector



1.5 Evaluating Emissions on a Per Capita Basis

Per capita emissions estimates do not reflect the sum of the carbon footprints of the residents of that locality. In addition to in-state electricity and fuel use, the carbon footprint of an individual or family includes emissions that result from out-of-state travel and the emissions that result from the manufacture and transport of products purchased by that individual or family.[11] Conversely, a per capita estimate of emissions in a state divides the total emissions from residential, commercial, transportation, and industrial emissions by the population of the state. By doing so, per capita emissions estimates remove the factor of increasing state population from emissions comparisons.

In New Mexico, the total state GHG emissions includes those that result from producing significant amounts of electricity used by consumers in other states, and significant emissions from the production, refining, and transport of oil and natural gas. When comparing the per capita emissions of different states, to include emissions associated with exported electricity in the per capita estimate for New Mexico may cause those emissions to be double counted, because the per capita emissions for electricity importing states are likely to take into account the emissions from generation of the imported electricity.[12]

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[11] http://www.epa.gov/climatechange/emissions/ind_calculator.html

[12] New Mexico both imports and exports electricity, with a net export of 30 to 40% of electricity produced. See Section 3.1.

Thus, this report estimates per capita emissions as the sum of the total emissions less the emissions associated with generation of exported electricity, divided by the state population. For 2013, the per capita GHG emissions for New Mexico were 34 metric tons of CO_2e. This is the same value calculated in our 2010 Update. However, this report (2013 Update) includes updated calculation methodologies resulting in a 2007 per capita GHG emissions rate of approximately 40 metric tons of CO_2e. Therefore, per capita GHG emissions decreased by approximately 15% from 2007 through 2013. The slower economy during this time period probably accounts for the majority of the reduction.

1.6 Emissions Estimation Approach

In its simplest form, emissions inventories are performed by summing the calculated emissions estimates for the specific source categories that are present. Emissions for specific source categories are estimated by multiplying activity factors (e.g., gasoline purchased, coal consumed) by emissions factors. Emissions factors can be developed using information about chemical properties (e.g., the amount of carbon in a given amount of a particular type of coal) and studies (e.g., the percentage of carbon that is retained in fly ash after combustion of coal). The assumptions used in developing emissions factors can introduce significant uncertainty. Additional uncertainty can be introduced in the activity factors, due to inaccuracies that can be inherent in the measurement process (e.g., vehicle miles traveled in the state, percentage of yard waste in landfills).

In order to maintain consistency to the extent possible with other emissions estimates, NMED has used the EPA SIT for state inventories[13] as a starting point. The approach used by the EPA in its national GHG emissions inventory and guidelines for states was developed based on guidelines from the Intergovernmental Panel on Climate Change,[14] the international organization responsible for developing coordinated methods for national GHG inventories. The initial estimates based on the EPA SIT were then augmented to conform to local data and conditions, as informed by New Mexico-specific source data and experts.

In cases where data sources may conflict, a higher priority was placed on local and state data analyses, with national data used as defaults where necessary. Priority was also given to larger emissions source categories, such as the fossil fuel production sector, and as a result sectors with relatively small emissions levels may not be reported in the same level of detail as other activities. Specific details regarding estimation of emissions from specific sectors are included in the following sections.

2.0 Fossil Fuel Industry (Oil, Gas, and Coal)

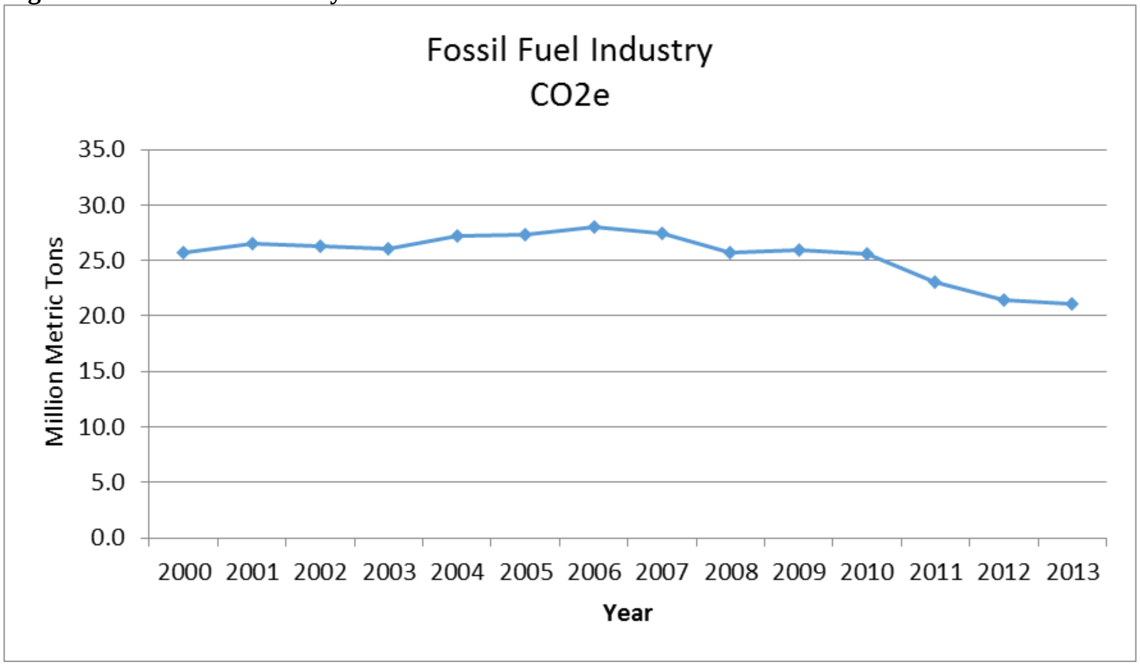
2.1 Emissions 2000 - 2013

Total NM GHG emissions from this sector (Figure 5) decreased from 2000 (25.7 $MMtCO_2e$) to 2013 (21.1 $MMtCO_2e$). The total emissions from this sector have averaged approximately 25 million metric tons per year since 2000. Although they consist of a relatively small proportion of the total, oil production emissions have increased by close to 50 percent from 2009 to 2013,

[13] http://www.epa.gov/climatechange/emissions/state_guidance.html
[14] http://www.ipcc-nggip.iges.or.jp/

whereas natural gas production emissions have decreased by 37 percent since 2010. The increase in emissions from the oil production sector are consistent with the increase in oil production since 2007. The drop in the number of active natural gas production wells coincides with decreases in emissions from that sector as well.

Figure 5: Fossil Fuel Industry GHG Emissions - CO_2e



2.2 Estimation Methodology & Data Sources

The general approach for this sector update was to use EPA's State Inventory Tool, and supplant it with actual process related emissions data (e.g., entrained CO_2 emissions from natural gas processing plants and oil refineries). The SIT uses EIA fuel consumption data to calculate combustion GHG emissions. As with other sectors, GHG emissions were recalculated using the 2016 version of the tool. The comparative analysis section (2.3) explains the differences in the calculated values included in this update and also explains how entrained CO_2 gas plant emissions may have been overestimated prior to 2008.

In addition to fuel combustion data, equipment counts and activity data are used by the SIT to calculate emissions. Process related methane and stationary combustion carbon dioxide emissions from oil and gas operations were calculated for the following five subsectors:

1) Natural gas production;
2) Natural gas processing;
3) Natural gas transmission;
4) Natural gas distribution; and
5) Oil production and refining.

Input data for the SIT for these subsectors include:

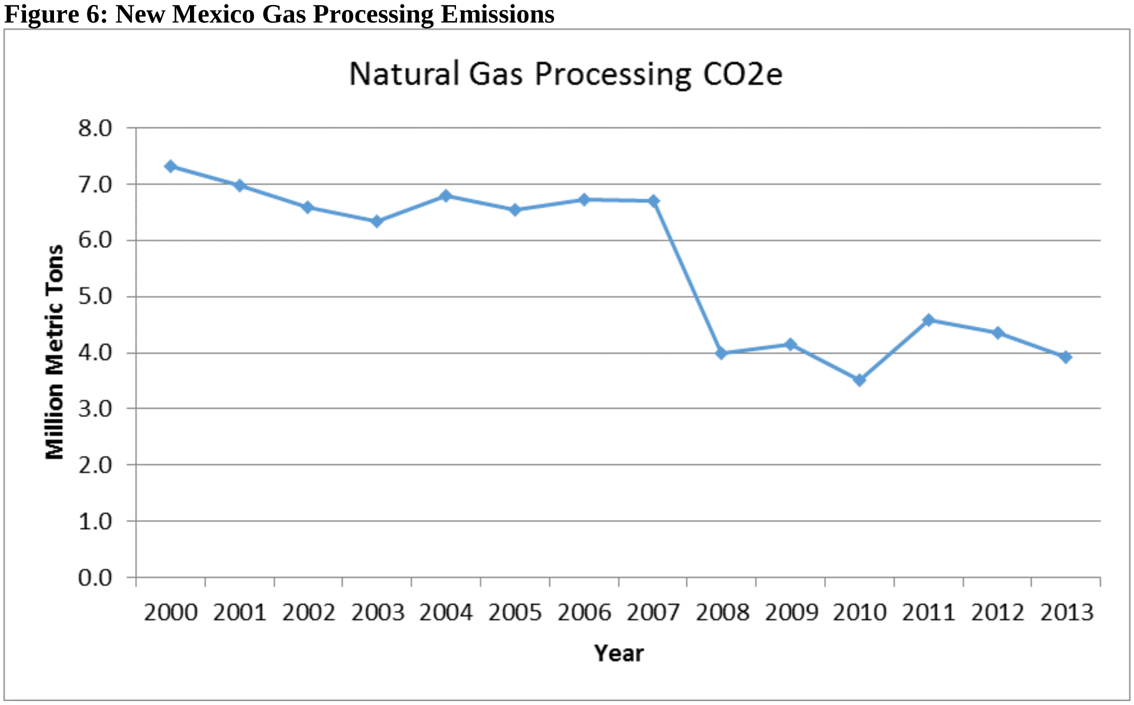
1) Well and gas processing plant counts;
2) Miles of gathering, transmission and distribution pipelines;

3) Gas storage and transmission compressor station counts; and
4) Barrels of oil produced, refined and transported.

Key input data for the natural gas industry sources were obtained from EIA: Lease Fuel Consumption (production), Plant Fuel Consumption (processing), and Natural Gas Consumed as Pipeline Fuel (transmission). For petroleum refinery fuel use, commencing in 2008, actual emissions were obtained from GHG emission inventory reports submitted to either the NMED or EPA. Prior years assumed a constant level of fuel use CO_2 emissions (1.6 $MMtCO_2e$) based on permit limits. However, emission reporting of actual fuel use CO_2 emissions for 2008 gave a smaller value of 1.0 $MMtCO_2e$ for estimated total refinery emissions.

An additional source of CO_2 emissions is the venting of CO_2 removed from natural gas during processing. This source is especially significant in the processing of coal bed methane, which in New Mexico commonly contains in excess of 10% CO_2. For the 2007 Update NMED estimated these emissions using a mass balance approach. Emissions were calculated as the product of volume of coal bed methane produced from the San Juan Basin (data from the Oil Conservation Division of the New Mexico Energy, Minerals and Natural Resources Department) and the estimated concentration of CO_2 at the gas plant inlet. CO_2 concentration was estimated by using a linear fit to concentration values over the period 1998-2002. For 2010 and subsequent update(s), NMED used actual vented CO_2 emissions post-2007 from natural gas processing plants (Figure 6). This is another area where reported emissions were less than previous estimates.

Figure 6: New Mexico Gas Processing Emissions



Methane emissions from oil production, refining, and transportation (Figure 7) were calculated using the SIT and show a steady increase since 2009. Input data obtained from EIA included oil production and refinery production data (Figure 8), with the amount transported assumed to be the same as refinery input. Commencing 2008, CO_2 combustion emissions are derived from reports submitted by refineries to EPA pursuant to 40 CFR Part 98. These emission reports indicate that refinery fuel combustion CO_2 emissions are approximately 30% less than previously estimated.

