Nevada Statewide Greenhouse Gas Emissions Inventory and Projections, 1990-2030

Nevada Division of Environmental Protection
2016 Report

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Acronyms and Abbreviations

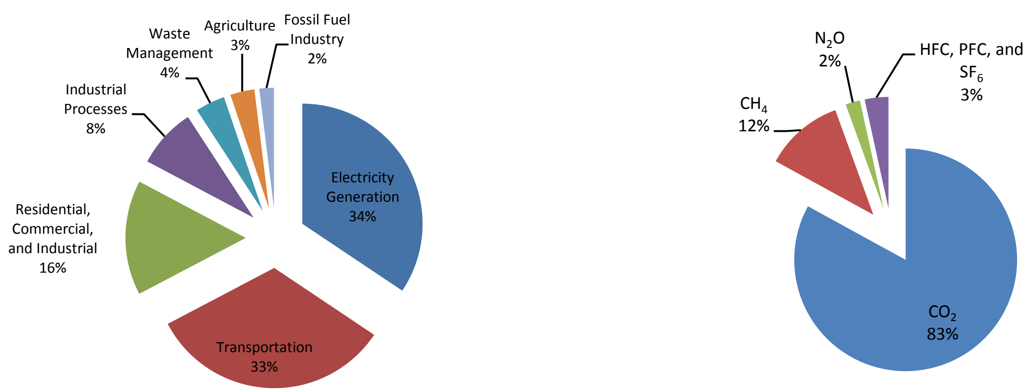
AAPFCO	Association of American Plant Food Control Offices
AVMT	Annual Vehicle Miles Travelled
BOD	Biochemical Oxygen Demand
BTU	British Thermal Unit
CH_4	Methane
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide equivalent
eGRID	Emission & Generation Resource Integrated Database
EIA	US Energy Information Administration
EIA-SEDS	Energy Information Administration State Energy Data System
EPA	US Environmental Protection Agency
FIA	USDA-Forest Inventory and Analysis Program
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GHGRP	Greenhouse Gas Reporting Program
GWP	Global Warming Potential
HFC	Hydrofluorocarbon
IPAA	Independent Petroleum Association of America
IPCC	Intergovernmental Panel on Climate Change
LFGTE	Landfill-Gas-to-Energy
LMOP	Landfill Methane Outreach Program
LPG	Liquefied Petroleum Gas
$MMTCO_2eq$	Million metric tons of carbon dioxide equivalent
MW	Megawatt
MSW	Municipal Solid Waste
N_2O	Nitrous Oxide
NASS	National Agricultural Statistics Service
NDEP	Nevada Division of Environmental Protection
NGCC	Natural Gas Combined Cycle
NIFC	National Interagency Fire Center
NPC	Nevada Power Company
NRS	Nevada Revised Statutes
ODS	Ozone Depleting Substance
PFC	Perfluorocarbon
PHMSA	US Department of Transportation Pipeline and Hazardous Material Safety Administration
PUCN	Public Utilities Commission of Nevada
SF_6	Sulfur hexafluoride
SIT	State Inventory Tool
SIT 2016	The 2016 version of EPA's State Inventory Tool
SPPC	Sierra Pacific Power Corporation
EPA	United States Environmental Protection Agency
VMT	Vehicle Miles Travelled
WIP	Waste in Place

Executive Summary

The Nevada Revised Statutes (NRS) require that a statewide greenhouse gas (GHG) inventory be prepared and issued at least every 4 years. It further stipulates that the report must include the origin, types, and amounts of GHGs emitted throughout the state, and all supporting analyses and documentation. This report represents a comprehensive inventory of anthropogenic GHG emissions in Nevada that specifically considers the 6 GHGs listed in NRS 445B.137: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulfur hexafluoride (SF_6). This report was developed using the United States Environmental Protection Agency's (EPA) State Inventory Tool (SIT). The SIT is a series of emissions calculators broken up by sectors designed to help states develop GHG inventories. This report utilizes the SIT to estimate historical emissions from 1990 to 2013 and project future emissions to 2030 for eight different sectors in Nevada.[1]

The inventory of Nevada's GHG emissions estimates 2013 gross GHG emissions totaled 44.039 million metric tons of carbon dioxide equivalents (MMTCO2eq) and net GHG emissions totaled 39.251 MMTCO2eq.[2] These emissions estimates are far less than the state's peak in 2005 when there were an estimated 60.362 MMTCO2eq of gross and net GHGs emitted.[3] The state's two largest sectors in terms of GHG emissions are electricity generation and transportation. Combined, the combustion of fossil fuels for the generation of electricity and transportation related purposes accounted for 67 percent of the state's total 2013 emissions. Figure ES-1 illustrates the relative gross GHG contributions of the various sectors considered in this report and also the relative contribution of the GHGs themselves to total Nevada emissions in 2013. Note that the land use, land use change, and forestry (forestry) sector is absent from Figure ES-1 as it acted as an emissions sink in 2013.

Figure ES-1: 2013 Nevada Gross GHG Emissions by Sector and Relative Contributions of GHGs



[1] 2013 is the most recent year with datasets available for all of the GHG sources considered.

[2] Net GHG emissions are calculated as total gross emissions minus the net amount of CO_2 sequestered by natural ecosystems (e.g. forestry sector).

[3] That gross and net emissions were the same implies that the forestry sector was a source and not a sink for emissions in that particular year.

Total Nevada emissions have increased 25 percent since 1990 but have decreased 27 percent from the 2005 peak. In general, a correlation exists between population growth and GHG emissions. For example, the increase in GHG emissions from 1990 to 2005 closely follows the Nevada's population growth during the same period. However, disregarding changes in population, large changes in GHG emissions can also occur as a result of changes in production technologies or methodologies that release GHGs. For example, the large decline in GHG emissions after 2005 resulted from the retirement of Mohave Generating Station, a coal-fired power plant. A similar situation, though with far less impact, occurred more recently in the waste management sector. With the installation of landfill-gas-to-energy technology (a process which converts CH_4 biogas into electricity) at Nevada's largest landfill, emissions in the sector were reduced by more than 500,000 $MTCO_2eq$ (a nearly 22 percent decrease in emissions). Table ES-1 provides a sector-by-sector summary of GHG emissions in Nevada for select years from 1990 to 2013.

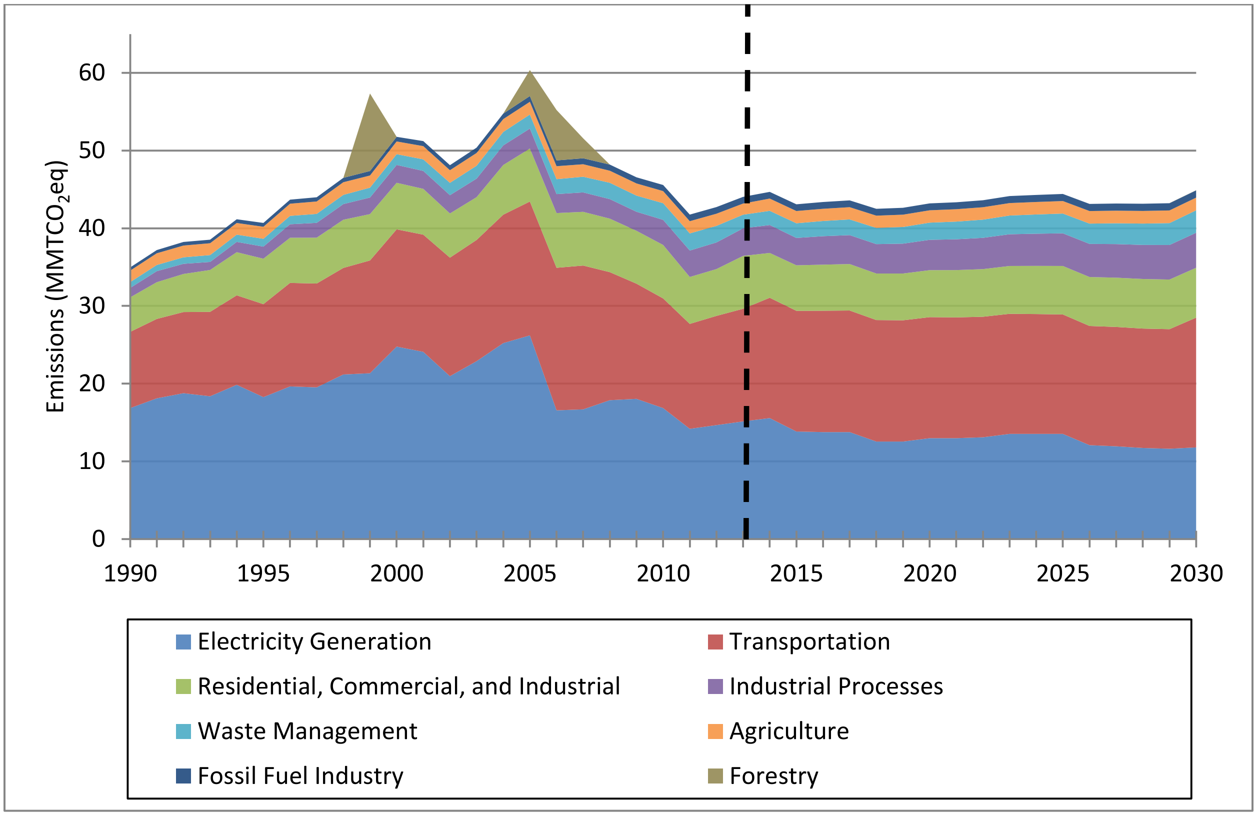
Table ES-1: Nevada Historical Emissions by Sector, $MMTCO_2eq$

Sector	1990	1995	2000	2005	2010	2011	2012	2013
Electricity Generation	16.855	18.267	24.771	26.213	16.858	14.190	14.665	15.144
Transportation	9.807	11.967	15.091	17.226	14.112	13.502	14.057	14.492
Residential, Commercial, and Industrial	4.441	5.848	5.987	6.819	6.880	6.037	6.025	6.807
Industrial Processes	1.214	1.556	2.298	2.573	3.230	3.403	3.425	3.550
Waste Management	0.749	1.003	1.384	1.808	2.144	2.209	2.136	1.751
Agriculture	1.484	1.550	1.642	1.636	1.558	1.570	1.563	1.436
Fossil Fuel Industry	0.412	0.493	0.593	0.739	0.785	0.849	0.855	0.860
Forestry	-5.851	-8.073	-0.635	3.349	-6.121	-2.183	-0.329	-4.788
Total Gross Emissions*	**34.962**	**40.684**	**51.765**	**60.362**	**45.567**	**41.759**	**42.726**	**44.039**
Total Net Emissions	**29.110**	**32.612**	**51.130**	**60.362**	**39.446**	**39.575**	**42.397**	**39.251**

* Gross emissions only account for the forestry sector on years when it is a source of GHG emissions

Emissions were projected to the year 2030. These emissions projections consider estimates of future emissions as well as known changes to a sector. Figure ES-2 shows Nevada's GHG emissions from 1990 to 2030 with a dashed vertical line separating where the historical period ends and the projections begin. Between 2014 and 2030 the transportation sector is expected to become the largest source of GHG emissions in the state. Total emissions statewide will remain relatively flat between 2013 and 2030 where emissions are projected to increase by less than 1 $MMTCO_2eq$. This is due, in part, because as Nevada continues to move away from coal-fired electricity generation, emissions in the electricity generation sector will continue to decline.

Figure ES-2: Nevada Historical and Projected Gross Sector Emissions, 1990 – 2030 ($MMTCO_2eq$)



1. Introduction

1.1 Overview

During the 2007 Nevada Legislative Session, the legislature passed Senate Bill 422, which is now codified in the Nevada Revised Statutes (NRS) Chapter 445B.137 and 445B.380. NRS 445B.137 defines the gases that are collectively referred to as greenhouse gases (GHG) and NRS 445B.380 requires that a statewide GHG inventory be prepared and issued at least every 4 years beginning in 2008. It further stipulates that the report must include the origin, types, and amounts of GHGs emitted throughout the state, and all supporting analyses and documentation. This report represents a comprehensive inventory of all anthropogenic GHG emissions in Nevada as it considers all 6 GHGs listed in NRS 445B.137: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulfur hexafluoride (SF_6). This report was developed using the United States Environmental Protection Agency's (EPA) State Inventory Tool (SIT).[1, 2] The SIT is a series of emissions calculators broken up by sectors designed to help states develop GHG inventories (the SIT is discussed in more detail in 1.2).

The GHGs considered in this report each have characteristic global warming potentials (GWPs) and therefore contribute to the overall atmospheric greenhouse effect differently. The GWP is used to derive a common metric, known as the CO_2 equivalent (CO_2eq), which uses the GWP of CO_2 as a reference unit. The biggest difference in values between this report and the 2012 version is that the 2012 report used GWPs from the International Panel on Climate Change's (IPCC) third assessment and this report utilizes the GWPs from the IPCC's fourth assessment. Table 1-1 lists the GWPs on a 100 year horizon for the gases considered in this report. The use of CO_2eq allows estimating and comparing total GHG emissions from sources emitting different GHGs.

Table 1-1: The 100 Year Global Warming Potentials (GWPs) for Selected GHGs [3, 4]

Gas	GWP
CO_2	1
CH_4	25
N_2O	298
HFC-23	14,800
HFC-32	675
HFC-125	3,500

[1] The six GHG gases listed in NRS 445B.137 are similarly included in the definitions of a GHG by the International Panel on Climate Change (IPCC) and by the United States Environmental Protection Agency (EPA).
[2] https://www.epa.gov/statelocalclimate/state-inventory-and-projection-tool (accessed October 2016).
[3] IPCC (2007) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. [S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press. Cambridge, United Kingdom 996 pp.
[4] While the Intergovernmental Panel on Climate Change (IPCC) has since updated the GWPs for the GHGs listed in Table 1-1, the modeling software provided by the EPA that is used in this report has not been updated to reflect those changes. The IPCC's most recent GWP's are published in their fifth assessment: https://www.ipcc.ch/report/ar5/ (accessed October 2016).

Gas	GWP
HFC-134a	1,430
HFC-143a	4,470
HFC-152a	124
HFC-227ea	3,220
HFC-236fa	9,810
HFC-4310mee	1,640
PFC-14 (CF_4)	7,390
PFC-116 (C_2F_6)	12,200
PFC-3-1-10 (C_4F_{10})	8,860
PFC-5-1-14 (C_6F_{14})	9,300
SF_6	22,800

This 2016 report covers the period from 1990 to 2030, covering historical and current emissions inventories from 1990 to 2013 and future emissions projected to 2030. The report is organized into sections covering each of the following sectors that produce GHGs:

- Electricity Generation;
- Transportation;
- Residential, Commercial, and Industrial (stationary emissions from fossil-fuel burning only);
- Industrial Processes (i.e., all non-energy related activities);
- Waste Management;
- Agriculture (all non-energy related activities);
- Fossil-Fuel Industry (e.g., coal and natural gas production and distribution); and
- Land Use, Land-Use Change, and Forestry (Forestry).

The presence (or absence) of specific activities in a sector largely determines the type of GHGs emitted. Table 1-2 summarizes the types of GHG emissions that each sector is expected to release in Nevada; a filled box in the table indicates that the specific GHG is emitted in that sector.