Figure 7: New Mexico Oil Production and Refining Emissions

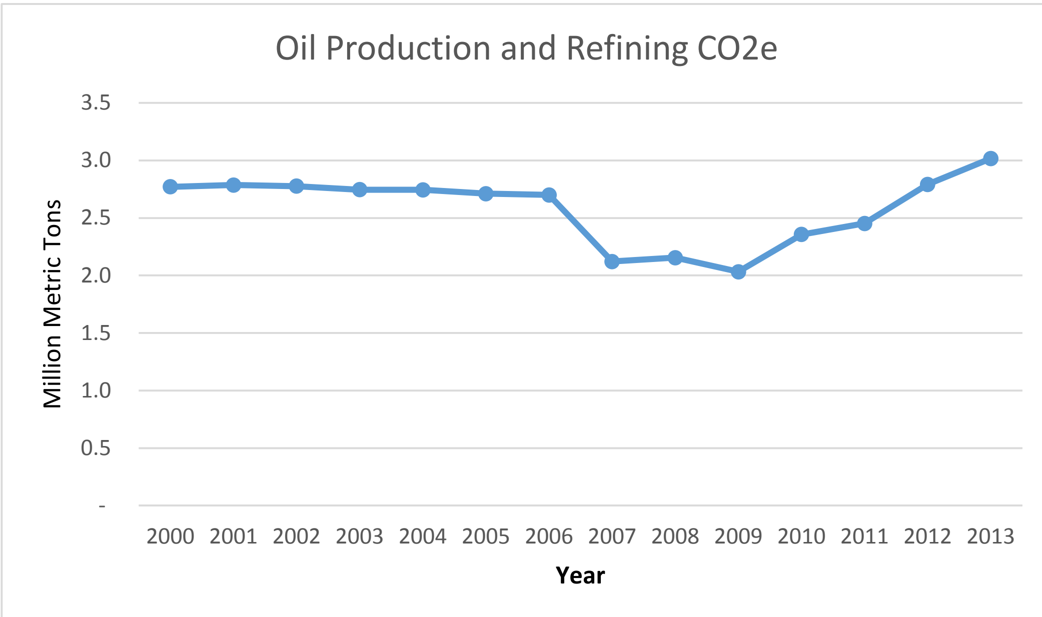
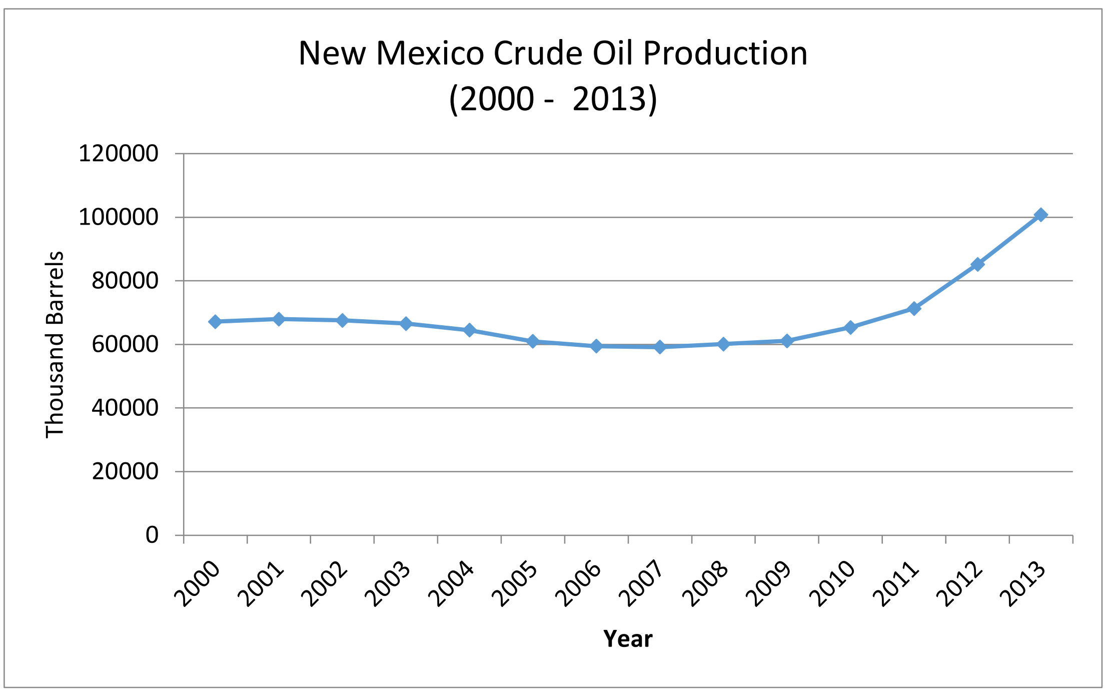
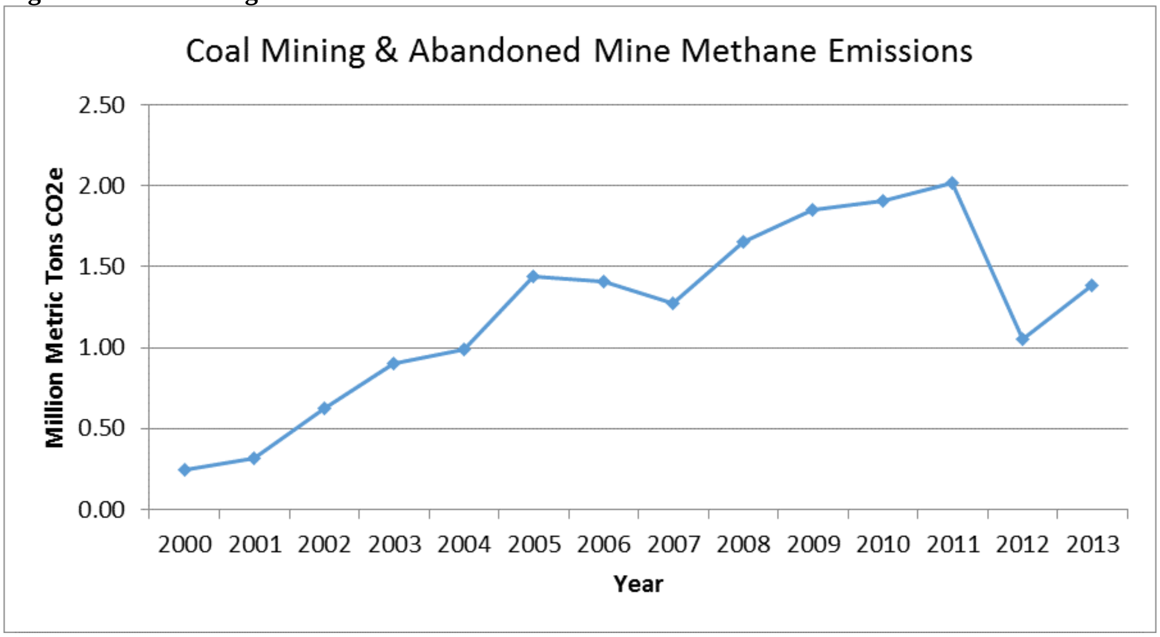


Figure 8: New Mexico Crude Oil Production - Thousand Barrels



Methane emissions from coal mining (Figure 9) were obtained from the 2016 SIT which includes emissions from both active and abandoned coal mines. Previous versions of the tool did not include complete abandoned coal mine input data. The inclusion of abandoned coal mine emissions has resulted in a slight increase of emissions from this sector.

Figure 9: Coal Mining and Abandoned Mine Methane Emissions



2.3 Comparative Analysis

The most significant change in the contribution of major sectors (natural gas, oil, and coal mining methane) from the 2010 Update is the decrease in the percentage of fossil fuel industry methane emissions from the natural gas production sector (Figure 10). This decrease is likely a result of reduced production in response to lower gas prices and decreases in total natural gas and condensate wells count since 2010. The number of natural gas and condensate wells decreased by 10,000 from 2000 – 2011 and subsequently decreased to pre-2000 levels in 2013 (Figure 11).

Figure 10: Natural Gas Production Methane Emissions

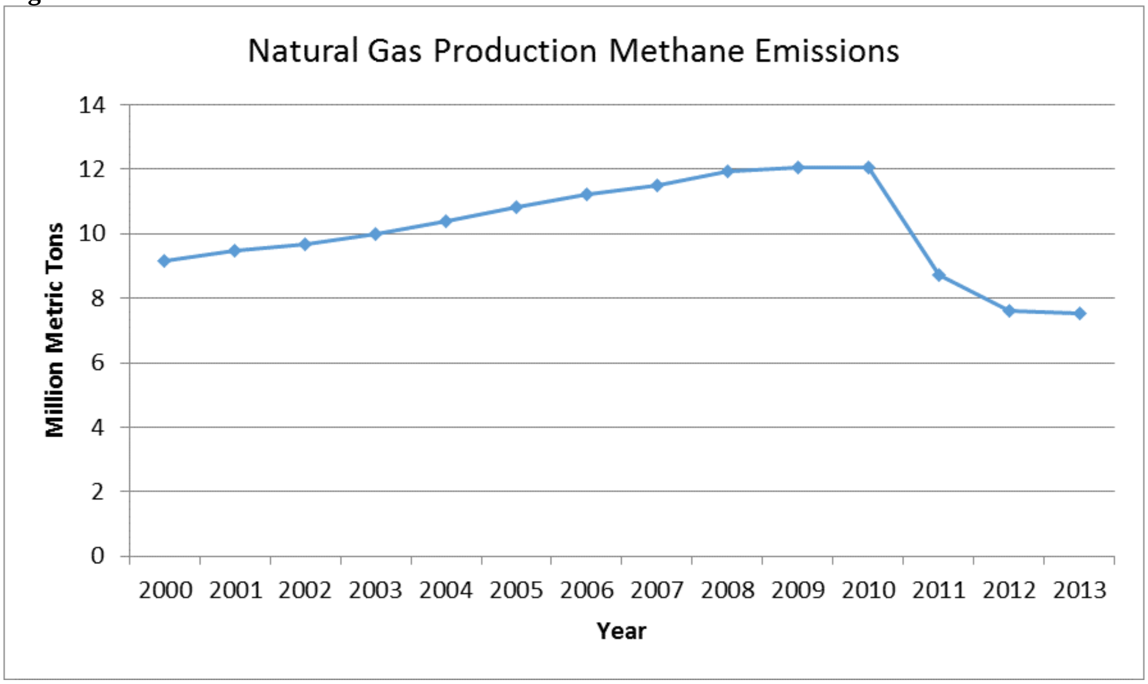


Figure 11: Well Counts - EPA SIT and Energy Information Administration

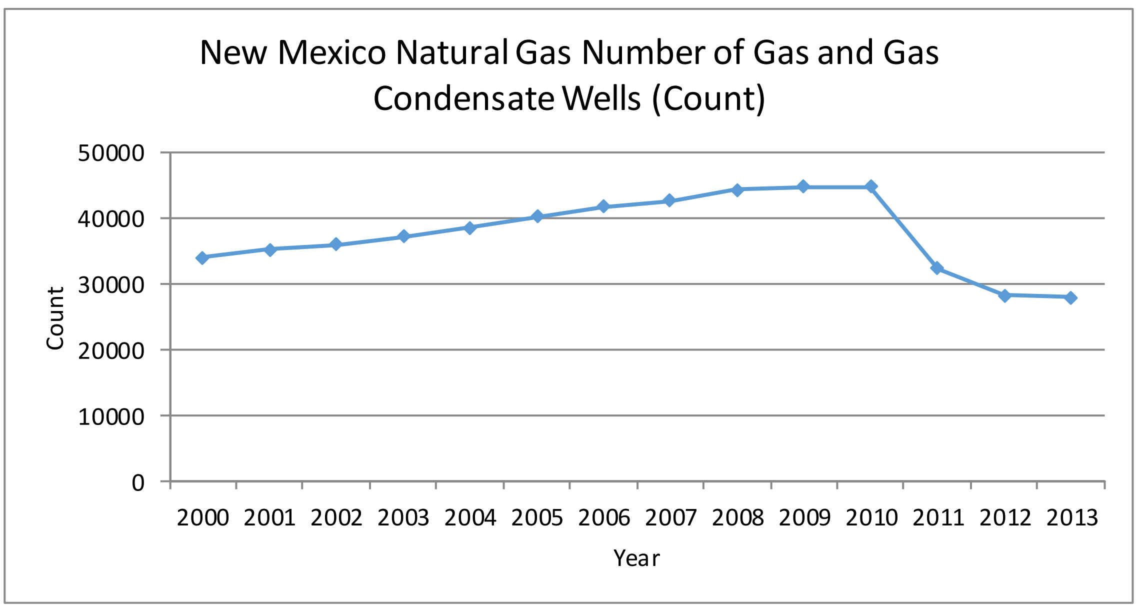
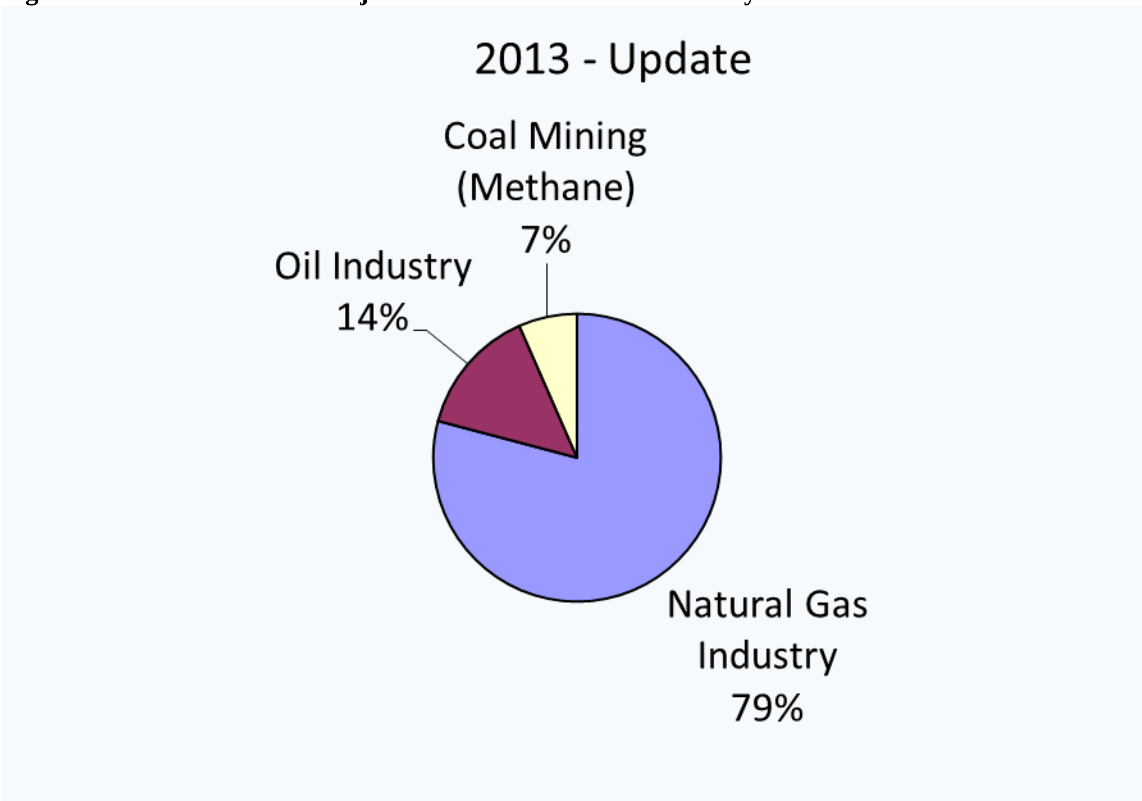


Figure 12 displays the relative contribution by percent from the fossil fuel sector. Oil and natural gas industry emissions increased and decreased respectively when compared to 2010. Coal mining and abandoned mine methane emissions slightly decreased during this time period. As previously mentioned, these changes primarily reflect commodity pricing and market conditions.

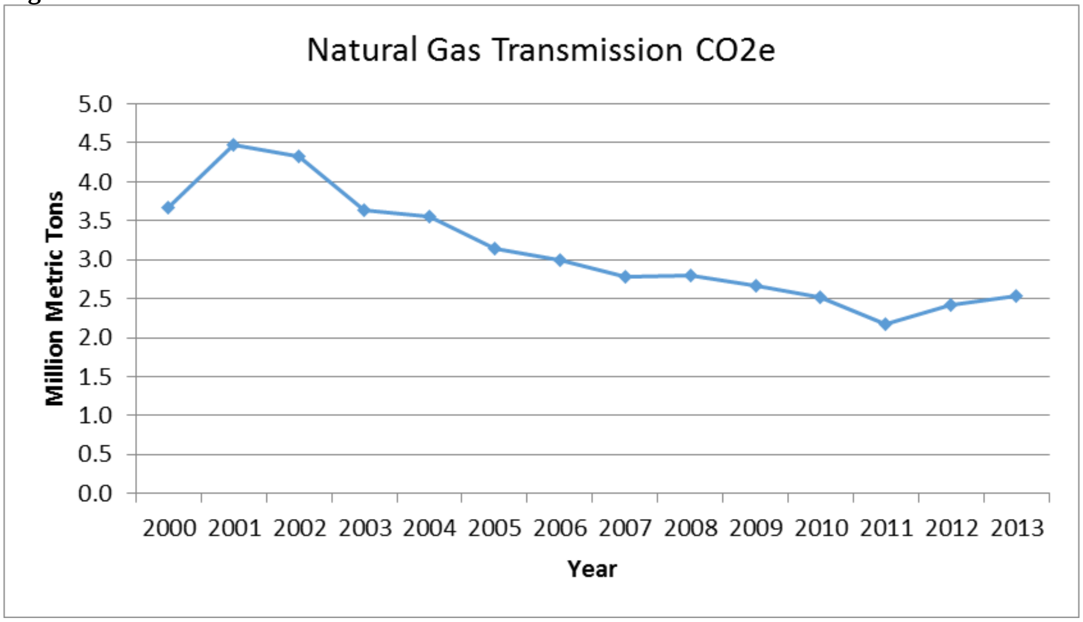
Figure 12: Contributions of Major Sectors to Fossil Fuels Industry Emissions



Among fossil fuel industry combustion CO_2 sources, the most dramatic long-term trend in emissions has been the apparent decrease in estimated emissions from natural gas transmission (Figure 13). We do not believe these data accurately reflect trends in this emissions source. Gas production and processing volumes have not decreased dramatically, and NMED has not noted such a great decrease in the number or activity of large compressor stations. Emissions calculation methods are simple; the only data input is the fuel consumption reported by EIA, which is in turn compiled from company reports to that agency.

As part of the 2007 Update, NMED examined company reports to EIA and found that in earlier years (such as year 2000), some upstream and midstream companies were reporting a significant portion of compressor fuel use, but in more recent years these companies did not report consumption in this category. One midstream company reported disposition of about 25 billion cubic feet of gas (equivalent to about 1.75 $MMtCO_2$) as "Other vented and flared" rather than as Lease Fuel, Processing Plant, or Pipeline Fuel Use; this gas consumption would not be accounted for by the current inventory methods, which use Lease Fuel, Processing Plant, or Pipeline Fuel Use as specific data inputs from EIA. We conclude that reliance on EIA data as the input for calculation of fuel combustion emissions in the oil and gas industry sector is likely to result in significant error.

Figure 13: Natural Gas Transmission Methane Emissions



2.4 Significant issues

Although coal mining methane emissions primarily from ventilation and degasification were relatively flat from 2010 to 2013, emissions from this sector have grown considerably over the last ten years. This source was relatively insignificant in earlier years, but now deserves more attention in regard to emissions inventory and possible emissions controls. As previously noted, the increase in the methane GWP from 21 to 25 not only increased emissions from this sector this year but also for previous years.

2.5 Key Uncertainties

Natural gas industry methane emissions are calculated by simplistic methods which are incapable of responding to state-specific factors that might cause emissions intensity (emissions per unit of activity) in NM to be higher or lower than the national average. Reliance on EIA data to calculate fuel combustion emissions for the sector as a whole and for individual subsectors may result in significant error, because of inconsistencies in company reporting to EIA and in EIA classification of fuels use.

3.0 Electricity Generation

3.1 Emissions 2000 - 2013

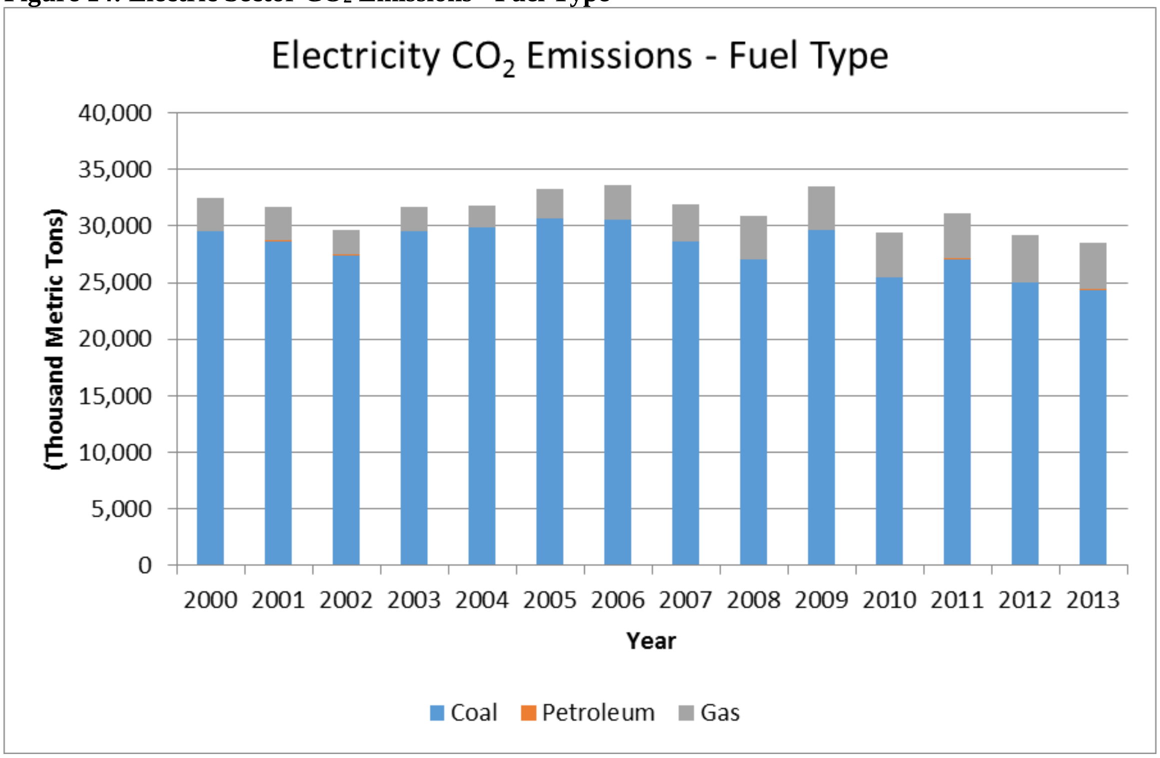
The electric generating sector continues to be the dominant source of GHG emissions in New Mexico. Although the contributions from coal-fired power plants is 85% of the total GHG emissions from this sector (Figure 14), the state has realized an increase in the annual supply of low- or zero-GHG emitting electric power since 2000. The supply of electricity from natural gas and renewable energy excluding hydroelectric power as a percent of the total energy produced increased by approximately 84 and 28,828 percent respectively from 2000 to 2013[15] (Figure 15).

[15] 2013- New Mexico Electricity Profile DOE/EIA-0348(01)/2

The total contribution of electricity generated from renewables is 7.2 percent. Electricity generated from coal has decreased to 67.3 percent compared to 85.4 percent in 2000. The contribution of power generated from natural gas in 2013 was 25 percent.

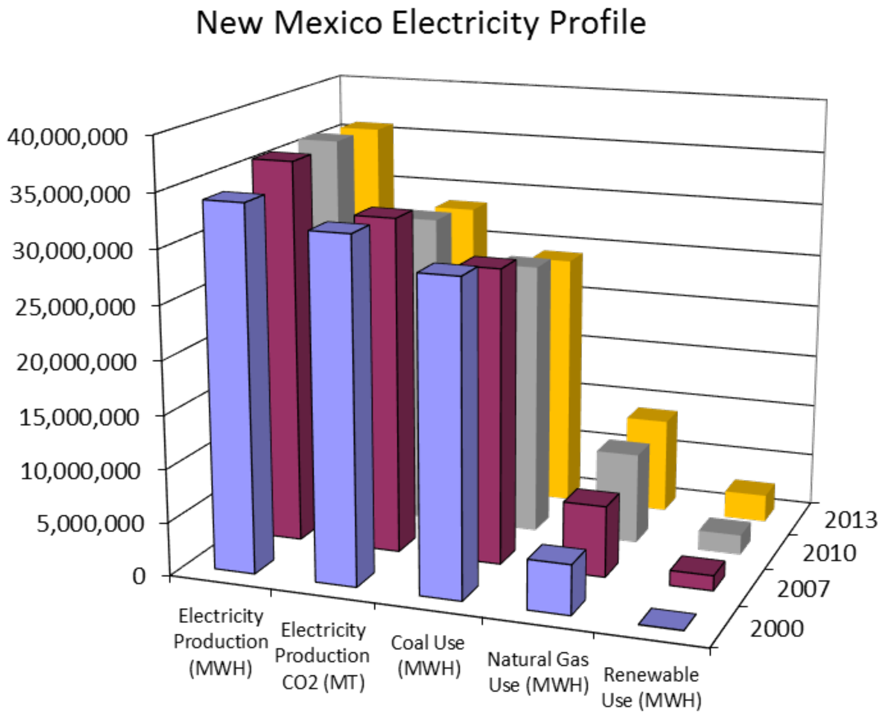
This trend is explained in part by the increase of natural gas generating capacity that was constructed in the early part of the decade and efforts by electric generating utilities to comply with the state's Renewable Portfolio Standard (RPS). The trend of additional electricity generated from low- or zero-emitting sources may continue with EPA's Clean Power Plan (CPP) rule which requires that New Mexico reduce certain power plant CO_2 emissions approximately 30 percent by 2030.[16] Perhaps more importantly, renewable energy sources of electricity are becoming more economically competitive with fossil fuel sources.