Table 1-2: The GHGs Considered in the Various Sections of the Report

Sector	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
Electricity Generation	■	■	■			
Transportation	■	■	■			
Residential, Commercial, Industrial (fossil fuel burning for energy-related activities)	■	■	■			
Industrial Processes* (non-energy related activities)	■		■	■	■	■
Waste Management		■	■			
Agriculture		■	■			
Fossil Fuel Industry		■				
Forestry**	■	■	■			

*HFCs, PFCs, and SF_6 are calculated together in this sector

**CO_2 can be emitted into the atmosphere and sequestered from the atmosphere in this sector

1.2 Approach, Datasets, and General Methodology

The principal goal of this report is to provide a general understanding of Nevada's historical, current, and future GHG emissions. In most cases, the approach followed was the one used by the EPA in its national GHG emission inventory, the EPA's SIT, and those methods suggested in its guidelines for states.[5] National inventory guidelines are based on the recommendations developed by the Intergovernmental Panel on Climate Change (IPCC)[6], an international organization responsible for, among other tasks, coordinating methods for national GHG inventories. The EPA's SIT was used as a starting point for all inventories and projections; initial estimates were revised when more accurate state and local datasets became available. The key sources for the data used in this report are listed in Table 1-3. In gathering the data, and in cases where data sources conflicted, priority was given to local and state data and analyses, followed by regional and national data.[7] In the absence of available data, the most appropriate statistical methodology was used to either interpolate or extrapolate the missing data points. In spite of any possible instance of under/overestimates in emissions estimates related to using particular datasets, the methods used in this report are considered by NDEP to be the most reliable available methods at the time this report was produced. The data and methodologies used in this report are specifically designed to compile a GHG emission inventory at the state level on an annual time scale; for this reason, the scale of this emission inventory is too coarse to effectively measure and evaluate the results of most individual GHG reduction programs or statute changes.

For the purpose of this inventory, emissions that were caused by activities that occurred within the geographical boundaries of the State of Nevada were reported. However, it is important to recognize that GHG emissions are not always spatially associated with the related activities. For instance, production (the source of emissions) and consumption of electrical power (the related activity) can take place at very different locations, sometimes in different states. This distinction is particularly critical in evaluating the impact of potential demand mitigation strategies. For example, reuse, recycling, and source reduction can lead to emission reduction from lower energy requirements in material production (e.g., paper, cardboard, and aluminum) even though the emissions associated with material production may not occur within that particular state.

[5] https://www.epa.gov/statelocalclimate/developing-state-greenhouse-gas-inventory (accessed October 2016).
[6] https://www.ipcc.ch/index.htm (accessed October 2016).
[7] In instances when regional and/or national data are used, the disaggregations can result in under/overestimates of emissions versus the other states in the original "group". This is due to the methods of redistribution which are largely comparisons of populations and in some cases gross domestic products (GDPs). Instances where this uncertainty could lead to an appreciable change in estimated emissions are noted throughout the report.

Table 1-3: Key GHG Inventory Data Sources

Sector	Source	Information Provided
All Sectors	US EPA State GHG Inventory Tool, 2016 version (SIT 2016)	Emission factors and other sector specific data
	Nevada State Demographer	Nevada population data
	The United States Census Bureau	US population data
Electricity Generation	US Energy Information Administration (EIA)	Fossil-fuel consumption at state level
		Net generation of electricity
	EPA Emissions & Generation Resource Integrated Database (eGRID)	GHG emissions at the plant level
	Public Utilities Commission of Nevada (PUCN)	Power company regulatory filings
	Energy Information Administration State Energy Data System (EIA-SEDS)	Annual consumption of fossil-fuel for the electricity generation sector, disaggregated by type of fuel
Transportation	Nevada Department of Transportation	Total Annual Vehicle Miles Traveled (AVMT)
	EIA-SEDS	Annual consumption of fossil fuel for the transportation sector, disaggregated by type of fuel
Residential, Commercial, and Industrial	EIA-SEDS	Fuel consumption
Industrial Processes	USGS Minerals Yearbook	Annual production and consumption, and projected consumption for different minerals
	US Greenhouse Gas Reporting Program	Sector GHG emissions
	EIA	Emission factor and national SF_6 consumption data for electric power transmission and distribution. Electricity sales at national and state level
Waste Management	US EPA Landfill Methane Outreach Program (LMOP)	Waste in place (WIP) data Information on gas-recovery technologies (in-place and planned)
	NDEP Bureau of Waste Management	Annual solid waste emplacement
Agriculture	USDA National Agricultural Statistics Service (NASS)	Livestock population and crop statistics for Nevada
	The Association of American Plant Food Control Officials (AAPFCO)	Fertilizer use data
Fossil Fuel Industry	Independent Petroleum Association of America (IPAA)	Oil and natural gas production
	US EIA	Oil and natural gas production
	US Department of Transportation Pipeline and Hazardous Material Safety Administration (PHMSA)	Natural gas transmission and distribution
Land Use, Land-Use Change, and Forestry	USDA-Forest Service Inventory and Analysis Program (FIA)	Forest productivity
	National Interagency Fire Center (NIFC)	Acreage affected by fires

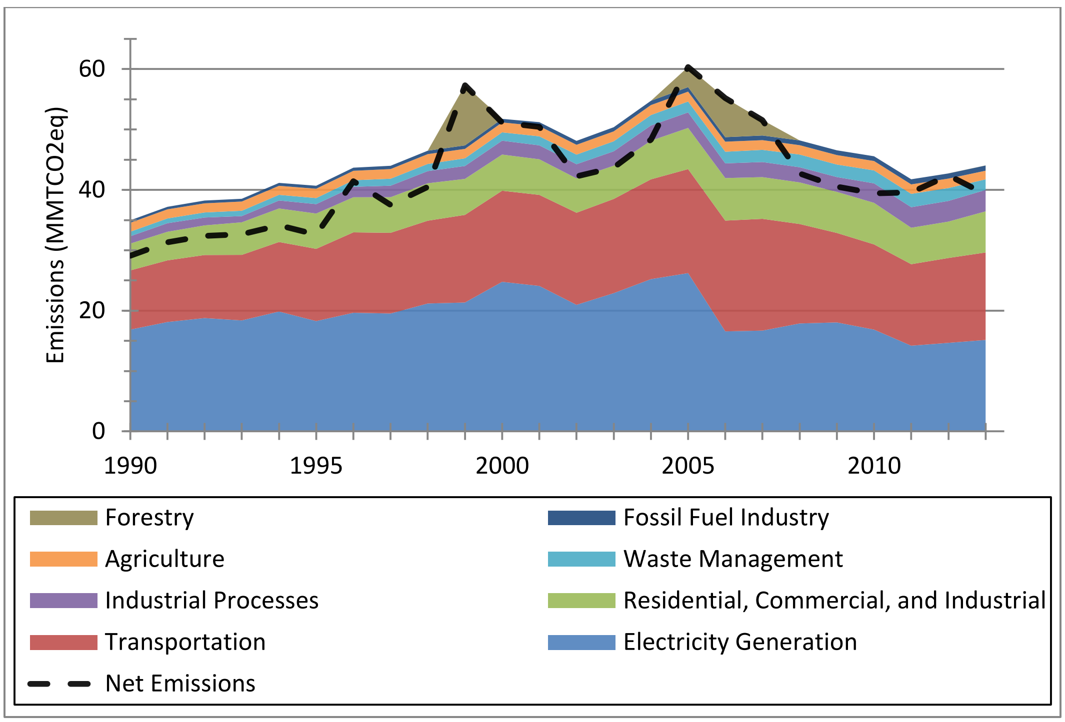
2. State of Nevada Greenhouse Gas Emissions

2.1 Historical Emissions (1990 to 2013)

The analysis of Nevada's GHG emissions indicates that for 2013 (the most recent year with datasets available for all of the GHG sources considered) statewide gross GHG emissions were estimated to be 44.039 million metric tons of carbon dioxide equivalents ($MMTCO_2eq$). Figure 2-1 shows Nevada's gross historical emissions from 1990 to 2013, where emissions are aggregated by sector and emissions for the forestry sector are only shown when they are positive.[8] GHG emissions increased every year from 1990 to 2000 but emissions peaked in 2005 at 60.362 $MMTCO_2eq$. With the retirement of the Mohave Generating Station that year, gross emissions decreased by more than 5 $MMTCO_2eq$ between 2005 and 2006. Further, the economic recession that occurred between 2007 and 2009 reduced emissions across nearly all sectors as Nevada's entire economy suffered from the recession's effects.

Figure 2-1 also includes a black dashed line indicating the state's net GHG emissions. Net emissions are the difference between GHG emissions and sinks in a given year. Because forestry sector emissions largely act as a sink for GHG emissions (the forestry sector is the state's only true GHG sink), statewide net emissions are generally lower when this sector is considered as both a source and a sink.

Figure 2-1: Nevada Gross Historical Emissions by Sector and Net Historical Emissions, 1990 – 2013



[8] Forestry sector emissions are largely dependent upon wildfires and prescribed fires (wildland fires) in the state. Typically the forestry sector acts as a sink for CO_2 but when there are many acres burned by wildland fires in a single year then emissions can be positive.

Historical emissions estimates from all sectors are presented in Table 2-1. The trends in Nevada's smaller sectors are more easily distinguished when presented this way. In 2013, two sectors contributed 67 percent of total gross emissions in the state (electricity generation and transportation). Forestry sector emissions are clearly the state's most volatile as uncontrolled wildfires are difficult to predict, control, and contain. Table 2-1 also highlights the impact of Nevada's increasing population on emissions across almost all sectors. That is, emissions from all sectors rose with similar increases in population until a meaningful change took place in that sector that reduced emissions (those changes are discussed in each sector's respective section).

Table 2-1: Nevada Historical Emissions by Sector, $MMTCO_2eq$

Sector	1990	1995	2000	2005	2010	2011	2012	2013
Electricity Generation	16.855	18.267	24.771	26.213	16.858	14.190	14.665	15.144
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Waste Management	0.749	1.003	1.384	1.808	2.144	2.209	2.136	1.751
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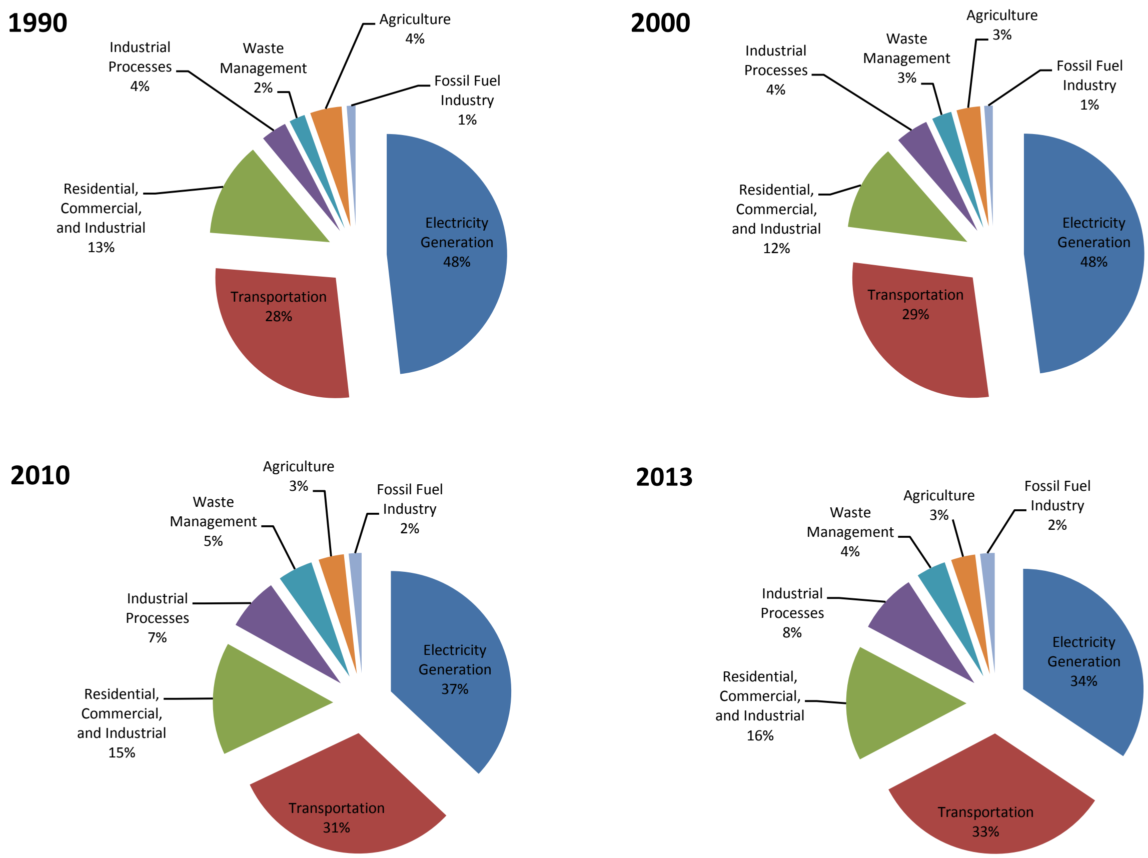
Total Net Emissions	**29.110**	**32.612**	**51.130**	**60.362**	**39.446**	**39.575**	**42.397**	**39.251**

* Gross emissions only account for the forestry sector on years when it is a source of GHG emissions

The state's two dominant sectors for GHG emissions are electricity generation and transportation. In 2013, electricity generation was 34 percent of gross emissions and transportation was 33 percent of the state's gross emissions. The positions of these two sectors in terms of contributions to the state's total emissions have not changed since 1990 when they were 48 and 28 percent, respectively. Figure 2-2 illustrates the relative contributions of each of the sectors investigated in this report to Nevada's total GHG emissions for the year's 1990, 2000, 2010, and 2013. While minor changes to Nevada's minor GHG contributing sectors is more noticeable above in Table 2-1, putting all of the sectors into comparison to total emissions in Figure 2-2 puts into perspective the relative importance of each source that makes up Nevada's total GHG emissions. The biggest change in emissions in the state between 1990 and 2013 has been the rise and fall of electricity generation sector emissions. With the retirement of the Mohave Generating Station in 2005 and NV Energy moving away from coal-fired generation towards cheaper and cleaner burning natural gas, emissions in the sector peaked in 2005 with millions of metric tons more emissions than that sector currently emits (see Section 3: Electricity Generation).