Figure 14: Electric Sector CO_2 Emissions - Fuel Type



[16] The Clean Power Plan is currently in litigation and the status of the outcome is not known as of the date of this report. However, additional information on the Clean Power Plan can be found at this link: http://www2.epa.gov/cleanpowerplantoolbox/clean-power-plan-state-specific-fact-sheets

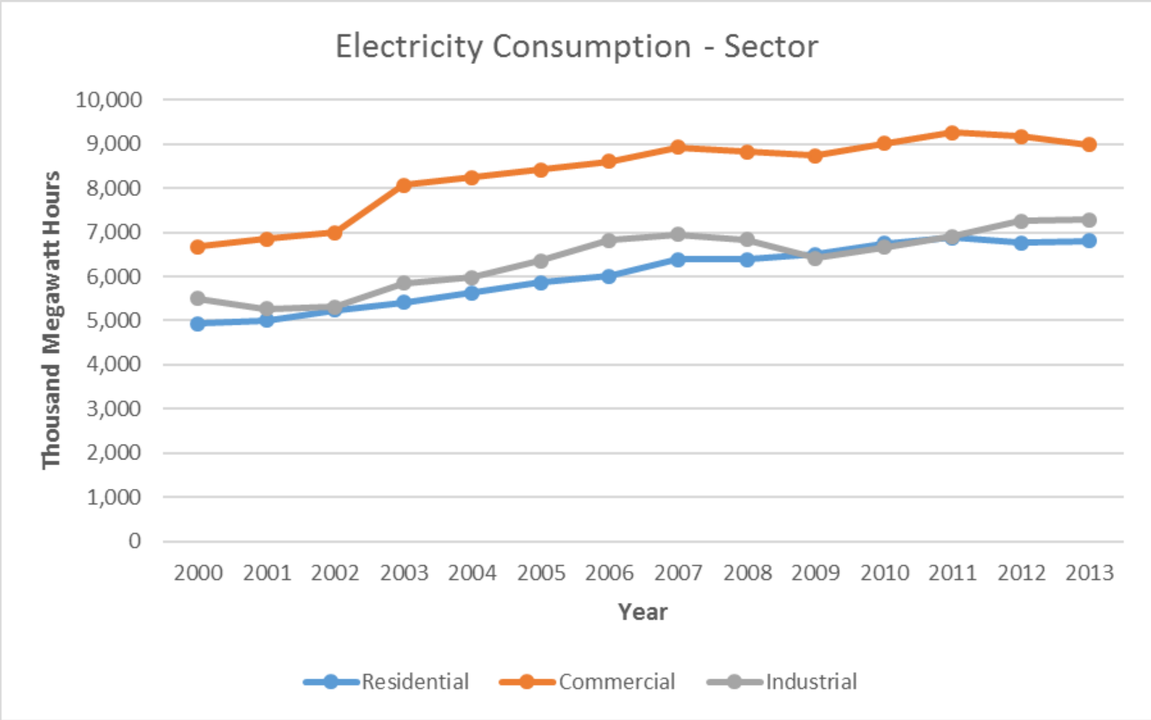
Figure 15: Electric Sector Comparison



The supply (megawatts/hour) of electricity produced increased approximately 5% from 2000 – 2013.[17] Total retail sales increased by approximately 23% over the same time period (Figure 16). Residential, commercial and industrial sector electricity consumption increased by approximately 38, 35, and 33 percent respectively. In-state retail sales climbed to approximately 70% of supply, reflecting the fact that although New Mexico exports a significant amount of power to other western states, exports are declining.

[17] 2013- New Mexico Electricity Profile DOE/EIA-0348(01)/2.

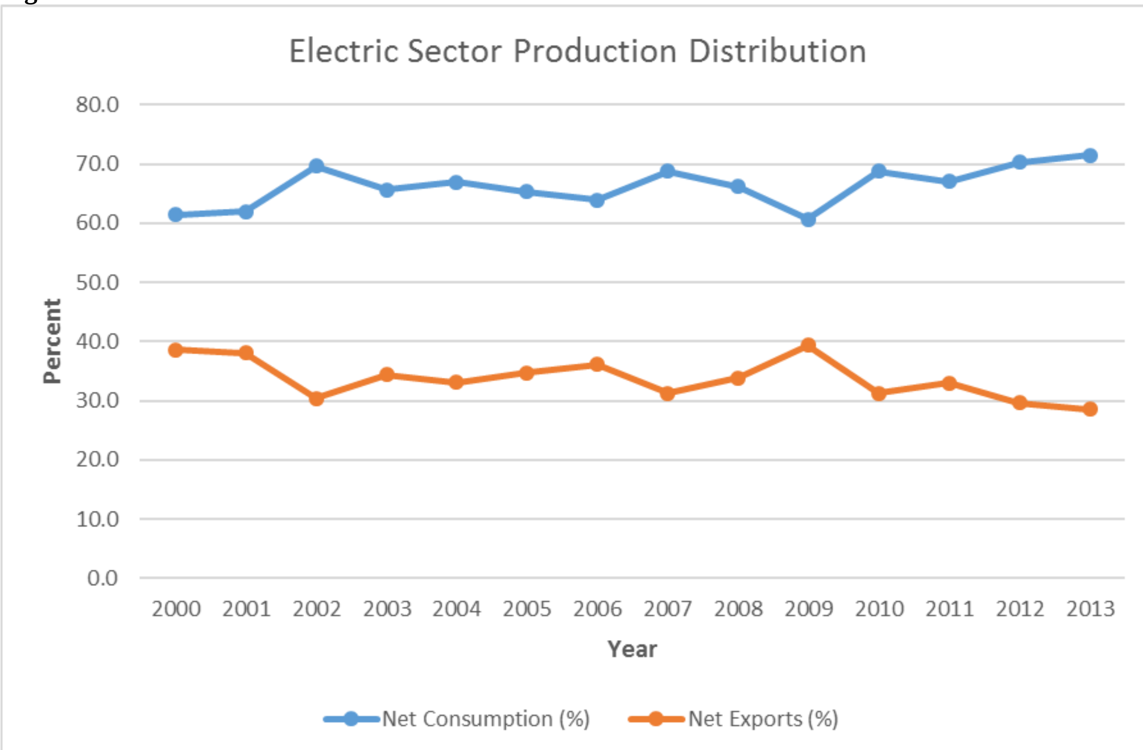
Figure 16: Electricity Consumption by Sector



New Mexico's annual exports are typically between 30-40% of the total net electricity generated (Figure 17).[18] Electricity exports as a percent of total electricity supply peaked at 40% at the beginning of the decade, declined to a low of 30% in 2003, and has fallen to below 30% in 2013. Consumption data include an adjustment to reflect 10% power losses from transmission and distribution.

[18] Ibid.

Figure 17: Electric Sector Production Distribution



3.2 Estimation Methodology & Data Sources

The EIA's New Mexico state profile electricity data along with EPA's State Inventory Tool (SIT) were used to analyze this section. EIA's State Energy Data System (SEDS) emissions data were chosen for this analysis because of the comprehensive nature of the data source. (EIA data includes Electricity Generation, exports, consumption and emissions by fuel type.)

3.3 Comparative Analysis

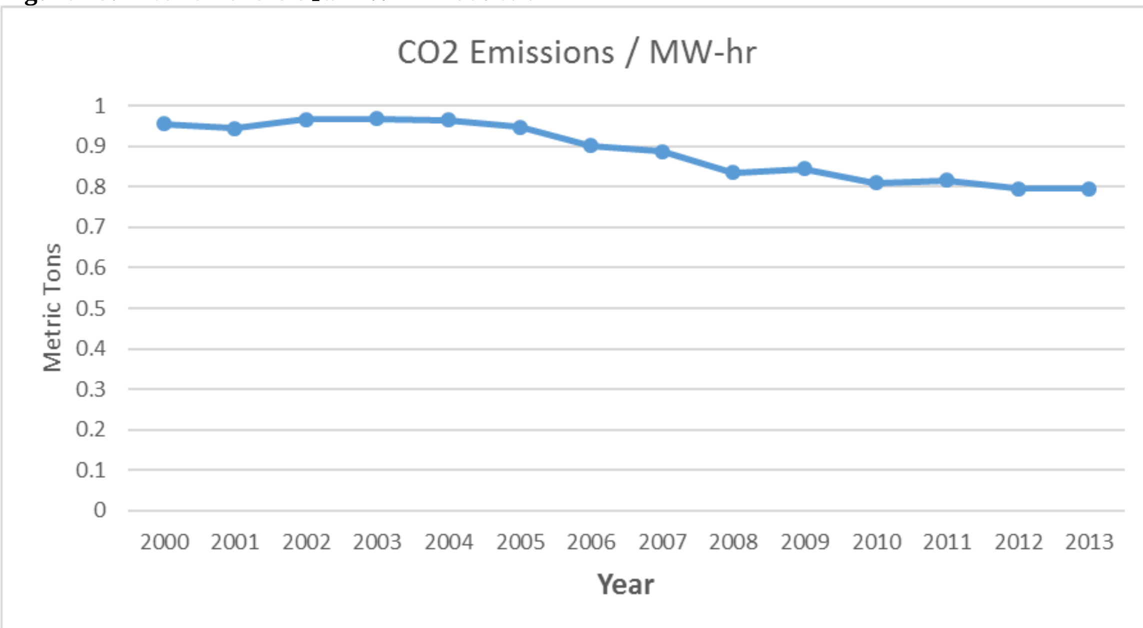
From 2007 to 2013, increased electricity generation was from natural gas and renewable sources, and coal generation decreased. Consumption of electricity appeared to be flat from 2007 through 2013, but the overall trend in consumption from 2000 to 2013 appeared to be increasing for all sectors (industrial, commercial, and residential). Electricity exports appear to be in decline commencing 2010.

3.4 Significant Issues

The continued development of renewable energy sources in New Mexico and out of state, EPA clean power plan rules for new and existing fossil fuel-fired electricity generation, and energy efficiency programs are expected to continue the decline of carbon emissions over time from this sector (Figure 18). However, development of electric grid infrastructure necessary to connect renewable sources of energy to end users and the effect of expiring renewable state tax credits create some uncertainty as to the projected emission reductions from this sector.

Additionally, the slight to modest increase in population from 2000 – 2013 when compared to more significant increases in residential electricity consumption suggest that the rise in New Mexico's average annual and maximum temperatures this century compared to historical averages may be contributing to increased energy consumption.[19] New Mexico's population increased about 1.13% annually during this time period yet residential electricity consumption increased by 38%.

Figure 18: Metric Tons CO_2e/MWhr Production[20]



3.5 Key Uncertainties

According to the uncertainty discussion associated with the SIT, "many different factors introduce uncertainties into estimating emissions from imports and exports of electricity. The precise fuel mix used to generate the power crossing state lines is very difficult to determine due to the highly complex nature of electricity flow through the US power grid. Therefore, an average fuel mix for all electricity generation within a specific region of the grid must usually be used. Moreover, these emission factors are generated by emission monitors (rather than carbon contents of fuels), which may overestimate CO_2 emissions to a small extent."[21] This inventory update did not attempt to differentiate between the fuel type and associated emissions from electricity exports and did not include an evaluation of electricity imports for the reasons stated above. However, it is likely that a large amount of exported electricity generated during this time period was coal based.

4.0 Transportation

4.1 Emissions 2000 - 2013

The transportation sector is the third largest source of GHG emissions in New Mexico. Large distances and a dispersed population lead to high transportation demand. Figure 19 Transportation Sector Emissions shows total and per capita transportation sector emissions for

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[19] NOAA National Center for Environmental Information, Climate at a Glance: US Time Series, Average and Maximum Temperature, published September 2016; website https://www.ncdc.noaa.gov/cag/.
[20] 2013- New Mexico Electricity Profile DOE/EIA-0348(01)/2.
[21] SIT 2008, Electricity Sector Uncertainties Discussion

the years 2000 to 2013 (see Section 4.2 below for a discussion of data sources). During this timeframe, GHG emissions from the transportation sector increased 14% prior to returning to 2000 levels by the end of the decade and remaining flat. This increase was due to a combination of factors, including increased freight traffic and increased state population. The downturn in the economy at the end of the decade likely contributed to emissions returning to 2000 levels. Additionally, increased urbanization, public transport options, and telecommuting likely contributed to part of this downward trend. Per capita emissions decreased by 13%, likely a result of better vehicle fleet fuel efficiency in addition to the factors previously stated.

Figure 19: Transportation Sector Emissions

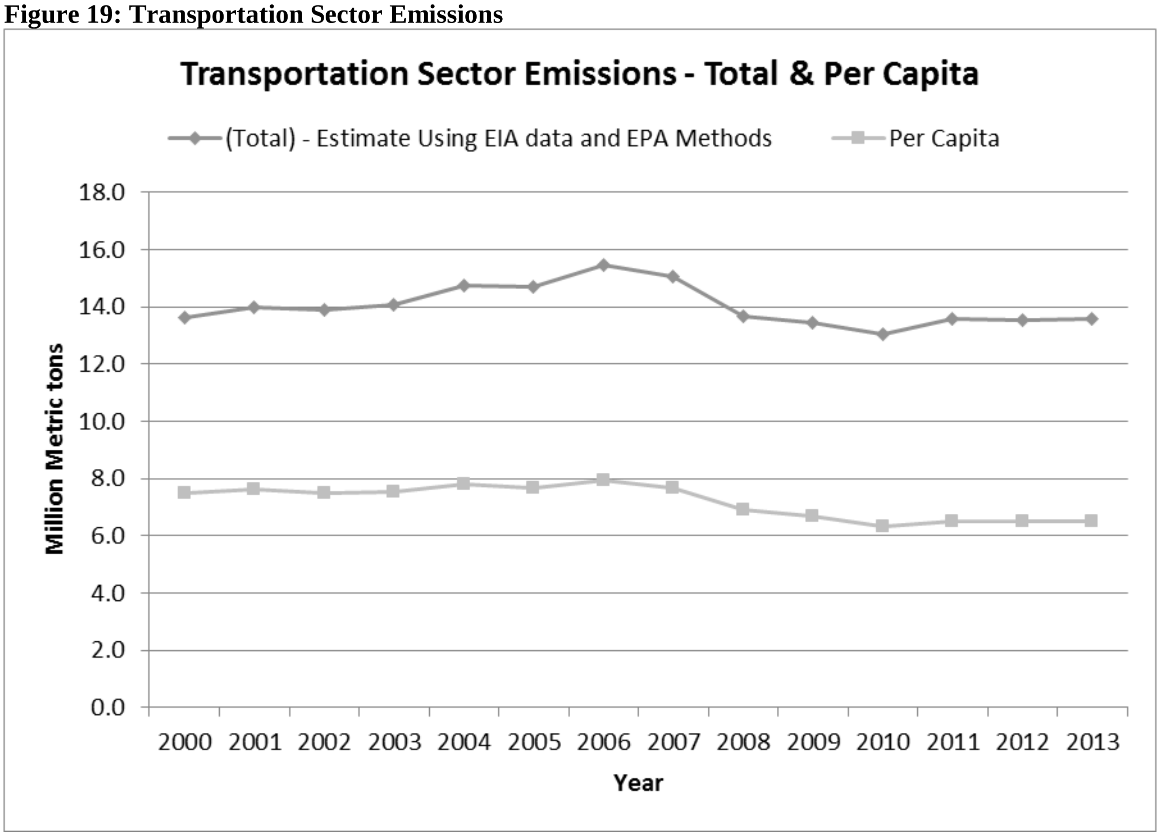
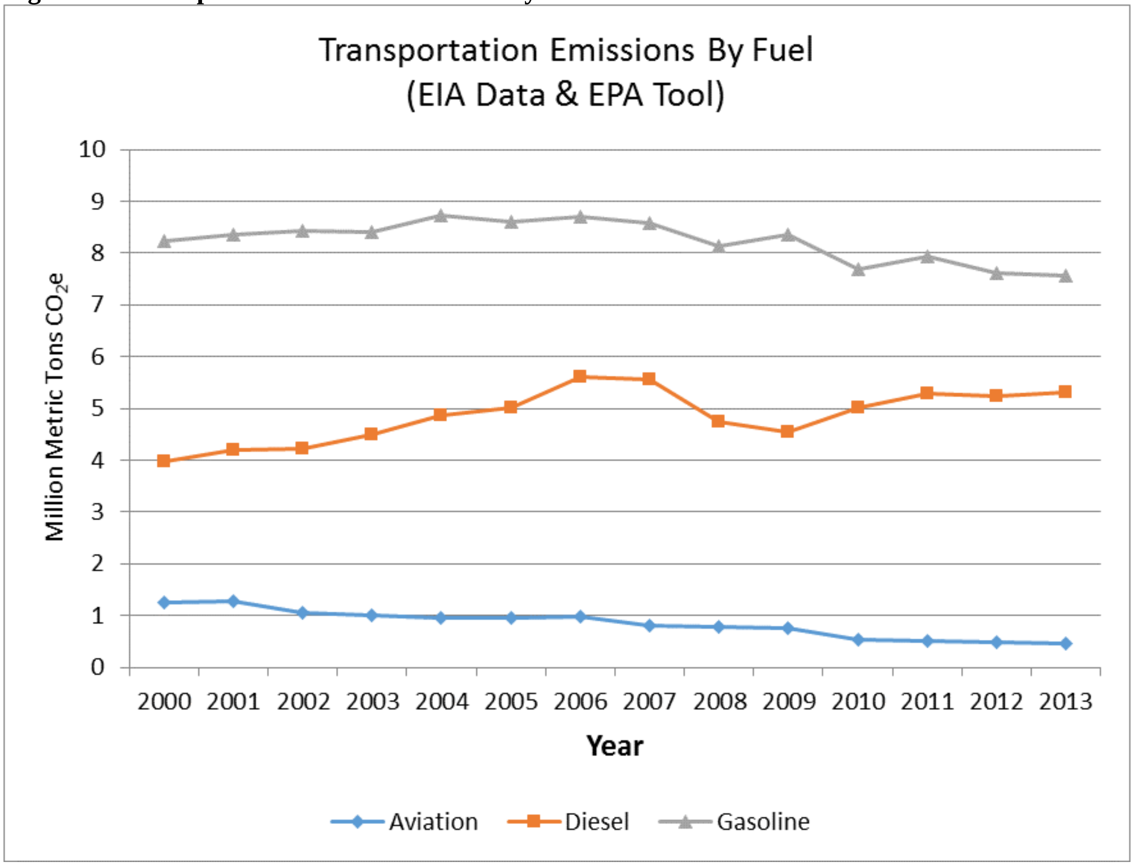


Figure 20 compares the amount of gasoline, diesel, and aviation fuel use from 2000 to 2013, using EIA data (emissions from other fuels are too low to be reflected in this figure). The 34% increase in emissions from diesel fuel use between 2000 and 2013 reflects the increase in freight traffic anticipated in the New Mexico 2025 Statewide Multimodal Transportation Plan (released in 2005). The Transportation Plan estimated that 85% of commercial traffic on I-10 and I-40 was simply crossing the state, without delivering or picking up any freight, and that such freight traffic would increase over time.

Figure 20: Transportation Sector Emissions by Fuel Use



During the period 2000-2013, the estimated emissions from gasoline consumption decreased by 8% and 20% on a gross and per capita basis respectively despite the state population growing by 14.7%. Several factors may have contributed to this drop of average gasoline usage per person. As newer vehicles are purchased, the average gas mileage rate for vehicles in the state may have improved, and increases in gasoline prices and use of public transportation may have resulted in less driving. However, data that would support or quantify such trends is not available at the time of this report.

EIA data indicates that emissions from aviation fuel use in the state dropped 63% from 2000 to 2013, primarily as a result of a drop in jet fuel consumed. The EIA data reflect consumption of aviation gasoline and jet fuel by both the public sector and the military.

4.2 Estimation Methodology & Data Sources

The transportation data used in this report was derived from EIA data, which is based on reported fuel sales. Note, however, that, unlike EIA and the SIT, this report does not include the natural gas used by pipeline equipment as part of the transportation sector fuel use. In this report, pipeline emissions are included in the Fossil Fuel sector.

Ethanol consumption has been deducted from the fuel sales reported by EIA in order to calculate GHG emissions from gasoline use. This is consistent with the calculation method used in the SIT, and reflects an assumption that the CO_2 emitted during combustion of biomass-derived fuels is the same as the CO_2 drawn from the atmosphere during growth of the biomass, and as such results in no net increase in CO_2 emissions. Nonetheless, ethanol, like gasoline, can require significant upstream GHG emissions in production and refining.

Because transportation sector emissions are directly related to fuel use, personal and governmental efforts to reduce transportation fuel use serve to reduce, or at least slow the growth of, GHG emissions from the transportation sector. Such efforts include but are not limited to car and van pooling, increased use of public transportation, increases in average vehicle fuel efficiency, and traffic management to reduce vehicle idling times.

4.3 Key Uncertainties

Key uncertainties are included in the discussions of specific aspects of the transportation sector emissions. See also Section 5.3.

5.0 Emissions from Fossil Fuel Combustion in the Residential, Commercial, and (Non-Fossil Fuel Industry) Industrial Sectors

5.1 Emissions 2000 - 2013

This section reports the GHG emissions from fossil fuel combustion in the residential, commercial,[22] and (non-fossil fuel industry) industrial sectors (RCI).[23] The residential and commercial sectors consume fossil fuels and electricity to heat and cool buildings and to power lights and appliances. The industrial sector consumes fossil fuels and electricity for these purposes and to heat and power industrial processes.

Fossil fuels include natural gas, oil (including gasoline and propane), and coal. While the combustion of fossil fuels results in emissions of N_2O and CH_4, more than 99% of the GHG emissions are in the form of CO_2.

Figures 21-23 show the direct emissions from combustion of fossil fuels and the indirect emissions from electricity use in the residential, commercial and (non-fossil fuel industry) industrial sectors, respectively. Figure 23 shows the direct emissions from combustion of fossil fuels in the (non-fossil fuel industry) industrial sector. From 2000 to 2013, the direct emissions resulting from combustion of fossil fuels in the residential commercial and industrial sectors increased by 0.8%, 1.3% and 6.3% respectively.
Between 2000 and 2013, the indirect emissions from the consumption of electricity in the residential and industrial sectors increased by 27 and 22 percent respectively (Figures 21 and 23). Commercial indirect emissions from the consumption of electricity decreased by slightly over 1%. Taking electricity consumption into account, the residential sector increased emissions

[22] The commercial sector "consists of service-providing facilities and equipment of: businesses; Federal, State, and local governments; and other private and public organizations, such as religious, social, or fraternal groups. The commercial sector includes institutional living quarters. It also includes [energy consumed at] sewage treatment facilities" EIA 2002. *State Energy Data 2001, Technical Notes,* page 5. http://www.eia.doe.gov/emeu/states/sep_use/notes/use_intro.pdf.

[23] GHG emissions resulting from the fossil fuel industry are reported in Section 2. Industrial sector GHG emissions that result from processes (e.g., leakage, venting and non-combustion chemical processes) are reported in Section 6.

from energy use by a total of 18% (taking into account the state's growing population, this is a per capita increase of 4%). During the same period, the total emissions from energy consumption in the commercial sector decreased by approximately 1% while industrial energy consumption increased by 12%.