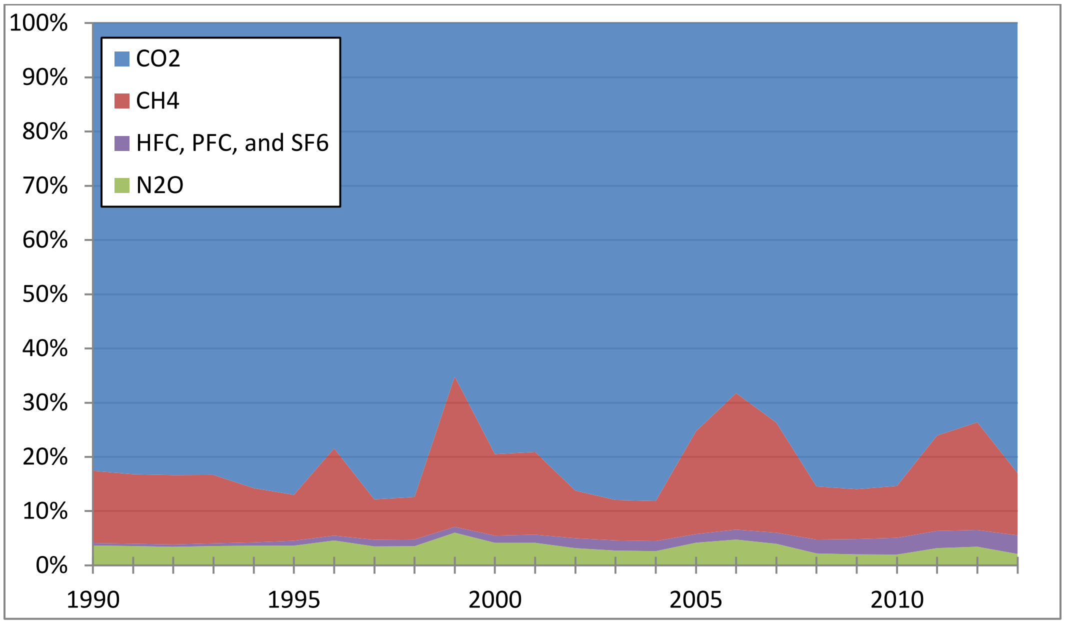
Figure 2-2: Relative Contributions of Gross Emissions by Sector, Select Years



This report also looks at the State's GHG emissions in terms of the individual contributions of the gases. Figure 2-3 shows the relative contributions of each GHG to Nevada's gross emissions.[9] Emissions have clearly been dominated by CO_2 with 81 percent of emissions on average and 83 percent of 2013 emissions, followed by CH_4, with 14 percent of emissions on average and 11 percent of 2013 emissions, N_2O, with 3 percent of average emissions and 2 percent of 2013 emissions, and finally HFCs, PFCs, and SF_6 which contributed 2 percent on average and 3 percent in 2013. The years in the Figure where CH_4 emissions are a much larger portion of total emissions are due to large wildfires (see 1996, 1999, 2005 through 2007, and 2012).

[9] Figure 2-3 ignores the effects of carbon sequestration in the forestry sector.

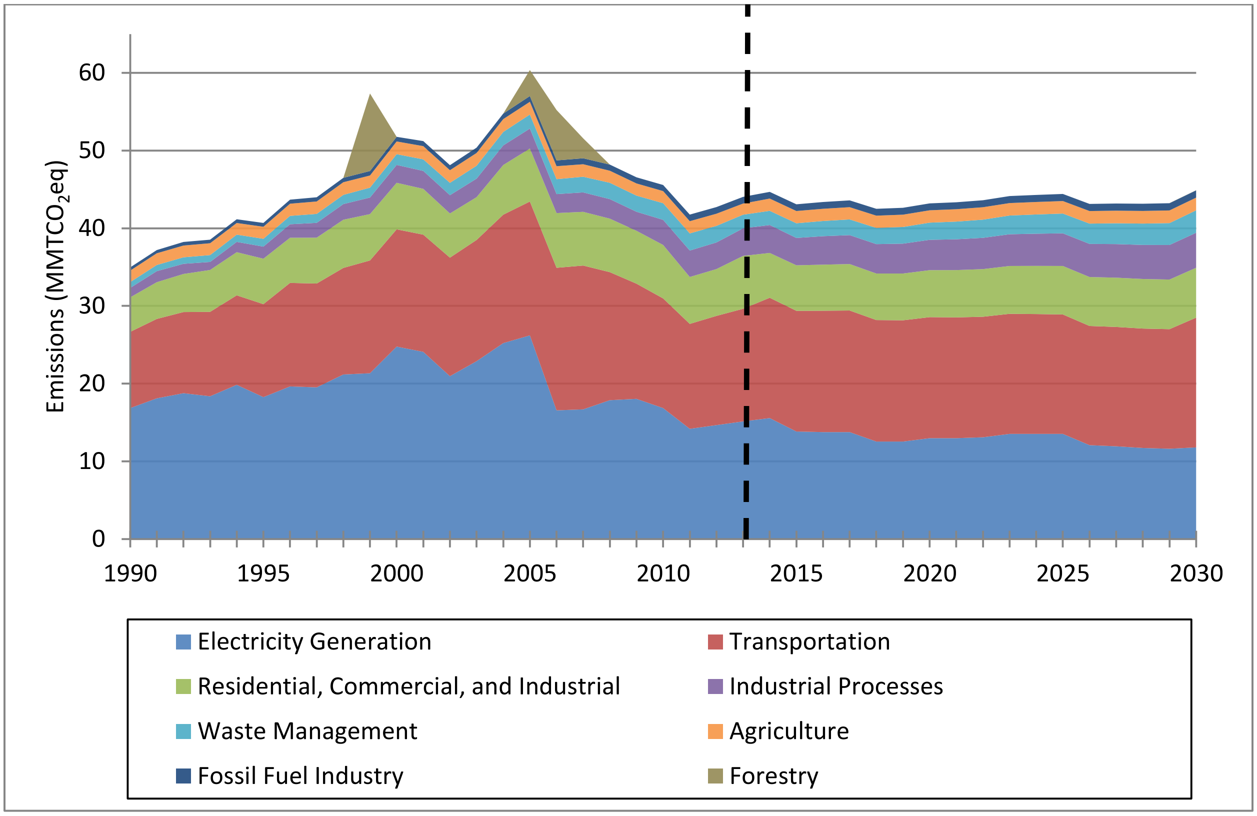
Figure 2-3: Relative Contributions of Individual GHGs, 1990 - 2013



2.2 Projected Emissions (2014 to 2030)

In nearly all sectors, there is projected to be a very slow but constant increase in GHG emissions for the period 2014 to 2030 which will be driven by predicted population and economic growth. In fact, over the entire period of study, 1990 to 2030, emissions incrementally increase with economic and population growth in nearly every category. The only instances when emissions decreased were during recessions or when a transformative technology was introduced to a sector that resulted in emissions being permanently reduced. Figure 2-4 illustrates Nevada's gross historical and projected emissions by sector from 1990 to 2030 with a dashed vertical line marking where the historical period ends and the projections begin. Overall, these projections indicate that Nevada's gross emissions of GHGs will increase by less than 1 $MMTCO_2eq$ between 2013 and 2030, reaching 44.877 $MMTCO_2eq$ in 2030. This is largely due to the continued emissions reductions in the electricity generation sector through the retirements of the state's aging coal-fired power plants and their replacement with natural gas and renewable energy-based forms of electricity generation. While statewide emissions will be nearly 10 $MMTCO_2eq$ greater than 1990 emissions, it is more than 15 $MMTCO_2eq$ less than the State GHG emissions peak in 2005.

Figure 2-4: Nevada Historical and Projected Gross Sector Emissions, 1990 – 2030 ($MMTCO_2eq$)

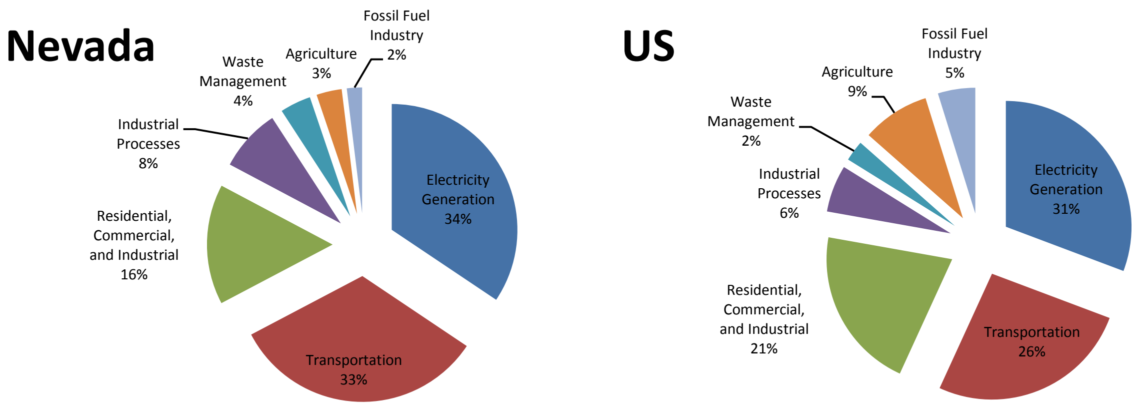


2.3 Nevada and the United States

In comparing Nevada's GHG emissions to total US GHG emissions, there are multiple differences. First, total US GHG gross emissions were 6,800 $MMTCO_2eq$ for 2013.[10] Net US emissions, after accounting for land use, land use change, and forestry sinks, were estimated to be 6,040.4 $MMTCO_2eq$. Nevada accounted for 0.65 percent of both gross and net US GHG emissions; Nevada accounted for 0.88 percent of the US population in 2013. 2013 US GHG emissions were estimated to be 21.5 $MTCO_2eq$ per person, whereas Nevadans are estimated to emit 15.7 $MTCO_2eq$ per person. The relative contributions of GHGs from each sector in this report when comparing the US and Nevada also differ. Figure 2-5 illustrates the relative contributions of both Nevada and US 2013 GHG emissions broken up by sector for comparison. Nationally, the US creates, on average, far more GHGs from the residential, commercial, and industrial combustion of fossil fuels (21 percent) than Nevada (16 percent). Agriculture emissions are also appreciably higher nationally (9 percent versus Nevada's 3 percent). Nevadans generate far more GHGs from the transportation sector than are generated nationally; 33 percent of Nevada's emissions are transportation based as compared to 26 percent nationally in 2013. Much of this likely has to do with Nevada's geography and comparatively small population per square mile of land.

[10] EPA (2016) *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2014*, U.S. Environmental Protection Agency. Washington, D.C. EPA/430-R-16-002. April 15, 2016, p ES-4.

Figure 2-5: Relative Contributions of Gross Emissions for Nevada and the US, 2013



3. Electricity Generation

3.1 Overview

GHG emissions associated with electricity generation have long accounted for a significant fraction of Nevada's total emissions and the amount of GHGs released (overwhelmingly CO_2, but in smaller amounts CH_4 and N_2O) depends on the type and quantity of fuel consumed during the production of electricity. Historically, Nevada's generation mix has been largely dependent on coal, a high carbon content fuel, but this has been changing over the past decade as the state's aging coal-fired power plants are retired and replaced with natural gas-fired power plants. Natural gas has about 55 percent the carbon content of coal per unit of useful energy.[11] Thus, as Nevada's generation mix has begun to include more natural gas, Nevada has had less GHG emissions in spite of producing more electricity.

Historical emissions were calculated using two methods. From 1990 to 2009 emissions were calculated using the SIT. The SIT depends on information from the Energy Information Administration State Energy Data System (EIA-SEDS) to perform its calculations. The EIA-SEDS provides fuel consumption estimates for the electricity generation sector at the state level by calculating fuel consumption at a multi-state level and distributing the results back to the states.[12] The fuel consumption estimates (the EIA-SEDS data) are then each multiplied by a specific emission factor that depends on the fuel type and the GHG being estimated. From 2010 to 2013 emissions were determined using the methodologies of EPA's Emissions & Generation Resource Integrated Database (eGRID).[13] This database is a comprehensive source of data on the environmental characteristics of almost all electrical power generated in the United States.[14] Unfortunately, eGRID is not updated on an annual basis. So instead of using eGRID directly for every year, the data sources that eGRID depends on were used to estimate GHG emissions when eGRID data was not directly available.

Projected emissions were determined by considering the emissions from Nevada's existing fleet of generating facilities (their expected usage, remaining useful life, etc.) and then adding to that the expected emissions of new generating facilities that are expected to be added to the state's fleet by 2030. New facilities were determined using regulatory filings submitted by Sierra Pacific Power Corporation (SPPC) and Nevada Power Company (NPC), collectively NV Energy. As a requirement to operating in the state, NV Energy has to submit Integrated Resource Plans and Energy Supply Plans to the Public Utilities Commission of Nevada (PUCN) every 3 years for both SPPC and NPC. These documents provide information as to when NV Energy is expecting to put into service new units and what types of units it expects them to be. Knowing when a unit is expected to go into service, what type

[11] Ibid, p 3-6.

[12] This method does have drawbacks such as possible errors in the distributions resulting in under/overestimates of emissions.

[13] When information was unavailable, CH_4 and N_2O emissions (minute contributors to total sector emissions) were still determined using the SIT.

[14] https://www.epa.gov/energy/egrid (accessed October 2016).

of unit that is expected to go into service, and the expected average usage of the new unit provides enough information to estimate emissions.

3.2 Historical Emissions

Electricity generation emissions are largely dependent on the fuel source being used to generate electricity. Nevada has for the past decade been moving away from coal-fired electric generation in favor of cleaner, less expensive, natural gas and, to a lesser extent, a variety of renewable energy sources (solar thermal, solar photovoltaic, and wind). Since the retirement of the Mohave Generating Station[15], electricity generation emissions have been reduced by more than 10 MMTCO$_2$eq. In 2013, emissions were 15.144 MMTCO$_2$eq as compared to 2005 emissions (2005 was the last year that Mohave was in operation), which were 26.213 MMTCO$_2$eq. Table 3-1 lists historical emissions from the electricity generation sector. It also lists the CO_2 emissions of the three main fossil fuel types used in the generation of electricity in the United States. This shows the proliferation of natural gas as the primary fuel source in the state and the slow decline of coal-fired generation.

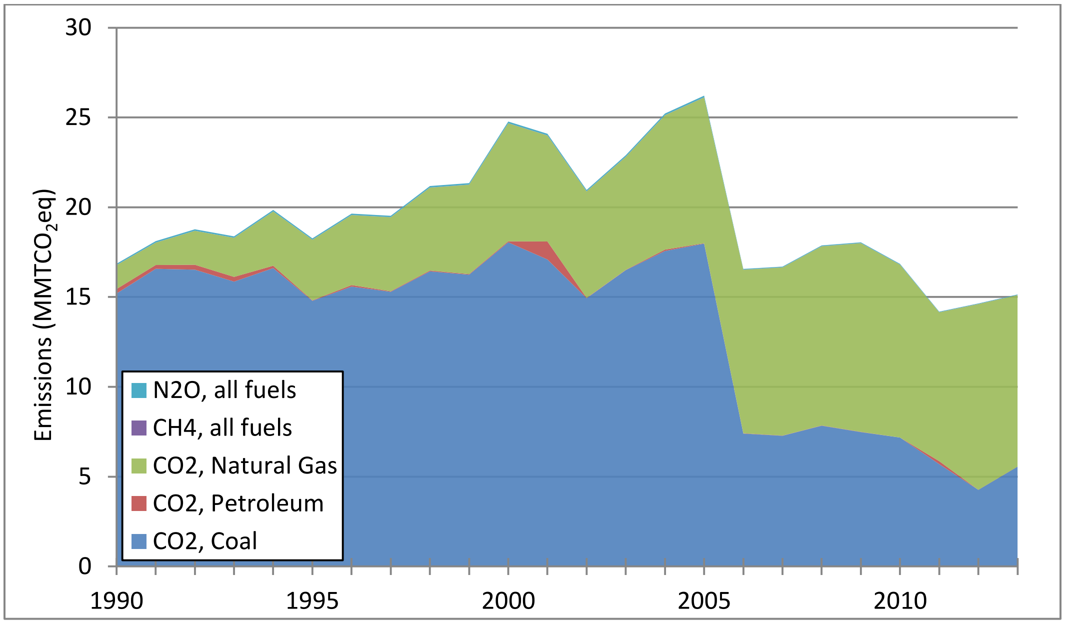
Table 3-1: Electricity Generation Sector Historical Emissions, MMTCO$_2$eq

	1990	1995	2000	2005	2010	2011	2012	2013
Total CO_2, all fuels	16.777	18.190	24.673	26.114	16.801	14.152	14.611	15.107
Coal	15.198	14.792	18.049	17.977	7.180	5.699	4.268	5.559
Petroleum	0.249	0.024	0.054	0.019	0.000	0.167	0.000	0.000
Natural Gas	1.331	3.374	6.569	8.118	9.621	8.286	10.343	9.548
Total CH_4, all fuels	0.005	0.005	0.008	0.008	0.007	0.005	0.006	0.006
Total N_2O, all fuels	0.073	0.072	0.087	0.091	0.039	0.031	0.027	0.031
Total Emissions	**16.855**	**18.267**	**24.771**	**26.213**	**16.858**	**14.190**	**14.665**	**15.144**

Figure 3-1 illustrates historical electricity generation sector emissions in the state from 1990 to 2013. Very large changes to the state's emissions often have to do with the opening or closing of a plant (for example 2005 versus 2006 emissions and the closure of the Mohave Generating Station). The short term changes to emissions, or those that generally happen on an annual basis, have far more to do with things like the weather and the economy. An especially hot summer could mean hundreds of thousands of A/C units being used when they otherwise wouldn't and power plants would need to be utilized to meet that demand and thus emissions increase.