Figure 21: Residential Sector GHG Emissions from Combustion of Fossil

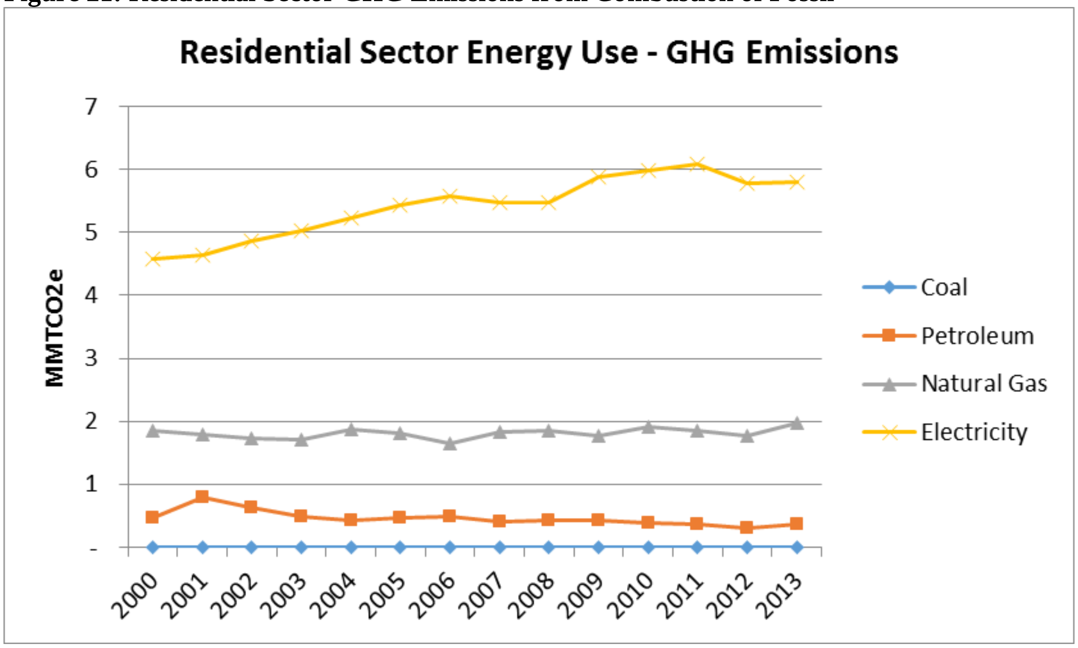


Figure 22: Commercial Sector GHG Emissions from Combustion of Fossil Fuels

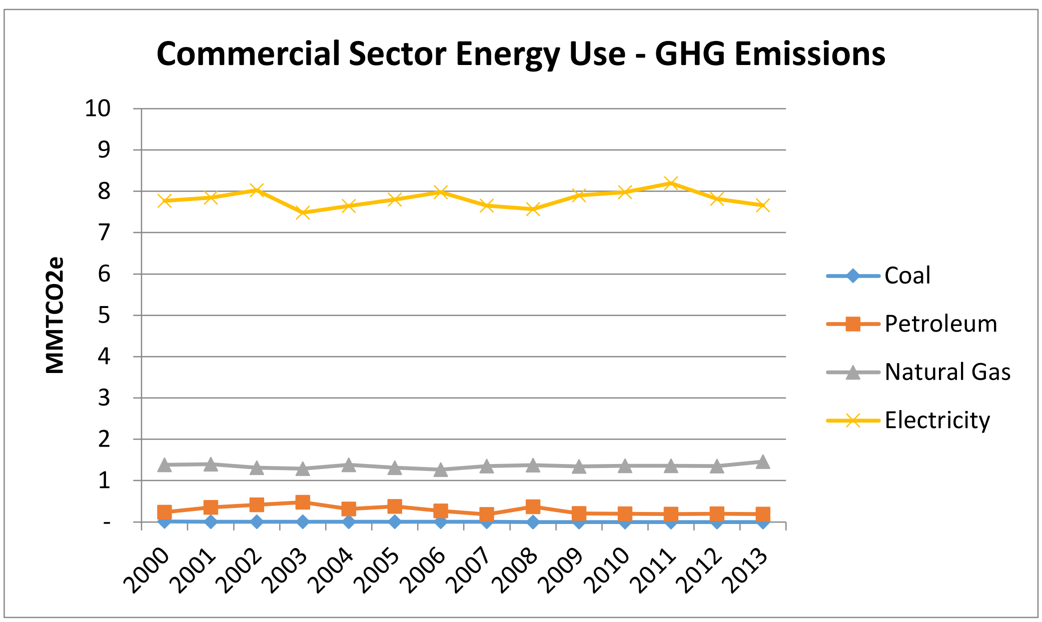
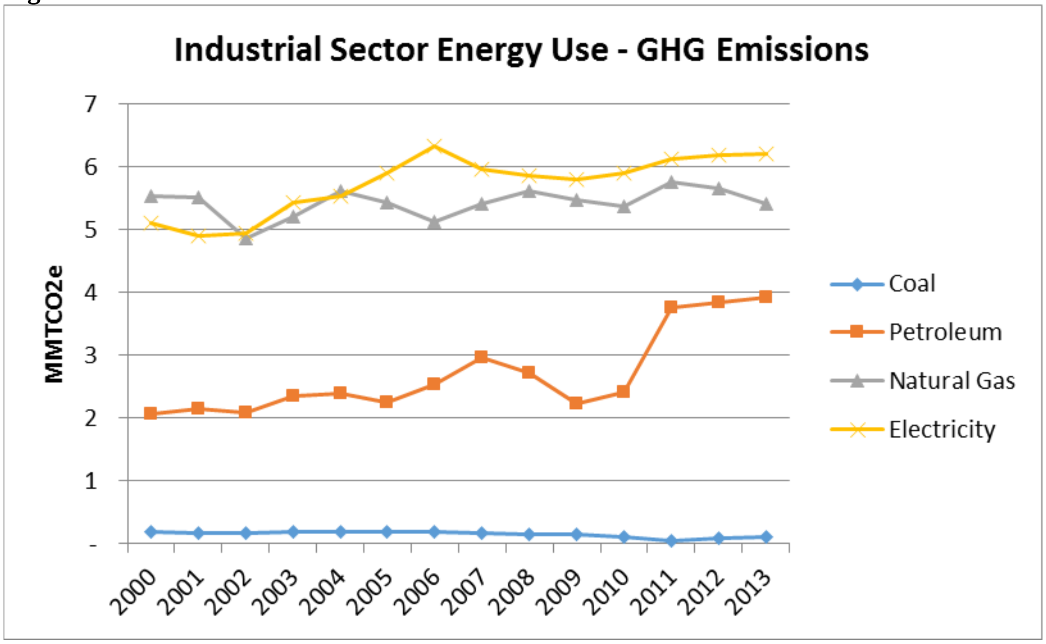


Figure 23: Industrial Sector GHG Emissions from Combustion of Fossil Fuels



5.2 Estimation Methodology & Data sources

The estimation methodology used in this report for emissions from Residential, Commercial and Industrial fossil fuel combustion sector was derived from EPA SIT. The tool uses fuel use data that is collected by the Energy Information Administration of the US Department of Energy and is available to the public.[24] The SIT multiplies the fuel consumption data with emission factors for each fuel use and combustion device type. The emission factors for this module have been increased in this 2013 Update resulting in changes to historical values.

5.3 Key Uncertainties

The amount of CO_2 emitted from fossil fuel combustion depends on the type and amount of fuel consumed, the carbon content of the fuel, and the fraction of the fuel that is oxidized. Consequently, the more accurately these parameters are characterized, the more accurate the estimate of CO_2 emissions. Nevertheless, there are uncertainties associated with each of these parameters.

Although statistics of total fossil fuel and other energy consumption are relatively accurate at the national level, there is more uncertainty associated with the state-level data. In addition, the allocation of this consumption to individual end-use sectors (i.e., residential, commercial, industrial, and transportation) at the state level is more uncertain than at the national level.

Uses of fuels for non-energy purposes introduce additional uncertainty to estimating emissions, as the amount or rate at which carbon is emitted to the atmosphere can vary greatly depending on

[24] www.eia.doe.gov. Specific NM information may be found at http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=NM#overview and http://www.eia.doe.gov/emeu/states/state.html?q_state_a=nm&q_state=NEW%20MEXICO.

the fuel and use. This guidance and the SIT provide default values for the amount of non-energy use and percentage of carbon stored by fuel type, based on data collected at the national level. State-specific data can reduce these uncertainties.

In comparison with fuel consumption data, the uncertainties associated with carbon contents and oxidation efficiencies are relatively low. Carbon contents of each fuel type are determined by the EIA by sampling and the assessment of market requirements, and, with the exception of coal, do not vary significantly from state to state. EIA takes into account the variability of carbon contents of coal by state in EIA's Electric Power Annual 2002 (2003b); these coefficients are also provided in the SIT.

6.0 Industrial Processes

6.1 Emissions 2000 - 2013

Emissions in this category span a range of activities, and indicate non-combustion sources of CO_2 from industrial manufacturing (cement, limestone and soda ash usage), the release of hydrofluorocarbons (HFCs) from cooling and refrigeration equipment, the use of various fluorinated gases in semiconductor manufacture (perfluorocarbons or PFCs as well as HFCs), and the release of sulfur hexafluoride (SF_6) from electric power transmission and distribution.

The combined 2013 GHG emissions (1.4 $MMtCO_2e$) related to industrial processes are shown in Figure 24. The trend has been a general decrease in emissions from 2002. The contribution from the various sub-categories is shown in Figure 25; emissions from each of these sub-categories has generally declined with the exception of ODS substitutes.

In 2001, the use of ODS substitutes overtook the semi-conductor industry as the largest contributor of GHG emissions from industrial processes. Emissions from the use of ODS substitutes has gradually doubled since 2000, while semiconductor related emissions have significantly decreased since 2002.

HFCs continue to be used to substitute for ozone-depleting substances in compliance with the Montreal Protocol, which explains the steady growth in emissions of HFCs since 2000. Even low amounts of HFC emissions from leaks and normal use can lead to high GHG emissions. The emission estimates for New Mexico during the review period were based on EPA default data, apportioned based on state population. The Industrial Processes module included data up to 2013.

6.2 Estimation Methodology & Data Sources

Common sources of fugitive emissions of SF_6 are a result of leakage from gas-insulated substations and switchgear seals. It can also be emitted during equipment manufacture, installation, servicing, and disposal. Emissions of SF_6 from electrical equipment have shown a slow decline from 2000 - 2013, believed to be a result of price increases during the 1990s and voluntary programs such as the EPA SF_6 Emission Reduction Partnership for Electric Power Systems.[25] The Industrial Process module of the SIT bases emissions on the quantity of SF_6

[25] Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007
http://www.epa.gov/climatechange/emissions/downloads09/InventoryUSGhG1990-2007.pdf

consumed annually, apportioned by state electricity sales divided by national electricity sales. This method assumes that all SF_6 consumed is used to replace SF_6 that was emitted. The module includes SF_6 consumption up to 2013.

Another contributor to industrial processes emissions are those associated with semiconductor manufacturing. This update includes Intel Corporation's Rio Rancho facility non-combustion GHG emissions from 2000 – 2013. As with previous updates, estimates of semiconductor emissions were obtained from Intel Corp except for emissions year(s) 2010 - 2013 which were reported by Intel to EPA. Intel's GHG's emissions peaked in 2002 and have steadily declined by a factor of six over this time period.

CO_2 is emitted from cement production during the calcination process, as calcium carbonate ($CaCO_3$) is converted to calcium oxide (CaO). Therefore, process emissions are directly related to the amount of clinker and masonry cement produced. The only cement plant in New Mexico, GCC - Rio Grande (a subsidiary of Grupo Cementos de Chihuahua), is located in Bernalillo County. The previous GHG emissions updates and emissions contained in this report through 2009 estimated Portland cement production from two sources ("1997 Apparent Use of Portland Cement by State and Market"[26] and the US Geological Survey's Cement Annual Report, 1997).[27] The mean production was multiplied by the SIT emission factor, and then corrected based on production data from the New Mexico Greenhouse Gas Action Plan.[28] The application of this correction factor essentially attributes two-thirds of the combined Arizona and New Mexico production to the GCC - Rio Grande facility.

GCC - Rio Grande's 2010 - 2013 GHG CO_2 process emissions reported to EPA as required by 40 CFR Part 98 Subpart H – Cement Production suggest that the historical approach may have significantly overestimated emissions from this facility as reported emissions were significantly less than the approximate ½ million metric tons previously reported. However, absent additional production data no changes will be made to historical emissions.

Emissions from soda ash consumption were estimated from national usage, apportioned to NM by the state's population divided by the US population.

Emissions from lime manufacture, which also emits CO_2 during a chemical conversion, were not estimated for this update. The only lime plant in New Mexico is a chemical lime plant that imports lime manufactured elsewhere to produce hydrated lime. There are no CO_2 emissions generated from this process. Because the lime is actually produced outside of New Mexico, those CO_2 emissions are not attributed to New Mexico.

This update includes emissions from ammonia production and urea use. Although ammonia is not produced in New Mexico, urea is commonly used as the reagent in selective catalytic reduction (SCR) systems for the control of nitrogen oxides (NO_X).

[26] Not publicly available.
[27] http://minerals.usgs.gov/minerals/pubs/commodity/cement/170497.pdf
[28] http://www.werc.net/outreach/Book.pdf

Figure 24: GHG Emissions from Industrial Processes 2000 -2013

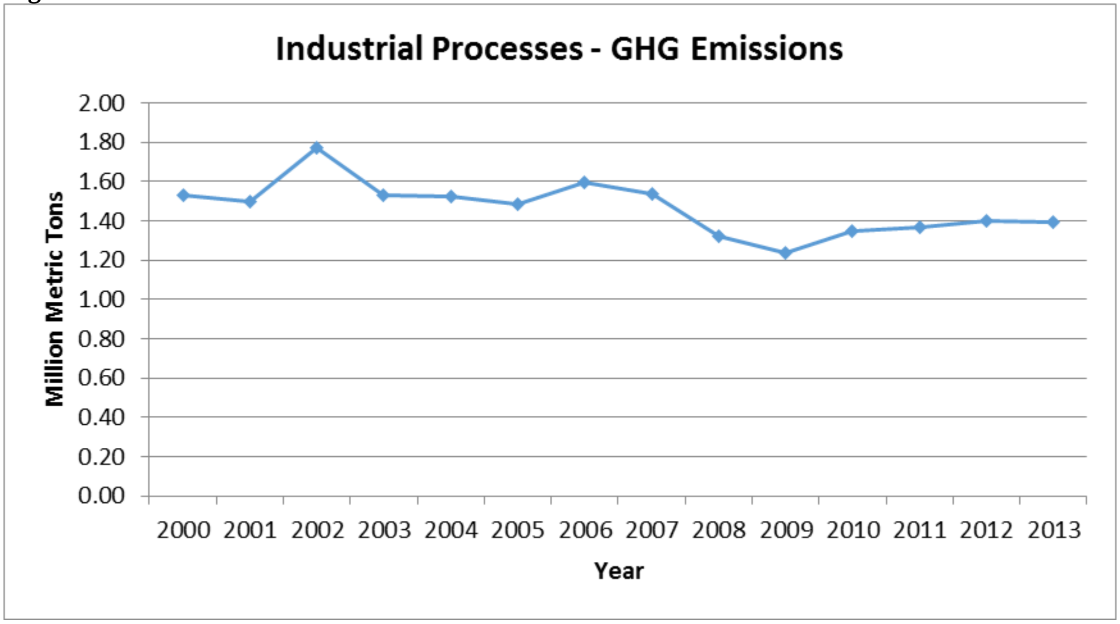
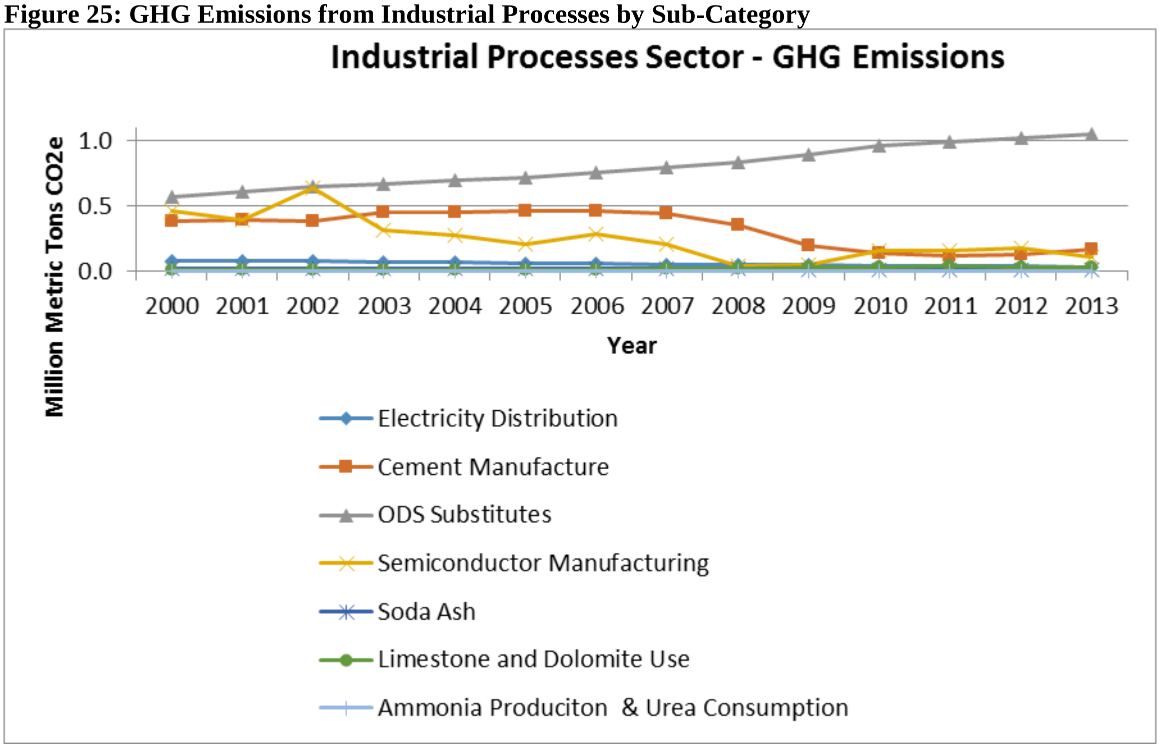


Figure 25: GHG Emissions from Industrial Processes by Sub-Category



In 2001, the use of ODS substitutes overtook the semi-conductor industry as the largest contributor of GHG emissions from industrial processes. Emissions from the use of ODS substitutes has gradually increased since 2000, while semiconductor related emissions have significantly decreased since 2002.