[15] The Mohave Generating Station was a 1,580 MW coal-fired power plant in Nevada that was retired in 2005.

Figure 3-1: Electricity Generation Sector Emissions, 1990 – 2013 ($MMTCO_2eq$)

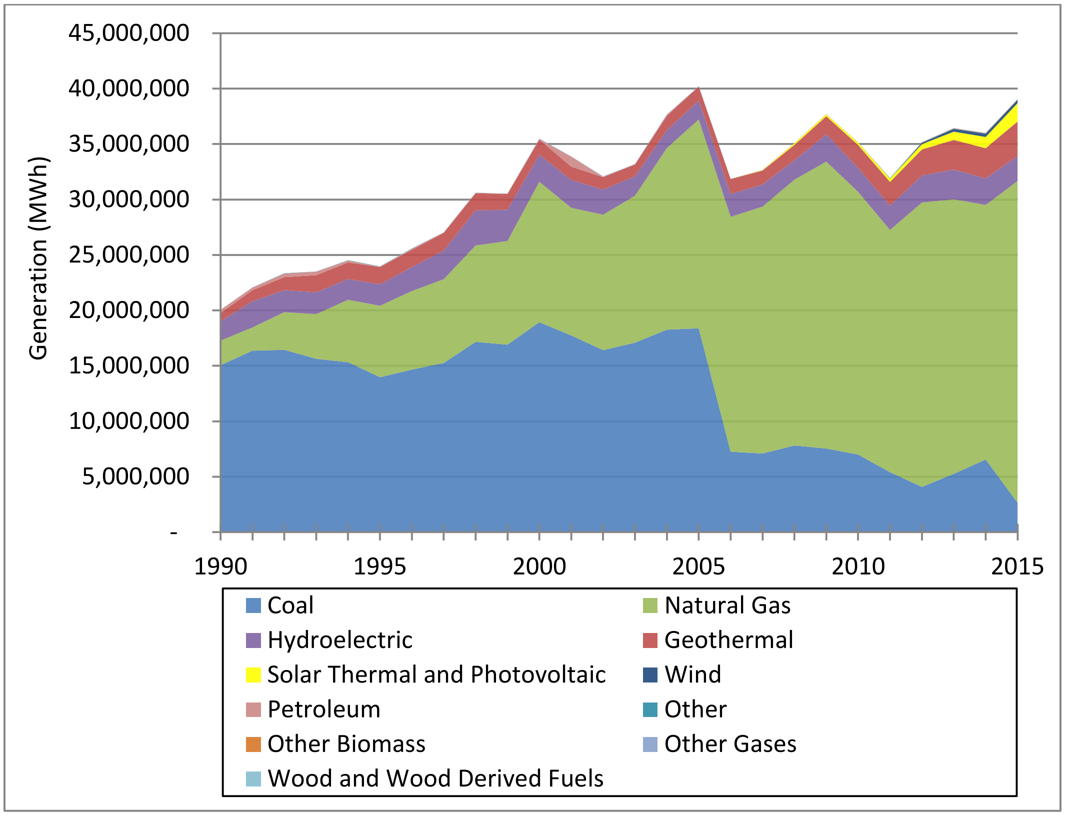


An alternative way to look at Nevada's electricity generation sector is through generation. Figure 3-2 illustrates data provided by the EIA on electricity generation amounts by fuel type in the state from 1990 to 2015.[16] One of the benefits to viewing the sector presented in this way is that all fuel types are considered, not just ones that emit GHGs. The renewable generation of electricity has long been a part of Nevada's diverse generation mixture. The generation of electricity via hydroelectric dams and geothermal deposits has been present prior to 1990 and the recent expansion into solar thermal, solar photovoltaic, and wind show that renewable generation has become a relied upon portion of the state's generation mix. The increasing use of renewable generation is important in mitigating GHG emissions because it means that for every megawatt (MW) of fossil fuel generation that is replaced with renewable generation, or for every MW of renewable capacity that is installed to meet future demand, GHG emissions are being offset.

Nevada currently has three coal-fired power plants in the state. Two of these plants, the Reid Gardner and North Valmy generating stations, have planned and tentative retirement dates prior to 2030, respectively.[17] The third, TS Power Plant owned by the Newmont Mining Corporation, is a 242 MW plant that went into operation in 2008 and overwhelmingly supplies its generation to the Corporation's mining activities. It is likely that this plant will be in operation well past 2030. With the planned retirements of Reid Gardner and North Valmy generating stations NV Energy must replace the generating capacity of these plants to continue to meet consumer demand.

[16] http://www.eia.gov/electricity/data.cfm#generation (accessed October 2016).
[17] The Reid Gardner Generating Station had its first unit come online in 1965 and will see its final unit shutdown at the end of 2017; the North Valmy Generating Station, whose first unit went into operation in 1981, has a tentative retirement planned for 2025.

Figure 3-2: Electricity Generation Sector Generation by Fuel Type, 1990 – 2015 (MWh)



3.3 Projected Emissions

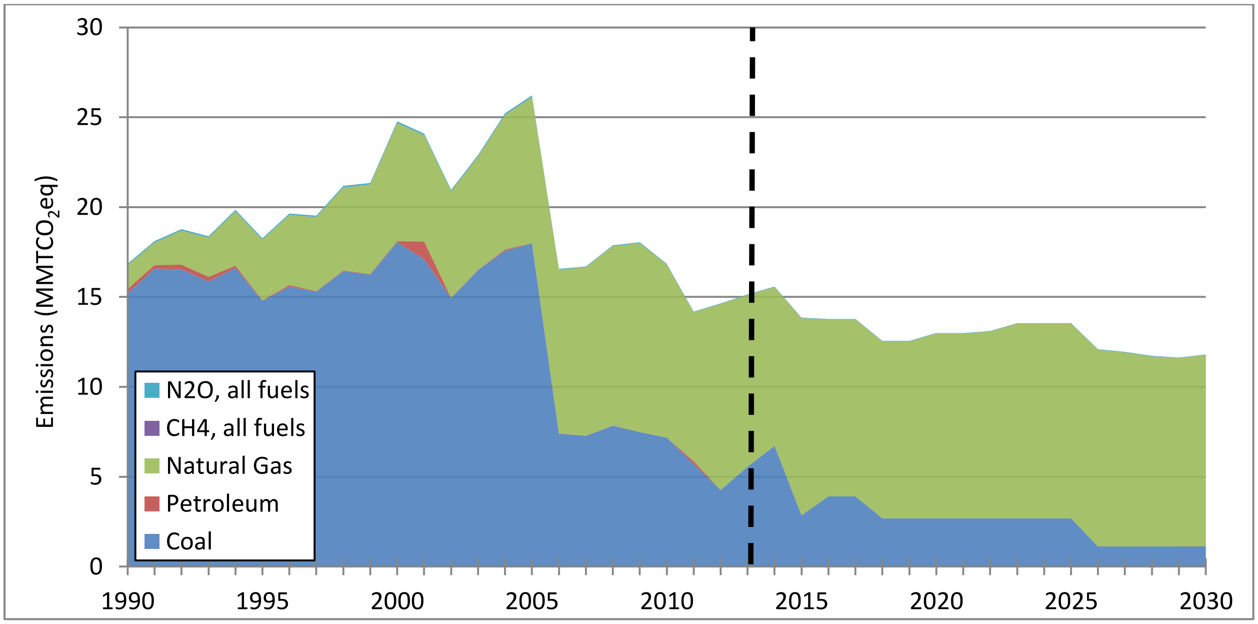
Electricity generation sector emissions are expected to continue to decline in the state. As stated above, with the retirements of the state's aging coal-fired power plants, that coal-fired capacity will need to be replaced and NV Energy has indicated in separate PUCN filings that they intend to do so primarily with natural gas combined cycle (NGCC) facilities.[18] In 2030, sector emissions are projected to be 11.803 $MMTCO_2eq$ and the electricity generation sector will no longer be the primary source of GHG emissions in the state.[19] Figure 3-3 illustrates historical and projected electricity generation sector emissions in Nevada from 1990 to 2030 with the dashed line in the figure showing where historical emissions end and projected emissions begin. NV Energy's filings to the PUCN indicate, under a business-as-usual case, when they are expecting to put a new unit online and the specific types of units that they are planning to put into use. This information is used with estimates of the new unit's average usage to project

[18] NV Energy indicated that the Reid Gardner Generating Station's generating capacity would be replaced with NGCC capacity in Volume 12 of NPC's 2016-2035 Integrated Resource Plan (PUCN docket #15-07004) and they indicated that North Valmy's capacity would be replaced with a NGCC unit in Volume 10 of its SPPC's 2017-2036 Integrated Resource Plan (PUCN docket #16-07001).

[19] The transportation sector is projected to overtake the electricity generation sector in terms of emissions as early as 2015.

emissions.[20] Emissions from existing units are estimated using averages of past emissions. One of the problems with estimating emissions in this way is that a unit that has historically been underutilized has the possibility of being used to capacity in the future to meet demand, which may result in underestimated emissions.

Figure 3-3: Historical and Projected Electricity Generation Sector Emissions, 1990 – 2030 (MMTCO$_2$eq)



[20] While it is reasonable to assume that that some of the needed capacity from the retiring base-load coal-fired facilities could be replaced with renewable generation, thereby further reducing the state's GHG emissions, the business-as-usual cases presented by NV Energy do not make that assumption so it is not assumed here.

4. Transportation

4.1 Overview

The transportation sector has been and continues to be a significant source of GHG emissions in the state, second only to the electricity generation sector (Section 3). However, with the continued shutdown of coal-fired electric generating units across the state and the adoption of natural gas and renewable energy generation (e.g., solar, wind, and geothermal), the transportation sector is projected to exceed the electricity generation sector in terms of emissions as early as 2015 and will become the largest source of GHG emissions in the state.

Historical and projected emissions for the transportation sector were calculated based on the SIT. The GHGs calculated in this sector are CO_2, CH_4, and N_2O. CO_2 emissions from vehicles are considered to be relatively easy to estimate as they are the result of fossil fuel combustion and can be directly related to the type of fossil fuel and the amount combusted. CH_4 and N_2O emissions from gasoline and diesel-powered vehicles are the result of complex combustion dynamics that, while dependent on many factors like installed vehicle technologies, air-to-fuel ratio, temperature, and other characteristics, can only be estimated to a degree of certainty. Emissions from alternative fuel vehicles are also considered.

In estimating CO_2 emissions, the SIT depends on information from the EIA-SEDS to perform its calculations. The EIA–SEDS provides fuel consumption estimates for the transportation sector at the state level. It does this by calculating fuel consumption on a multi-state, regional level and then distributing the results back to the individual states in the region.[21] When projecting emissions, it takes into consideration the average fuel consumption of recent years in order to get future consumption estimates at a multi-state, regional level before redistributing the results back to the states in the region. In order to estimate CH_4 and N_2O emissions (minor contributors to total sector emissions), the types and conditions of vehicles, vehicle fuel types, and vehicle miles of travel (VMT), each in a given year, are needed. CH_4 and N_2O emissions are estimated by disaggregating said data into different vehicle categories and classes of age (using national averages) and applying emissions factors for various vehicle attributes. The SIT provides estimates for all of the needed data and provides opportunities for states to replace the data when and if they have more refined estimates (typically generated by state/local entities) they would prefer to use.

4.2 Historical Emissions

Historical emissions from the transportation sector peaked in 2007 at 18.508 $MMTCO_2eq$ and this appears to have been due to the economic recession. In 2013, emissions were estimated to be 14.492 $MMTCO_2eq$. Figure 4-1 illustrates total sector emissions compared to VMT and also compared to Nevada's population. Figure 4-1 clearly depicts a breakdown in the correlation that at one point existed between these datasets and total sector emissions during the recession.

[21] This method can result in under/overestimating emissions as the disaggregations for the original region is based on comparisons of population and GDP amongst the state's in the group.

Figure 4-1: Total Historical Transportation Sector Emissions Compared Against VMT and Nevada State Population, 1990 to 2013

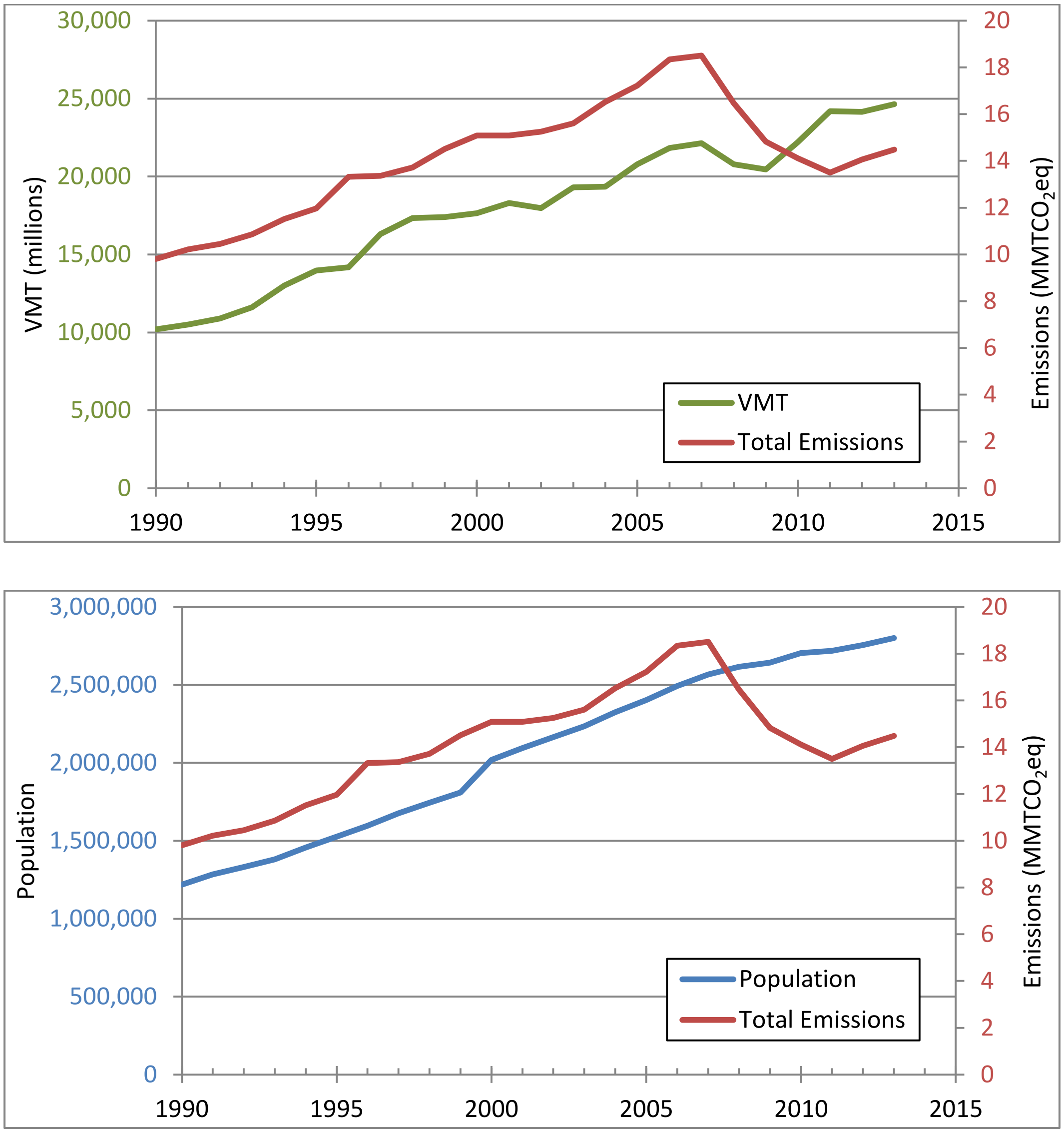
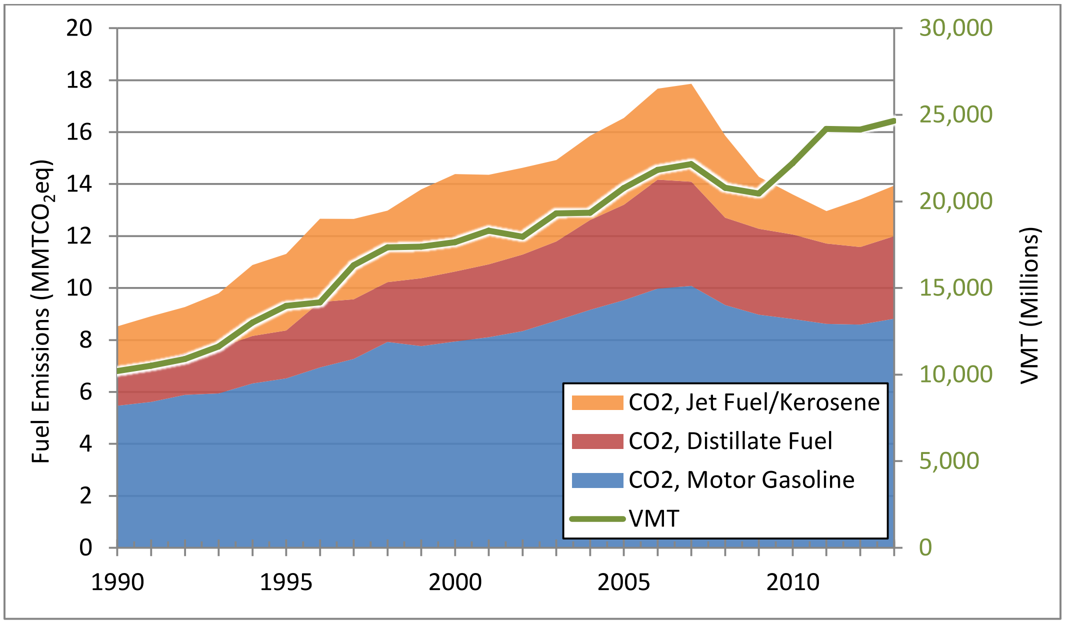


Figure 4-2 illustrates the CO_2 emissions of the three major fuel types as a 2D area affect compared to VMT in the state. Even though all three fuel types show the effects of the recession in terms of reduced emissions, jet fuel/kerosene shows the most pronounced and prolonged retraction in emissions. If you consider that jet fuel/kerosene usage[22] is predominantly associated with air travel, it appears as though the disparity between transportation emissions and VMT that begins with the recession can largely be attributed to air travel in Nevada returning to pre-recession levels at a very different rate than the rest of the fuel use in the sector.

[22] Kerosene is also used to a much lesser extent in diesel powered vehicles (where it is referred to as #1 diesel).

Figure 4-2: Fuel Type CO_2 Emissions Compared to VMT in Nevada, 1990 - 2013



Historical emissions from the transportation sector are listed in Table 4-1. The table shows total sector emissions and total CH_4 and N_2O emissions for select years and it also highlights the emissions from fuels that either make up a very large portion of sector emissions or are used to power AFVs in the state. Diesel powered vehicle fuel emissions come from jet fuel/kerosene (to a much lesser extent) and distillate fuel (which is the majority of diesel vehicle fuel emissions); when used in diesel-powered vehicles these fuels are otherwise referred to as #1 and #2 diesel, respectively. The SIT does not provide for the separation of fuel types in a way to highlight diesel fuel emissions specifically.

Table 4-1: Transportation Sector Historical Emissions, $MMTCO_2eq$

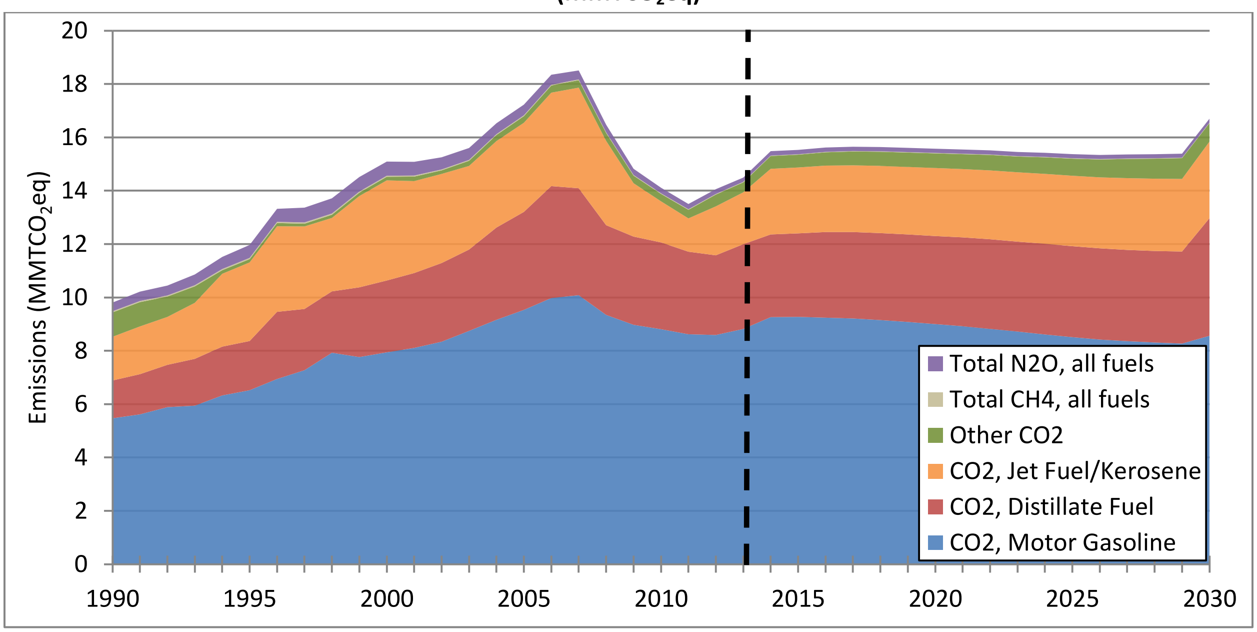
	1990	1995	2000	2005	2010	2011	2012	2013
Total CO_2, all fuels	9.438	11.435	14.521	16.794	13.880	13.282	13.855	14.311
Distillate Fuel	1.418	1.844	2.694	3.674	3.253	3.094	2.987	3.177
Jet Fuel, Kerosene	1.638	2.947	3.753	3.341	1.541	1.249	1.835	1.945
LPG	0.005	0.005	0.000	0.021	0.017	0.014	0.022	0.019
Motor Gasoline	5.468	6.521	7.940	9.531	8.808	8.619	8.591	8.817
Natural Gas	0.043	0.046	0.070	0.149	0.211	0.258	0.376	0.308
Other Fuels	0.866	0.072	0.064	0.078	0.050	0.048	0.044	0.045
Total CH_4, all fuels	0.043	0.047	0.040	0.033	0.023	0.023	0.023	0.022
Total N_2O, all fuels	0.326	0.486	0.530	0.400	0.210	0.197	0.179	0.160
Total Emissions	**9.807**	**11.967**	**15.091**	**17.226**	**14.112**	**13.502**	**14.057**	**14.492**

Despite the increase in VMT since 2009, transportation emissions have been somewhat stable due to a cleaner fleet of motor vehicles statewide. This is the result of the EPA's strengthening of vehicle emissions standards. Beginning in 1996, vehicles not only came equipped with an onboard diagnostics system to self-test for emissions systems failures, but they also faced much more rigorous federal emissions standards. The EPA has continued to strengthen new vehicle emissions standards as well as vehicle fuel standards. As older vehicles "age-out" of the fleet consisting of all on-road vehicles and are replaced with newer models, the fleet will emit less CO_2 per vehicle as a whole and grow cleaner. However, even though the fleet continues to grow cleaner on a per vehicle basis, this is counterbalanced by an increasing number of vehicles on Nevada's highways and higher AVMT, which may contribute to a growth in emissions.

4.3 Projected Emissions

Total sector emissions in 2030 are projected to increase to 16.698 $MMTCO_2eq$, which is still lower than the sector's 2007 high. Figure 4-3 shows the historical and projected emissions estimates from the transportation sector from 1990 to 2030. The dashed vertical line in the figure shows where the historical period ends and the projections begin. The sector will remain largely flat in terms of emissions over the projected period with the overwhelming majority of emissions coming from CO_2 based sources such as motor gasoline, distillate fuel, and jet fuel/kerosene. This stands to reason when considering the advances in vehicle technologies that will likely lead to the automotive industry meeting the EPA's Model Year 2022 to 2025 average 54.5 miles per gallon fuel economy standard. Decreases in fleet-wide fuel consumption will proportionally reduce CO_2 emissions, which will be offset by projected increases to the state's population and subsequent increases in numbers of vehicles and VMT.

Figure 4-3: Historical and Projected Transportation Sector Emissions, 1990 – 2030 ($MMTCO_2eq$)



5. Residential, Commercial, and Industrial

5.1 Overview

This section summarizes the GHG emissions associated with the burning of fuels in the residential, commercial, and industrial sectors. Industrial Process emissions, that is, emissions associated with the transformation of raw materials from one state to another that results in the release of GHGs into the atmosphere, is discussed in Section 6. The GHG emissions accounted for in this sector are CO_2, CH_4, and N_2O. Emissions are generally calculated by applying specific emission factors (expressed in mass of carbon per unit of energy content, e.g. lbs GHG/BTU) and combustion efficiency (expressed in percentages) to the different types of fuels consumed in each sector. Table 5-1 lists the types of fuel consumed by each sub-sector.

Table 5-1: Fuel Types Consumed by Sub-Sector [23, 24]

Fuel Type	Residential	Commercial	Industrial
Coal	Coal	Coal	Other coal
Natural Gas	Natural gas	Natural gas	Natural gas
Petroleum	Distillate fuel Kerosene Liquefied Petroleum Gas (LPG)	Distillate fuel Kerosene LPG Motor gasoline Residual fuel	Distillate fuel Kerosene LPG Motor gasoline Residual fuel Lubricants Asphalt/Road oil Crude oil Feedstocks Still gas Special naphthas Unfinished oils Waxes Aviation gasoline blending components Motor gasoline blending components

The SIT also takes into account that some industrial processes (e.g., road asphalting or synthetic rubber production) consume fossil fuels (e.g., oil or LPG) in a manner that permanently stores that fuel into the final product with no emissions into the atmosphere. The SIT provides emission factors, energy content, combustion efficiencies, and the fractions of permanently stored fuels. Fuel consumption data was provided by the EIA-SEDS.[25]

[23] ICF (2016) *User's Guide for Estimating Direct Carbon Dioxide Emissions from Fossil Fuel Combustion Using the State Inventory Tool*, ICF International, Prepared for U.S. Environmental Protection Agency. February 2016, p 1.6.

[24] Some fuels that are considered by the SIT are not included in this table as there was zero consumption in Nevada over the 1990 to 2013 period.

[25] It is important to note that the way the EIA-SEDS disaggregates fossil-fuel can result in under/overestimates of emissions versus the other states in the original "group". This is due to the methods of redistribution which are largely comparisons of populations and in some cases gross domestic products (GDPs).

5.2 Historical Emissions

Nevada's 2013 residential, commercial, and industrial emissions were estimated to be 6.807 $MMTCO_2eq$. Sector emissions accounted for 15.3 percent of the state's net GHG emissions in 1990 and 17.4 percent 2013. Table 5-2 below lists historical sector emissions by GHG and by sub-sector. Emissions from this sector for 2013 are dominated by CO_2 (more than 99 percent).

Table 5-2: Residential, Commercial, and Industrial Sector Emissions ($MMTCO_2eq$)

	1990	1995	2000	2005	2010	2011	2012	2013
Total CO_2	4.399	5.797	5.907	6.773	6.841	6.001	5.989	6.763
Residential	1.192	1.310	1.835	2.217	2.363	2.393	2.168	2.454
Commercial	1.067	1.432	1.625	1.760	1.823	1.872	1.758	1.930
Industrial	2.140	3.056	2.470	2.796	2.655	1.736	2.064	2.379
Total CH_4	0.029	0.034	0.042	0.030	0.027	0.026	0.025	0.031
Residential	0.021	0.023	0.030	0.019	0.017	0.017	0.016	0.021
Commercial	0.005	0.006	0.008	0.007	0.006	0.006	0.006	0.006
Industrial	0.003	0.005	0.004	0.005	0.004	0.002	0.003	0.004
Total N_2O	0.012	0.016	0.015	0.015	0.013	0.010	0.011	0.013
Residential	0.004	0.004	0.005	0.004	0.003	0.003	0.003	0.004
Commercial	0.001	0.002	0.002	0.002	0.002	0.002	0.001	0.002
Industrial	0.007	0.010	0.007	0.010	0.008	0.005	0.007	0.007
Total Emissions	**4.441**	**5.848**	**5.987**	**6.819**	**6.880**	**6.037**	**6.025**	**6.807**

Figure 5-1 depicts sector emissions from 1990 to 2013. Industrial sub-sector emissions were the major GHG contributor until 2011 when they were surpassed by residential emissions. Figure 5-2 illustrates the relative contributions of each of the sub-sector's GHG emissions from 1990 to 2013. Emissions of CO_2, largely from the combustion of natural gas, were the largest source of emissions in both the residential and commercial sub-sectors while petroleum was the largest source of emissions in the industrial sub-sector.