6.3 Significant issues

See discussion above.

6.4 Key Uncertainties

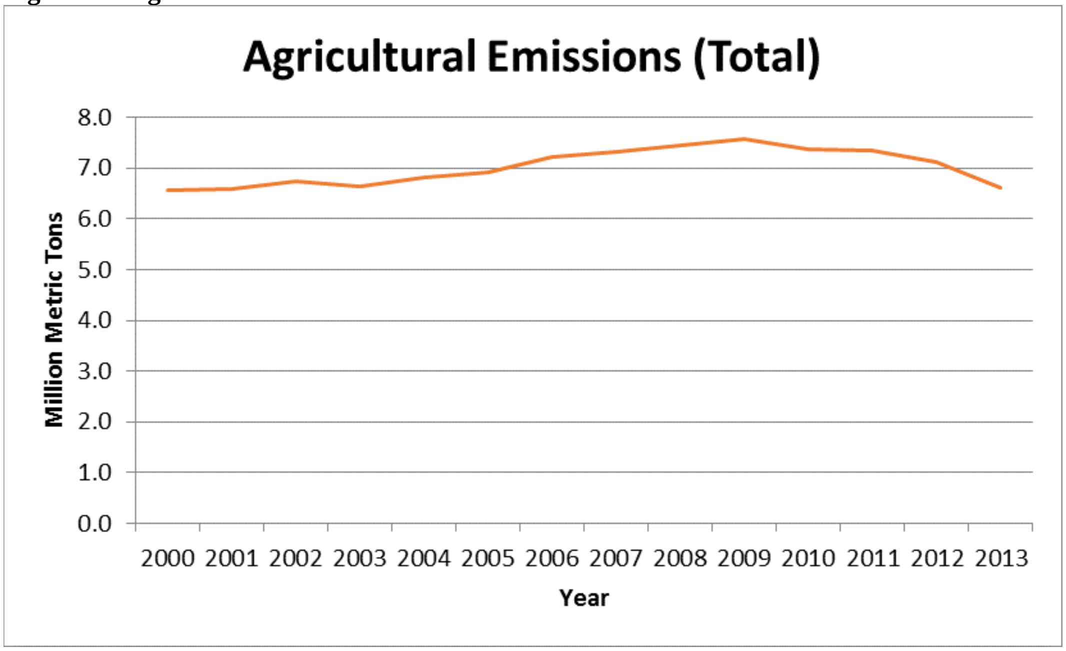
Industrial process emissions continue to be determined by the level of production from a few key industries, and it remains difficult to obtain accurate production information, as such information may affect the competitiveness of New Mexico manufacturers and the specific nature of their production processes. For example, the USGS reports the combined production of the three cement plants in Arizona and New Mexico, and assumptions must be made to apportion production to the GCC - Rio Grande facility in Bernalillo County. Emissions from other sectors are based on national production apportioned to New Mexico by the ratio of state population to national population.

7.0 Agriculture

7.1 Emissions 2000 - 2013

The agriculture sector of the GHG inventory constitutes 8% of the overall greenhouse gas emissions for New Mexico. The net emissions were approximately 6.6 $MMtCO_2e$ in 2013.

Figure 26: Agricultural GHG Emissions



Agricultural emissions include CH_4 and N_2O emissions from enteric fermentation, manure management, agricultural soils, and agricultural residue burning.

CH_4 is produced as a waste product of digestion by ruminants such as cattle, in a process known as enteric fermentation. This CH_4 is released primarily by belching. Cattle, buffalo, sheep, and goats account for the majority of methane emissions produced.

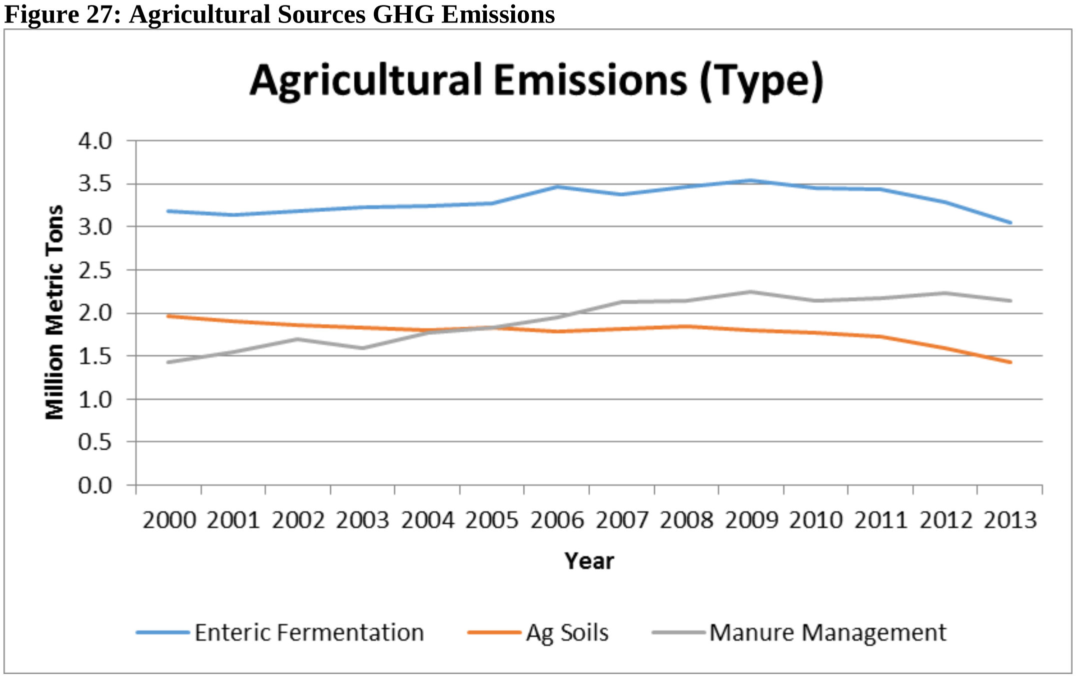
Manure management methods include the handling, storage, and treatment of livestock waste. CH_4 is emitted when the manure is not stored in a sufficiently oxygenated environment, leading to anaerobic decomposition, while the nitrogen in livestock manure and urine encourages nitrification and de-nitrification, releasing nitrous oxide.

CH_4 and N_2O emissions from the storage and treatment of livestock manure (e.g., in compost piles or anaerobic treatment lagoons) occur as a result of manure decomposition.
Activities that increase the nitrogen in soil and thereby contribute to the category of N_2O emissions include fertilizer (synthetic, organic, and livestock) application and production of nitrogen fixing crops.

Agricultural burning contributed a very small amount to the agricultural sector emissions.

Enteric fermentation is the greatest source of agricultural emissions, followed by manure management, agricultural soils, and then agricultural residue burning (not shown).

Figure 27: Agricultural Sources GHG Emissions



The Agriculture (Ag) module of the SIT was developed using Microsoft® Excel 2000. The SIT was developed in conjunction with EPA's Emissions Inventory Improvement Program.

7.2 Estimation Methodology & Data sources

The 2016 SIT was the primary methodology used for calculating GHG for the agricultural sector.

The sectors included within the Agricultural module are enteric fermentation, manure management, agricultural soils, and agricultural residue burning. Different methodologies exist for calculating the GHG emissions from each sector.[29] The module permits data entry or the selection of default data which is entered into worksheets with prefabricated formulas. Data from

[29] ICF, International, 2008. Draft User's Guide for Estimating Methane and Nitrous Oxide Emissions from Agriculture Using the State Inventory Tool, July 2008.

the US Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) are the default data for the SIT and were used to calculate the GHG emissions from the agricultural sector. The 2007 inventory update utilized data from the NASS though it was manually entered into the program and was incomplete as specific animal classification (e.g., heifer stockers, steer stockers, and beef replacement) categories were not included and therefore resulted in an underestimation of GHG emissions from this sector. However, this update includes all applicable animal categories and corrects the emissions for the previous years.

NASS conducts hundreds of surveys to estimate livestock inventories every year and prepares reports covering almost every aspect of United States agriculture. According to Lonnie Bustillos, Deputy Director of the Las Cruces, New Mexico, National Agricultural Statistics Services field office, annual livestock inventory and crop production and harvest survey samples are stratified by operation size and extrapolated to a state level. Every five years the NASS conducts an Agricultural Census to determine more accurate livestock inventories and use these data to true animal counts for previous years (Bustillos, 2013). The NASS data are used in the SIT because they are specific to New Mexico, reported annually, and represent the best available data.

7.3 Significant issues

New Mexico is nationally ranked ninth in total milk production and fifth in total cheese production (Dairy Producers of New Mexico, 2012). As a result, in part, of relatively depressed milk prices, cow counts have trended slightly downward ranging from a high of approximately 340,000 cows (2007) to a low of 318,000 cows (2010). In addition to below breakeven commodity pricing, dairy farmers are facing drought, declining and scare water supplies, and rising feed and fuel cost. The combination of these factors has strained some New Mexico dairies. If the number of dairies declines, then New Mexico may experience a decline in GHG from the agricultural sector as enteric fermentation and manure management methane emissions consist of approximately 80% of GHG emissions from this sector.

7.4 Key Uncertainties

A detailed explanation of the key uncertainties according to the Agricultural module of the SIT is located in Appendix B.

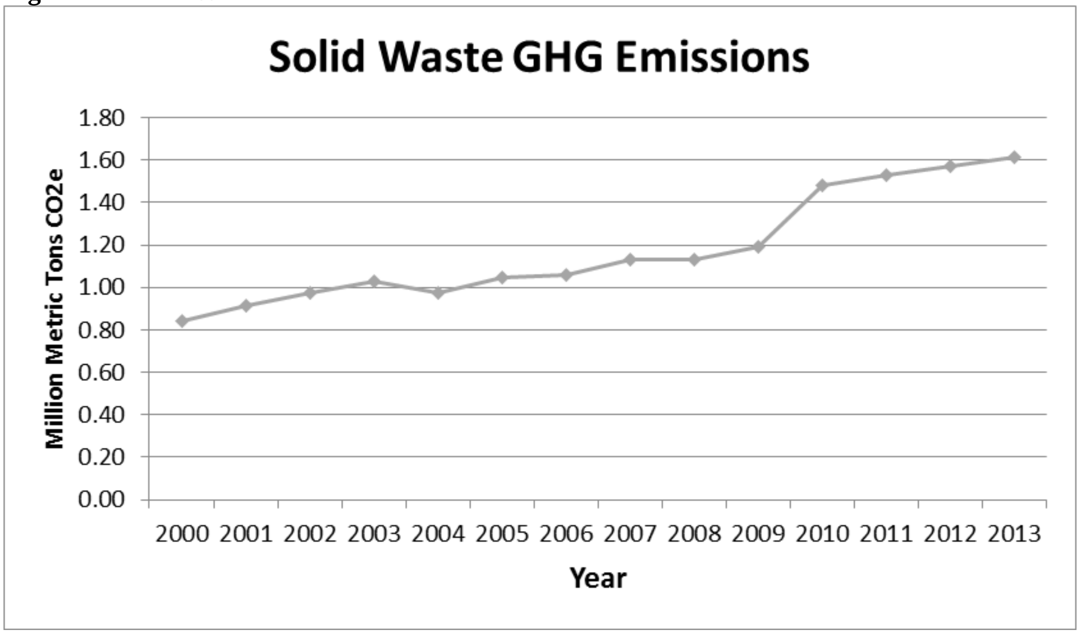
8.0 Waste Management

8.1 Emissions 2000 - 2013

Greenhouse gas emissions from the waste management sector include solid waste management and waste water management. Municipal solid waste includes CH_4 emissions from landfilling of municipal solid waste and CO_2 and N_2O emissions from the combustion of municipal solid waste.[30] Solid waste emissions have nearly doubled from 0.84 metric tons in 2000 to 1.62 metric tons in 2013.