Figure 5-1: Residential, Commercial, and Industrial Sector Emissions, 1990 – 2013 ($MMTCO_2eq$)

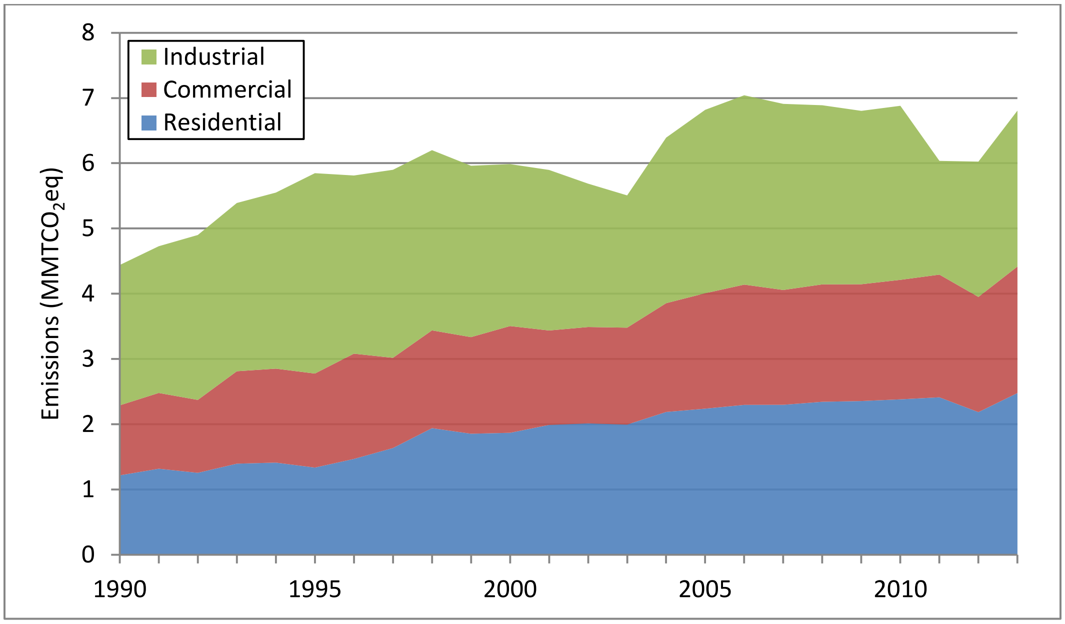
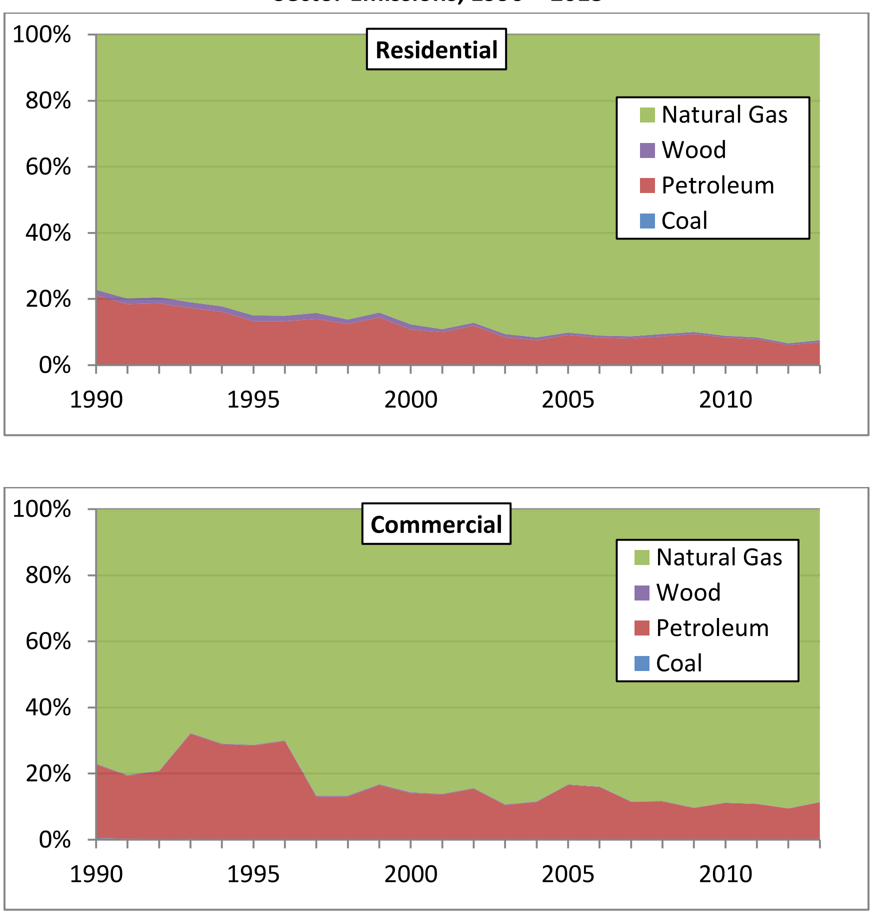
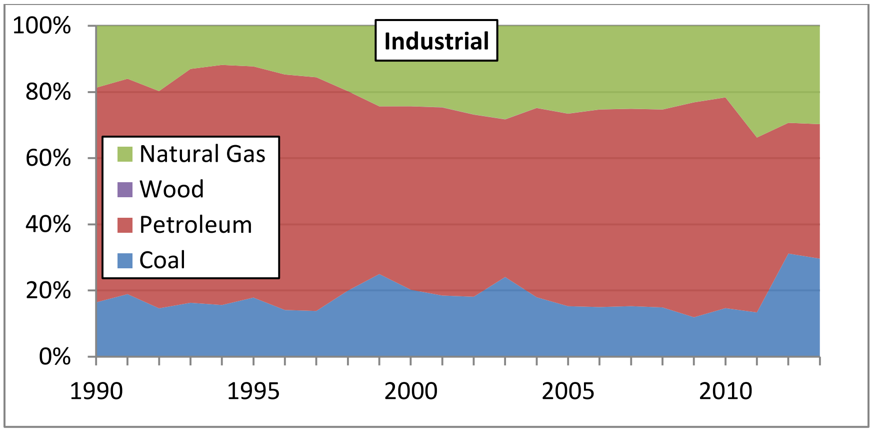


Figure 5-2: Relative Contributions of Residential, Commercial, and Industrial Sub-Sector Emissions, 1990 – 2013

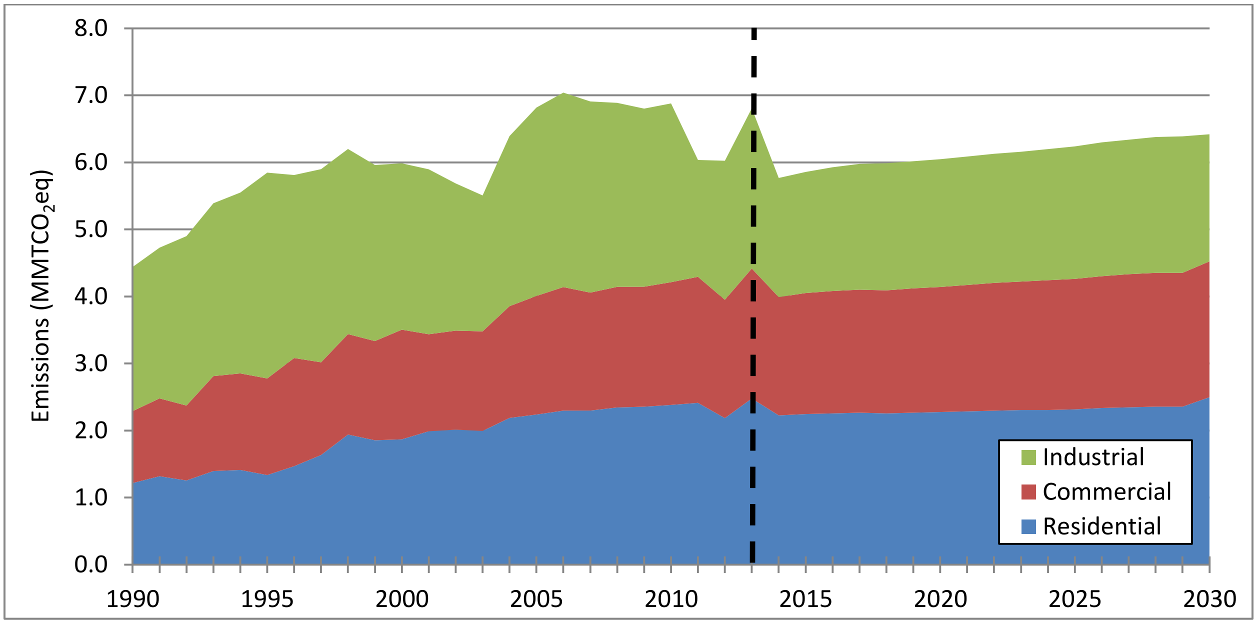




5.3 Projected Emissions

Residential, commercial, and industrial sector emissions projections were calculated using the SIT. Through the utilization of EIA-SEDS fuel consumption projections, the SIT projects GHG emissions. It also utilizes EIA fuel-specific carbon coefficients that are paired with corresponding combustion efficiencies. The one drawback to this approach is that it does all of this in a top-down fashion. That is, the EIA-SEDS (and the SIT projection tool) project fuel consumption on a multi-state "regional" level and disaggregates the results back to the states by comparing the populations and GDPs of the states in the region. The result, in this instance, is to project that Nevada emissions will be immediately reduced by more than 1 MMCO$_2$eq and then not reach 2013 levels again before 2030. Figure 5-3 illustrates the historical and projected emissions estimates from the residential, commercial, and industrial sectors from 1990 to 2030. The dashed vertical line shows where the historical period ends and the projections begin. Once again, the SIP projection tool creates a reduction in emissions that NDEP does not believe is accurate. Unfortunately, there is no better way to estimate future emissions in this sector. The only significant trend in these projections is that sector emissions will continue to rise. Total sector emissions in 2030 are projected to be 6.420 MMTCO$_2$eq which is less than the 2013 estimate of 6.807 MMTCO$_2$eq.

Figure 5-3: Historical and Projected Residential, Commercial, and Industrial Sector Emissions, 1990 – 2030 (MMTCO$_2$eq)



6. Industrial Process

6.1 Overview

This section reports GHG emissions from non-energy related industrial processes in Nevada. In these processes, it is the transformation of raw materials from one state to another that results in the release of GHGs into the atmosphere. The GHGs associated with industrial process related activities that were considered in this report include CO_2, N_2O, Hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulfur hexafluoride (SF_6). Table 6-1 lists the industrial processes that were considered in this report, the associated type of GHG emissions, and a brief description of sources and methodologies used to estimate GHG emissions. Processes that are not present in Nevada or for which no data is available, but are considered in the SIT, are not considered in this report.

Table 6-1: Reported Industrial Processes in Nevada

Activity	Associated GHG emissions	Data Required	Data Source
Cement Manufacture	CO_2	Emission factors and production data for clinker and cement kiln dust	*SIT* *USGS Minerals Yearbook* *Greenhouse Gas Reporting Program*
Lime Manufacture	CO_2	Emission factors and production data for high-calcium lime and for dolomitic lime	*SIT* *USGS Minerals Yearbook* *Greenhouse Gas Reporting Program*
Limestone and Dolomite Use	CO_2	Emission factors and consumption data for limestone, dolomite, and magnesium produced from dolomite	*SIT* *USGS Minerals Yearbook*
Ammonia production & Urea consumption	CO_2	Emission factors and ammonia production and urea consumption data	*SIT*
Soda Ash Consumption	CO_2	Emission factors and consumption data for ash	*SIT* *USGS Minerals Yearbook* *US Census and NV Census*
Nitric Acid Production	N_2O	Emission factor, production data, and percent N_2O Released after pollution control for nitric acid production	*SIT* *NV GHG Emission Inventory (2012)*
Ozone Depleting Substance (ODS) Substitutes	HFC, PFC, SF_6	National emissions, state and U.S. population	*SIT* *US Census and NV Census*
Semiconductor Manufacturing	HFC, PFC, SF_6	National emissions, Economic Census	*SIT*
Electric Power Transmission and Distribution Systems	HFC, PFC, SF_6	Emission factor and national SF_6 consumption data for electric power transmission and distribution. Electricity sales at national and state level	*SIT* *DOE – EIA*

6.2 Historical Emissions

Nevada's 2013 industrial process emissions were estimated to be 3.550 $MMTCO_2eq$. This accounted for 8 percent of the state's gross GHG emissions. Table 6-2 below lists historical industrial process emissions. Emissions have steadily increased since 1990 largely due to the manufacture of Ozone Depleting Substance (ODS) substitutes. According to the EPA's 2016 Inventory of U.S. Greenhouse Gas Emissions and Sinks, "[t]he use and subsequent emissions of HFCs and PFCs as ODS substitutes has been increasing . . . This increase was in large part the result of efforts to phase out CFCs and other ODSs in the United States. In the short term, this trend is expected to continue, and will likely continue over the next decade."[26] There is a large increase in lime and cement manufacturing related emissions between 2009 and 2010 (and going forward). This is due to a change in datasets in these two processes.[27] In 2010, facilities started reporting their GHG emissions directly to the EPA; those emissions are available to the public through the EPA's Greenhouse Gas Reporting Program (GHGRP). Prior to 2010, in this report, cement and lime manufacturing related emissions were estimated using the SIT methodologies.

Table 6-2: Industrial Process Emissions (MMTCO$_2$eq)

Sub-Sector	1990	1995	2000	2005	2009	2010	2011	2012	2013
Total CO_2	1.045	0.936	1.275	1.273	1.162	1.872	2.012	1.981	2.053
Cement Manufacture	0.288	0.270	0.359	0.362	0.216	0.421	0.433	0.397	0.438
Lime Manufacture	0.744	0.621	0.861	0.843	0.902	1.405	1.531	1.539	1.551
Limestone and Dolomite Use	-	0.029	0.036	0.047	0.025	0.027	0.030	0.026	0.045
Soda Ash	0.013	0.016	0.019	0.021	0.018	0.019	0.019	0.018	0.019
Urea Consumption	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total N_2O	-	0.250	0.271	0.253	-	-	-	-	-
Nitric Acid Production	-	0.250	0.271	0.253	-	-	-	-	-
Total HFC, PFC, and SF_6	0.169	0.370	0.753	1.048	1.291	1.358	1.391	1.444	1.497
ODS Substitutes	0.001	0.203	0.632	0.903	1.171	1.262	1.294	1.347	1.400
Semiconductor Manufacturing	-	-	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Electric Power Transmission and Distribution Systems	0.167	0.167	0.120	0.143	0.120	0.096	0.096	0.096	0.096
Total Emissions	**1.214**	**1.556**	**2.298**	**2.573**	**2.453**	**3.230**	**3.403**	**3.425**	**3.550**

Figure 6-1 shows the historical process emissions from 1990 to 2013 and Figure 6-2 shows the relative contributions of the GHGs to this sector's emissions from 1990 to 2013. When looking at lime manufacture, the impact of using the GHGRP's dataset (that is based on directly reported facility emissions) is clearly shown. Also, HFC, PFC, and SF_6 are all highly potent GHGs (see Table 1-1) and as they continue to replace ODSs the emissions associated with this process will continue to rise.

[26] EPA (2016), Op Cit, p 4-97.
[27] This alternative dataset was used as per the SIT methodologies.

Figure 6-1: Industrial Process Emissions, 1990 – 2013 (MMTCO$_2$eq)

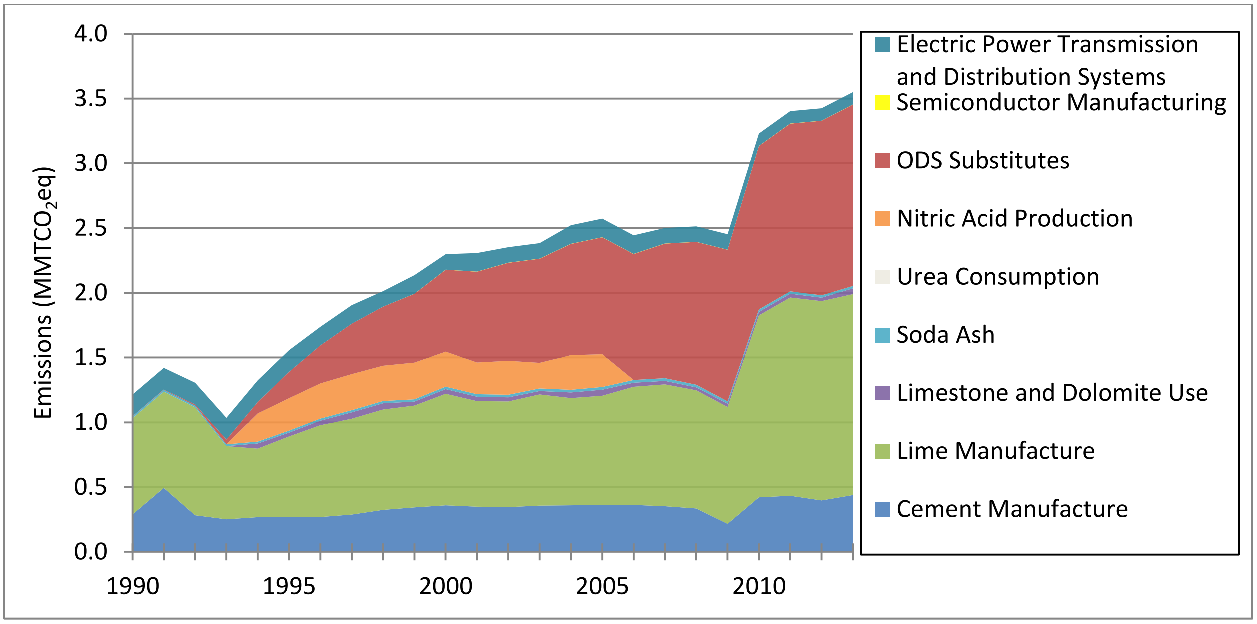
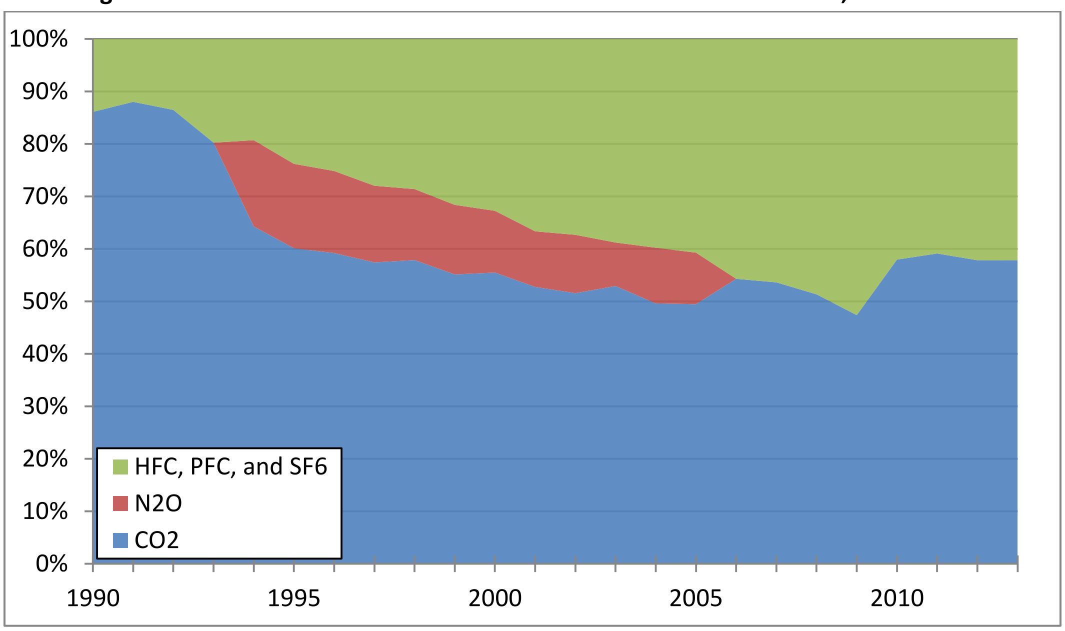


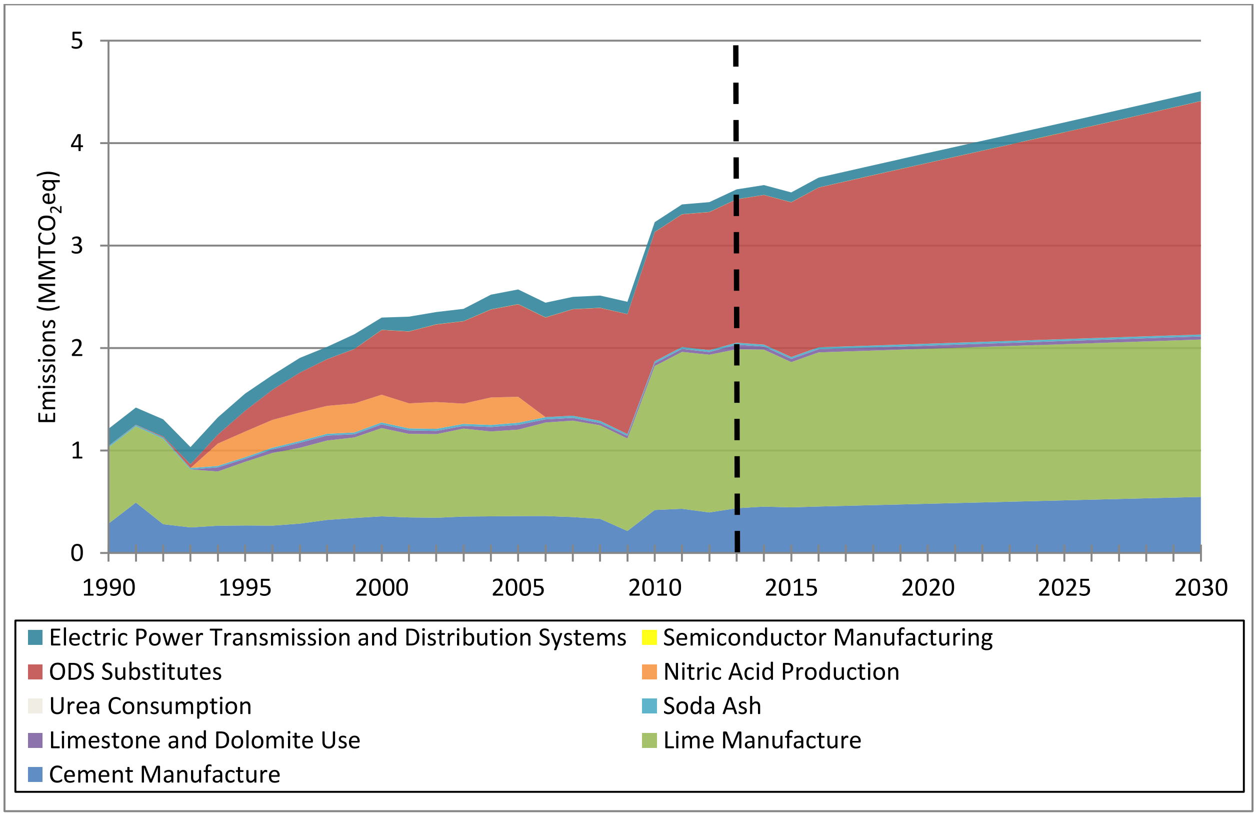
Figure 6-2: Relative Contributions of Industrial Process Related GHGs, 1990 – 2013



6.3 Projected Emissions

The method of projecting emissions from industrial processes differed based on the process, and were conducted as recommended by the SIT. In general, trends from the period 1990-2013 (with a focus in some instances on the years following the recession) were used to project emissions for 2014-2030. In some cases, different and/or alternative approaches were adopted and compared. Figure 6-3 illustrates historical and projected GHG emissions for the industrial process sector; the dashed vertical line marks the end of historical emissions and the beginning of the projections. The first thing that might be noticed in the projections is the rate of increasing ODS substitute emissions. ODS substitute emissions are projected to increase from 1.460 MMtCO2eq in 2013 to 2.277 MMtCO2eq in 2030. Their contribution to total IP GHG emissions will increase from 39.4 percent in 2013 to 50.5 percent in 2030. The next two-largest contributors of GHG emissions are lime and cement manufacture and they have comparatively little growth in the near term. Increases in emissions related to these sectors are largely dependent upon construction of new manufacturing facilities and there simply aren't any that have been announced.

Figure 6-3: Historical and Projected Industrial Process Emissions, 1990 – 2030 ($MMTCO_2eq$)



7. Waste Management

7.1 Overview

Waste management sector GHG emissions are separated into two source categories, solid waste and wastewater treatment. Emissions from solid waste in Nevada are calculated based on waste in landfills. In landfills, CO_2 and CH_4 are produced through the decomposition of organic matter.[28] The decomposition process is relatively complex and long-lived and results in a biogas consisting of roughly equal parts CO_2 and CH_4 by volume. Neither the directly emitted CO_2 nor the converted CO_2 emitted from combusting CH_4 at landfills are counted as anthropogenic GHG emissions. This is because the carbon primarily released by the decomposition of organic materials derived from biomass sources (e.g., food waste and yard trimmings) is an initially sequestered, equivalent amount of carbon (in the form of CO_2) drawn from the atmosphere. While some of Nevada's landfills simply flare recovered landfill gas, thereby converting the CH_4 portion of the biogas into CO_2, the largest of Nevada's landfills collects and burns its biogas to generate electricity in a process known as landfill-gas-to-energy (LFGTE).

Wastewater emissions in Nevada are the result of the treatment of municipal and industrial wastewater. Generally, wastewater is treated by technologies designed to accelerate naturally occurring processes. Aerobic and anaerobic conditions are created, resulting in the release of CH_4 through the decomposition of organic matter in the wastewater and the release of N_2O through the concurrent nitrification and denitrification of the wastewater.

The SIT methodologies were used to estimate GHG emissions. Emissions for solid waste were estimated by using historical EPA landfill estimates[29], data received from the NDEP's Bureau of Waste Management, and the EPA Landfill Methane Outreach Program (LMOP), which was also used in this report to estimate the impacts of landfill flaring and LFGTE projects. Emissions from the treatment of municipal wastewater were estimated using Nevada state population figures. Emission factors and emissions from the treatment of industrial wastewater used in the processing of red meat were provided in the SIT. The sources of the dataset used to estimate waste management sector GHG emissions are summarized in Table 7-1.

Table 7-1: Sources Used to Estimate Waste Management Sector GHG Emissions

Process	Source	Reference
Emission factors	- SIT	
Solid waste totals	- SIT - NDEP Bureau of Waste Management	http://ndep.nv.gov/bwm/index.htm
Landfill flaring and LFGTE projects	- EPA Landfill Methane Outreach Program (LMOP)	https://www.epa.gov/lmop
Wastewater treatment	- SIT	

[28] No municipal solid waste in Nevada undergoes incineration. N_2O is a direct result of waste incineration. Therefore, there are no N_2O emissions associated with solid waste in Nevada.

[29] EPA's landfill estimates are based on waste-in-place (WIP) figures (obtained via a variety of sources including the Landfill Methane Outreach Program (LMOP) and working with local state agencies across the country) redistributed across the years of activity based on Nevada's population statistics.

7.2 Solid Waste

It is estimated that landfill waste continues to emit CH_4 for decades after its initial emplacement. Emission rates from landfills follow a first order decay model, with ever-diminishing levels of CH_4 being released for decades. Depending on the climate, the rate of decay of the organic matter in landfills can change (arid climates such as Nevada's means landfill waste takes longer to decay). Therefore, in order to calculate annual emissions from landfills it is not only important to estimate the current waste in place (WIP), (i.e., the amount of waste since the beginning of landfill activity), but also the relative amount of waste that has been historically emplaced on an annual basis.

Landfill waste in this report is divided into two categories, municipal solid waste (MSW) and industrial landfill waste. MSW is solid waste that originates from residential, commercial, and institutional sources. Industrial waste is non-hazardous solid waste generated at industrial plants and construction sites, and from demolition debris. MSW and industrial waste are stored in the same landfills in Nevada but are assumed to have different organic fractions; that is, the percentage of organic matter in their waste that will decompose to form CO_2 and CH_4. The EPA assumes that MSW has a 65 percent organic fraction and that industrial waste has an 11 percent organic fraction.[30] These assumed organic fractions are then applied to Nevada's ratio of MSW to industrial waste (Nevada's ratio is assumed to be different from the national average) and the CH_4 producing capacity of Nevada's industrial landfill waste can be calculated.[31]

7.2.1 Historical Emissions

Nevada's solid waste emissions in 2013 were 1.449 MMTCO_2eq. This represented roughly 4 percent of the state's gross CO_2eq emissions. Solid waste emissions peaked in 2011 at 1.915 MMTCO_2eq. That emissions peaked is due to the installation of gas-recovery systems. The installation of gas-recovery systems in Nevada did not occur until the late 1990s (the first landfill flaring activity began in 1998 and the first LFGTE project began operating in 2012). The installation of this equipment significantly reduces the GWP of Nevada's landfills as it effectively converts the CH_4 fraction of the landfill's emissions into CO_2.[32] Table 7-2 lists historical solid waste emissions estimates. Figure 7-1 shows the historical emissions from 1990 to 2013; in the figure actual emissions are solid and avoided emissions from gas-recovery systems are the dashed areas at the top of the figure.

[30] EPA (1993) *Anthropogenic Methane Emissions in the United States, Estimates for 1990: Report to Congress*, U.S. Environmental Protection Agency, Office of Air and Radiation. Washington, D.C. EPA/430-R-93-003. April 1993, 4-19.

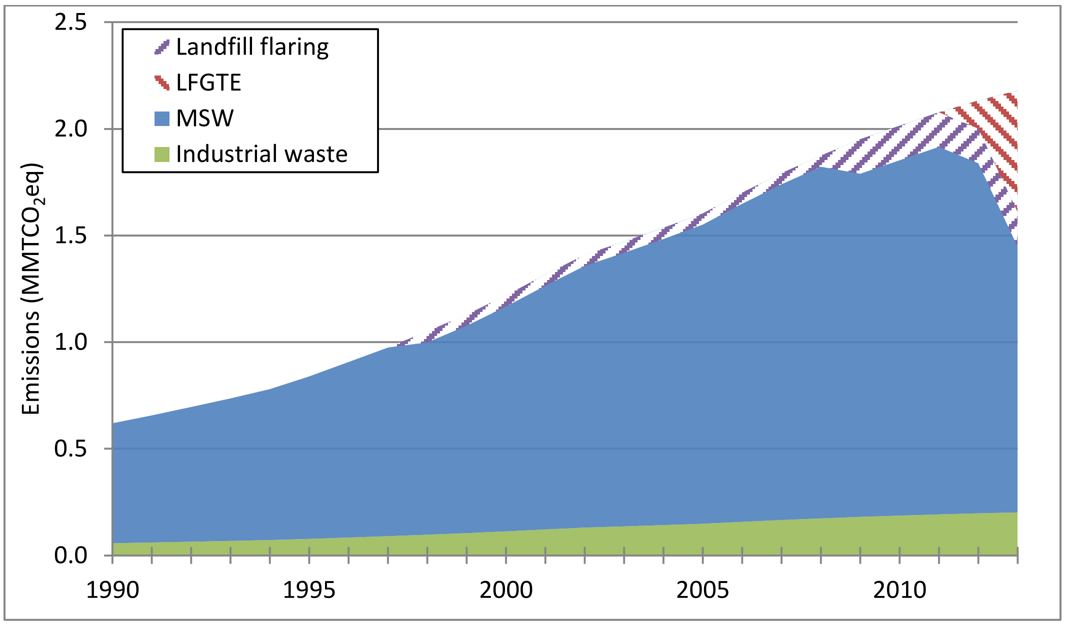
[31] The assumed CH_4 producing capacity of industrial landfill waste as a percentage of the CH_4 producing capacity of the MSW nationally is 7 percent. This report assumes Nevada's producing capacity is 10.22 percent.