[30] Ibid.

Figure 28: Solid Waste GHG Emissions



The following background information is provided by ICF International in the Draft User's Guide for Estimating Emissions from Municipal Solid Waste Using the SIT.

Greenhouse gases are emitted from landfills as CH_4 and CO_2 are produced from anaerobic decomposition of organic matter by methanogenic bacteria. Organic waste first decomposes aerobically (in the presence of oxygen) and is then decomposed by anaerobic non-methanogenic bacteria, which convert organic material to simpler forms like cellulose, amino acids, sugars, and fats.[31]

Additionally, some landfills flare recovered landfill gas, which converts the CH_4 portion of the gas to CO_2. Also, there are some landfills that collect and burn landfill gas for Electricity Generation or other energy uses (known as landfill gas-to-energy projects, or LFGTE), which are treated similarly to landfills that flare their gas.[32]

Table 3 identifies the following landfills that have flares or LFGTE systems.

Table 3: Landfills with Flares or GTE Systems

Landfill	Flare or LFGTE system
Camino Real Landfill (Sunland Park)	LFGTE and Flare
Rio Rancho Landfill (Rio Rancho)	Flare
Cerro Colorado (Albuquerque)	Flare
Caja Del Rio Landfill (Santa Fe)	Flare

Neither the CO_2 emitted directly as biogas nor the CO_2 emitted from combusting CH_4 at flares is considered an anthropogenic GHG emission. The source of the CO_2 is primarily the decomposition of organic materials derived from biomass sources (e.g., crops, forests), and in the United States these sources are grown and harvested on a sustainable basis. Sustainable harvesting implies that photosynthesis, which removes CO_2 from the atmosphere, is equal to decomposition, which adds CO_2 to the atmosphere. However, some CO_2 is from non-biogenic sources (e.g., plastic and rubber made from petroleum), and is counted in GHG emission inventories.

N_2O is produced at the high temperature found in waste combustors by the combination of nitrogen (contained in both the waste and in the air) and oxygen gas in the air.[33] There are no waste combustion facilities currently permitted in New Mexico.

Waste-related greenhouse gas sinks and carbon storage from landfilled yard trimmings and food scraps are not accounted for in solid waste management.[34]

8.2 Wastewater Emissions

Wastewater management includes methane and nitrous oxide from municipal wastewater treatment facilities. Wastewater emissions were calculated using the SIT. The module includes

[31] Ibid.
[32] Ibid.
[33] Ibid.
[34] Ibid.

wastewater related emission inputs from fruit and vegetables, red meat, poultry, and pulp and paper. However, none of these industries are of significant scale to generate meaningful GHG emissions in New Mexico and are not included in the totals. The 2013 emissions from this sector are 0.23 (MMtCO_2e). However, the annual rate of change has consistently been approximately 2.1%. Wastewater emissions are largely a function of population growth and the estimated 1.0% annual population growth has been realized between 2000 and 2013 as projected.

EPA reports the changes noted above reflect that the default factor for N_2O emissions from nitrogen in effluent discharged changed from 0.01 to 0.005 kg N_2O-N/kg sewage N-produced, to be consistent with the US national inventory. Furthermore, the fraction of the population not on septic was updated from 75% to 79%, also to be consistent with the factors used in the US national inventory. The combination of these two changes resulted in the net change of emissions in 2013 when compared to 2004.

8.3 Estimation Methodology & Data Sources

The 2016 SIT in conjunction with state specific data was used to determine the GHG emissions for this sector. The emissions from these types of facilities are site specific; the NMED Solid Waste and Air Quality bureaus provided more specific waste related data than the estimated default data provided by the SIT.

The data provided by the Solid Waste Bureau (SWB) in their Annual Reports include the tonnages of waste landfilled and diverted, including tonnages of waste from out-of-state sent to New Mexico for disposal. This information is provided in Appendix B. The post 2007 waste generation data found in the SIT are estimates and were not relied upon for calculating sector emissions.

8.4 Significant issues

The growth rate in New Mexico plays an important role in waste emissions. The state population grew 14.7% from 2000 - 2013 at approximately 1.3% per year.[35] Recent census data indicate New Mexico's growth rate has slowed so future increases from this sector and perhaps others will not grow at the rate they did from 2000 – 2013. Changes in the amount of diverted or imported waste may have a greater impact on future emissions than population growth.

8.5 Key Uncertainties

According to the SIT, the following uncertainties exist. Uncertainty surrounds key elements of these calculations, including the activity data and factors.

There are several sources of uncertainty associated with the recommended method for estimating CH_4 emissions from landfills. CH_4 production is impacted by temperature, rainfall, and landfill design, characteristics that vary by each landfill and cannot be accounted for individually. Additionally, the time period over which landfilled waste produces CH_4 also is not certain. This methodology is based on information from CH_4 recovered from various landfills, which may not be representative of landfills as a whole. Little information is available on the amount of CH_4 oxidized during diffusion through the soil cover over landfills. The assumed ten percent is based

[35] From the Bureau of Business & Economic Research at the University of New Mexico, Statistics at a glance 2016. http://bber.unm.edu/

on limited measurements. In addition, the methodology presented here assumed the waste composition of all landfills is the same; in reality, waste in different landfills likely varies in composition. The presence of landfill gas recovery systems may affect activity in the anaerobic zones of landfills, since active pumping may draw more air into the fill, thus inhibiting methanogenesis.

9.0 Title V GHG Emissions Reporting

Compilation and Analysis of New Mexico's Greenhouse Gas Emissions Inventory Data 2008-2011 provides a comprehensive evaluation of New Mexico's Title V bottom-up GHG emissions inventory. This report can be found at the following link: https://www.env.nm.gov/aqb/GHG/documents/GHG_data_outreach_VER20_Final.pdf.

NMED also has an Emissions Analysis Tool (EAT) which includes GHG and criteria pollutant emissions data for facilities subject to either EPA or state GHG emissions reporting requirements. The tool allows users to download and analyze emissions data, and view data either using a map or list. There are a variety of charts which display emissions by pollutant, facility, and industry. Emissions data from 2008 through 2015 are provided. Please be sure to review the tool disclosure for additional information. The link to this tool is https://eatool.air.net.env.nm.gov/aqbeatool/.

Appendices

Appendix A: Key Uncertainties in Agricultural Module of SIT

According to the SIT, the following uncertainties exist.

1. Domesticated Animals

The quantity of methane (CH_4) emitted from enteric fermentation from livestock is dependent on the estimates of animal populations and the emission factors used for each animal type. Therefore, the uncertainty associated with the emission estimates stems from those two variables. Animal populations fluctuate throughout the year, and thus using a single point estimate (e.g., horses and sheep), multiple point estimates (e.g., cattle and swine), or periodic estimates (e.g., goats) introduces uncertainty into the average annual estimates of these populations. In addition, there is uncertainty associated with the original population survey methods employed by USDA.

Emission factors vary in each animal, depending on its production and diet characteristics, as well as genetics. This makes determining an exact emission factor for each state and all possible animal sub-groupings impossible. However, for cattle, these variables were simulated when estimating emissions for the United States (EPA 2004), thus providing a reasonable average for the regions defined in this analysis. While some of the characteristics used for cattle differ from the IPCC default values, a review of the US situation determined that these factors are justified. For other (non-cattle) animal populations there is also uncertainty associated with the emission factors, but it is believed not to vary as drastically within each species.

2. Livestock Manure

Similar to emission estimates of methane from enteric fermentation, emissions from manure management are dependent on the estimates of animal populations and the various factors used for each animal type. Therefore, the uncertainty associated with the emission estimates stems from those variables. Animal populations fluctuate throughout the year, and thus using a single point estimate (e.g., horses and sheep), multiple point estimates (e.g., cattle and swine), or periodic estimates (e.g., goats) introduces uncertainty into the average annual estimates of these populations. In addition, there is uncertainty associated with the original population survey methods employed by USDA.

The largest contributors to uncertainty in emissions from manure management are the lack of extensive data describing the management systems used in each region, and the methane generating characteristics used to estimate emissions from each of these systems. Also, the nitrous oxide emission factors are derived from a limited data set and are provided as global estimates, not country or state specific.

In particular, methane conversion factors (MCFs) vary widely for anaerobic lagoon systems, based on design and handling procedures. The default range from the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000) is between zero and 100 percent, reflecting the vast discrepancies that can occur in this type of system. In the United States, MCFs were estimated based on observed system performance and climatic factors, though the methodology employed introduces additional uncertainty because it is based on data from relatively few systems (EPA 2004).

In addition, there is uncertainty in the maximum methane producing potential (Bo) used for each animal group. This value varies with both animal and diet characteristics, so estimating an average across an entire population introduces uncertainty. While the Bo values used in this analysis vary by animal subcategory to try to reflect as many of these differences as possible, there is not sufficient data available at this time to estimate precise values that accurately portray the Bo for all animal types and feeding situations (EPA 2004).

Finally, nitrous oxide emission factors used for this analysis are the global defaults provided by the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000). These factors are based on limited studies, and do not take into account the fact that US emission factors may vary significantly on both a national and state level.

3. Agricultural Soil Management

The amount of nitrous oxide (N_2O) emissions from managed soils is dependent on a large number of variables besides nitrogen (N) inputs, including soil moisture content, pH, soil temperature, organic carbon availability, oxygen (O_2) partial pressure, and soil amendment management practices. However, the effect of the combined interaction of these variables on N_2O flux is complex and highly uncertain. The IPCC default methodology that is followed here is based only on N inputs and does not incorporate other variables. As noted in the Revised 1996 IPCC Guidelines (IPCC/UNEP/OECD/IEA 1997), this is a generalized approach that treats all soils equally, with the exception of cultivated histosols (EPA 2004). This methodology covers the following three sub-categories: direct emissions due to cropping practices, direct emissions due to animal production, and indirect emissions from agricultural applications of N. Uncertainties exist in both the emission factors and activity data used to derive emission estimates in each sub-category.

As noted in Section 2.2 [Of the SIT Ag module], scientific knowledge is limited regarding N_2O production and emissions from soils to which nitrogen is added. Thus it is not currently possible to develop statistically valid estimates of emission factors for all possible combinations of soil, climate, and management conditions. The emission factors presented throughout this chapter are midpoint estimates based on measurements described in the scientific literature. They are representative of current scientific understanding, but also possess a significant level of uncertainty.

Uncertainties also exist in the default activity data used to derive emission estimates in each sub-category. In particular, the fertilizer statistics do not include non-commercial fertilizers (except estimated manure and crop residues). Site-specific conditions are not taken into consideration when determining the amount of nitrogen excreted from animals. Limited research on nitrogen-fixing crops has resulted in the use of conversion factors that may not account for the variety of conditions in all states. Expert judgment, with its inherent uncertainty, was used to estimate the amount of crop residues left on soils as no data were available.

Additional uncertainty surrounds the emission sub-categories for which state-level data may not be available, i.e., land application of sewage sludge and cultivation of histosols. Emissions of N_2O due to leaching and runoff are also relatively uncertain at this time, due to the uncertainty of the volatilization rates and proportion of leached nitrogen.

4. Agricultural Crop Wastes

The methodologies presented in this chapter [Of the SIT Ag module] account for non-carbon dioxide emissions, including methane, nitrous oxide, carbon monoxide, and nitrogen oxides, from field burning of agricultural residues. As in the Inventory of US GHG and Sinks, major sources of uncertainty in this sector are the quantity of residue burned per year and the variability in states' burning practices (US EPA 2004). Both the emission factors and activity data introduce uncertain elements into the calculations.

The gas emission ratios have a relatively high level of uncertainty as they are region-specific (not country- or state-specific). Low level uncertainty also surrounds residue dry matter content, burning efficiency, and combustion efficiency values used (US EPA 2004).

Since there is no national or state-level collection of data on the fraction of crop residue burned, and burning practices vary by state and crop, these data are highly uncertain. Additional sources of uncertainty include crop production data and residue to crop production ratios at low levels (US. EPA 2004).

Appendix B: Annual Solid Waste Reports (Tons)

Source and Management	2005	2006	2007	2008	2009	2010	2011	2012	2013
Generated in New Mexico	3.1E+06	3.3E+06	3.2E+06	3.0E+06	2.9E+06	3.E+06	2.7E+06	2.7E+06	1.7E+06
Waste from Out-of-State	4.7E+05	6.3E+05	6.7E+05	6.1E+05	5.5E+05	6.E+05	6.1E+05	5.3E+05	4.6E+05
Waste Diverted from Landfills	1.1E+05	4.1E+05	4.3E+05	3.8E+05	5.8E+05	5.E+05	5.5E+05	5.3E+05	2.0E+05
Total Solid Waste Disposed in New Mexico Landfills	**3.4E+06**	**3.5E+06**	**3.5E+06**	**3.2E+06**	**2.8E+06**	**3.0E+06**	**2.8E+06**	**2.7E+06**	**2.6E+06**

Please note: According to Connie Pasteris of the New Mexico Solid Waste Bureau Outreach Section, the “Generated in New Mexico” tonnage value may be incorrect. All other values in the above table are considered to be correct. These numbers are slightly different than the tonnages published in the Annual Report because the data continues to be entered as the facilities’ annual tonnages are reported.