[32] Note that the 100 year GWP of CH_4 is 25 times greater than that of CO_2.

Table 7-2: Nevada Solid Waste Emissions ($MMTCO_2eq$)

Sub-Sector	1990	1995	2000	2005	2010	2011	2012	2013
Waste Emissions	0.620	0.840	1.219	1.603	2.015	2.078	2.133	2.180
MSW	0.562	0.762	1.106	1.455	1.828	1.885	1.935	1.978
Industrial Waste	0.057	0.078	0.113	0.149	0.187	0.193	0.198	0.202
Avoided emissions	-	-	-0.052	-0.052	-0.163	-0.163	-0.294	-0.731
Landfill Flaring	-	-	-0.052	-0.052	-0.163	-0.163	-0.163	-0.163
LFGTE	-	-	-	-	-	-	-0.131	-0.569
Total Emissions	**0.620**	**0.840**	**1.167**	**1.551**	**1.852**	**1.915**	**1.839**	**1.449**

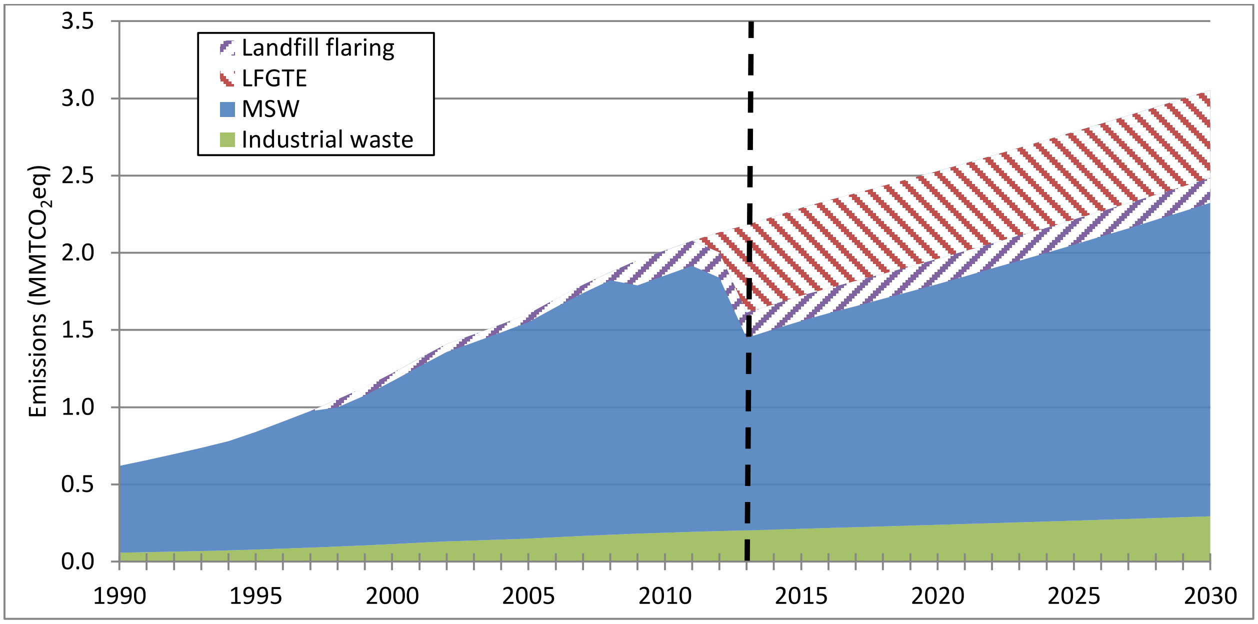
Figure 7-1: Solid Waste Emissions, 1990 – 2013 ($MMTCO_2eq$)



7.2.2 Projected Emissions

Emissions from solid waste are expected to grow through 2030 with the previous 2012 peak being surpassed in 2022. This is because waste is tied to changes in population. As Nevada's population increases, so too will its solid waste. Projections of solid waste have been traditionally tied directly to changes in Nevada's population; that is, when the population increases by a particular percent, there is an equal increase in waste disposed. One of the problems with this method is that it fails to consider changes in recycling efforts, gas-recovery systems, and other changes relating to how people manage their waste and how waste is treated once it gets to the landfill. Because of this, projected emissions in this report are based on forecasted post-recession WIP figures. In this estimate, projections for solid waste emissions do not include increases to landfill gas-recovery systems as none have been formally announced and data in regards to the scaling of existing systems was unavailable. Figure 7-2 shows the historical emissions and a projection of solid waste emissions; actual emissions are solid and avoided emissions from gas-recovery are the dashed areas at the top of the figure. The vertical dashed line marks the end of historical emissions and the beginning of the projections.

Figure 7-2: Historical and Projected Solid Waste Emissions, 1990 – 2030 ($MMTCO_2eq$)



7.3 Wastewater

The disposal and treatment of municipal and industrial wastewater results in the emission of CH_4 and N_2O. The amount of CH_4 produced depends on the organic content (or loading) of the water (expressed in terms of biochemical oxygen demand); wastewater with a high biochemical oxygen demand (BOD) will emit more CH_4. Emissions of N_2O depend on the nitrogen content of the wastewater, which is itself dependent on the consumption of dietary proteins in the population.

7.3.1 Historical Emissions

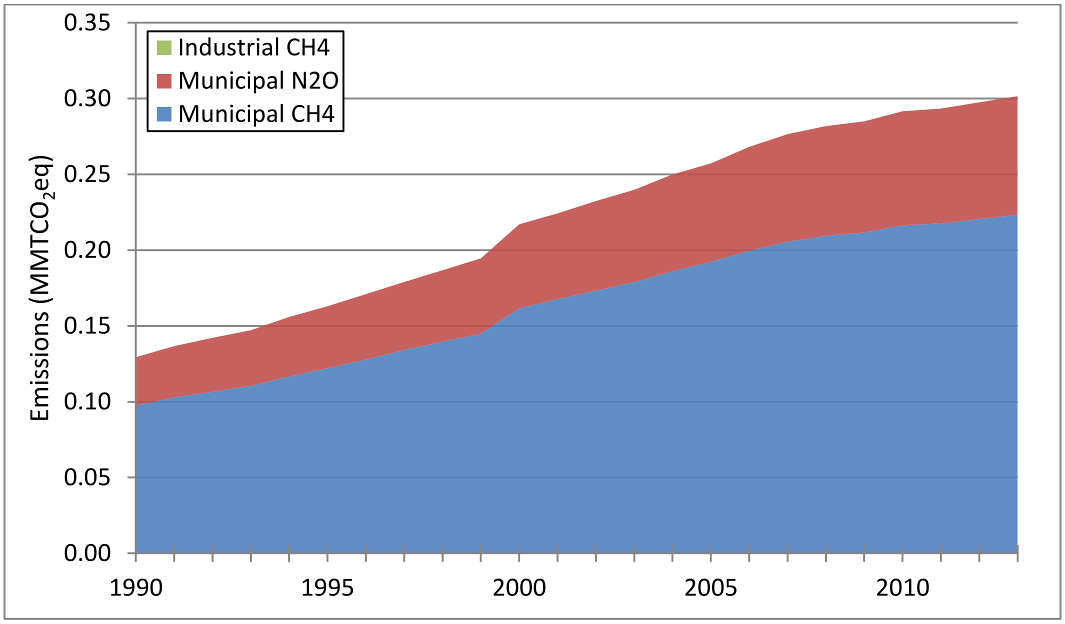
Wastewater emissions in Nevada are a minute source of the state's total GHG emissions. Nevada's total wastewater emissions in 2013 were 0.302 $MMTCO_2eq$. Because wastewater emissions are in general tied to population, every year that the state's population increases the emissions associated with the treatment of wastewater will likely also increase. Table 7-3 lists historical wastewater emissions and Figure 7-3 shows the historical emissions from 1990 to 2013. Note that the emissions associated with the treatment of industrial wastewater are negligible.[33]

Table 7-3: Nevada Wastewater Emissions ($MMTCO_2eq$)

Sub-Sector	1990	1995	2000	2005	2010	2011	2012	2013
Municipal Wastewater Treatment	0.129	0.163	0.217	0.257	0.292	0.293	0.298	0.302
CH_4 Emissions	0.098	0.122	0.162	0.192	0.216	0.218	0.221	0.223
N_2O Emissions	0.032	0.041	0.055	0.065	0.075	0.076	0.077	0.078
Industrial CH_4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total Emissions	**0.129**	**0.163**	**0.217**	**0.257**	**0.292**	**0.293**	**0.298**	**0.302**

[33] In Nevada, industrial wastewater emissions are the result of the processing of red meat.

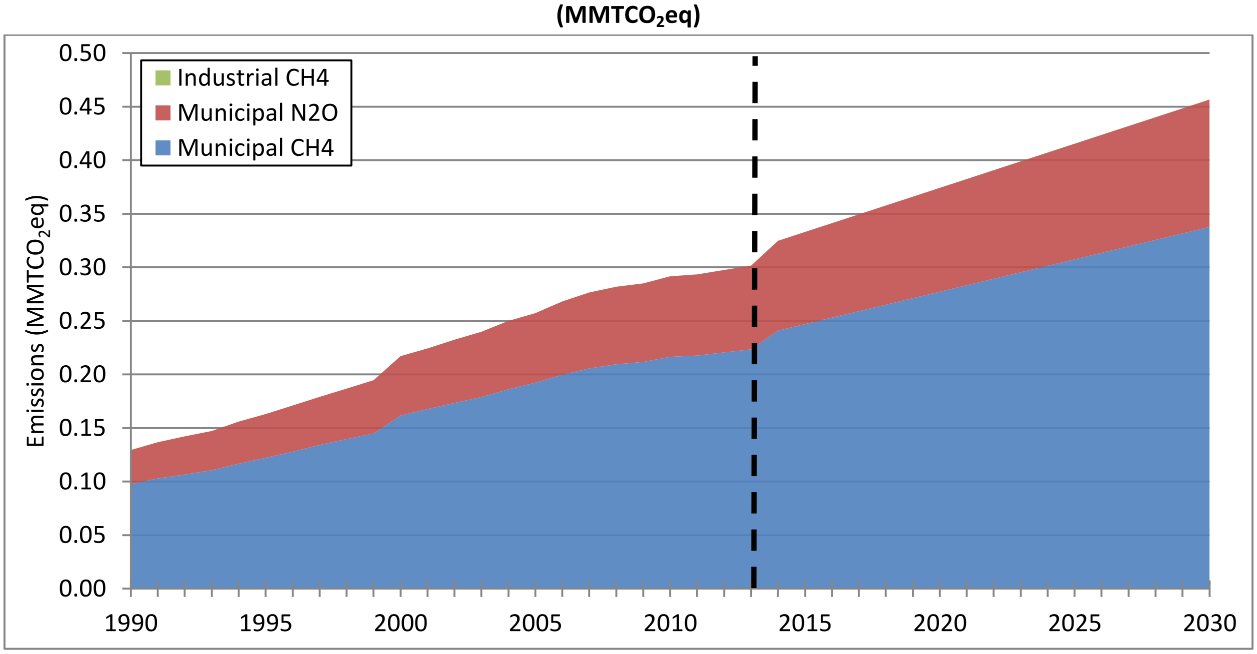
Figure 7-3: Wastewater Emissions, 1990 – 2013 (MMTCO$_2$eq)



7.3.2 Projected Emissions

Emissions from wastewater treatment were projected by forecasting the linear trend from the 1990 to 2013 historical period, as recommended by the SIT. Emissions from the treatment of wastewater are predicted to account for less than 20 percent of total waste management emissions without any significant change in their contribution for the period 2014 to 2030. Figure 7-4 shows the historical and projected wastewater treatment emissions; the vertical dashed line marks the end of the historical emissions and the beginning of the projections.

Figure 7-4: Historical and Projected Wastewater Treatment Emissions, 1990 – 2030 (MMTCO$_2$eq)



8. Agricultural Sector Emissions

8.1 Overview

This section reports CH_4 and N_2O emissions from agricultural activities in Nevada. Several processes are considered in the agricultural sector, but in this report they are generally categorized as enteric fermentation, management of livestock manure, management of agricultural soils, and agricultural residue burning. Enteric fermentation produces CH_4 and is a natural product of animal digestion; ruminants (four-stomached mammals such as cattle, sheep, and goats) are particularly high CH_4 emitters because of their unique digestive process. Livestock manure (i.e., animal waste) produces both CH_4 and N_2O during the manure's natural decomposition process. Agricultural soils emissions are the result of the release of N_2O. This occurs through three main pathways; 1, direct emissions due to the harvesting of plants; 2, direct and indirect emissions from fertilizer application; and 3, direct and indirect emissions due to animal waste in pastures, ranges, and paddocks. Finally, agricultural residue burning emissions (both CH_4 and N_2O) are the result of burning crop wastes.[34]

Depending on their source, emissions associated with energy production for use in the agricultural sector are split between Section 3: Electricity Generation and Section 5: Residential, Commercial, and Industrial Sectors. Emissions from the combustion of fossil fuels used in agricultural equipment are included in Section 4: Transportation. The SIT methodologies were used to estimate GHG emissions. Emissions were estimated by relating estimated livestock populations, crop production, and fertilizer use with process specific emission factors. The sources of the dataset used to estimate agricultural sector GHG emissions are summarized in Table 8-1.

Table 8-1: Sources Used to Estimate Agricultural Sector GHG Emissions

Process	Source	Reference
Emission factors	- SIT	
Livestock population data	- National Agriculture Statistics Service of the USDA	https://www.nass.usda.gov/Quick_Stats/
Crop production data	- National Agriculture Statistics Service of the USDA	https://www.nass.usda.gov/Quick_Stats/
Fertilizer use data	- The Association of American Plant Food Control Officials (AAPFCO) via the SIT	http://www.aapfco.org/

8.2 Historical Emissions

Nevada's agricultural sector is a minor source of the state's GHG emissions. Historical agricultural emissions peaked in 2001 with 1.702 $MMTCO_2eq$ and this is due largely to emissions from enteric fermentation also peaking in 2001; sector emissions have been in slow decline since. Table 8-2 shows the agricultural sector emissions broken down by sub-sector. Total 2013 agricultural sector emissions were estimated to be 1.436 $MMTCO_2eq$. Overall, emissions from enteric fermentation accounted for roughly 58 percent of total sector emissions; agricultural soil management (including synthetic and

[34] The process of agricultural residue burning releases CO_2 as well as CH_4 and N_2O, but in accordance with international GHG accounting guidelines, the SIT Agriculture module does not include CO_2 emissions from crop residue burning.

organic fertilization, tilling practices and production of nitrogen-fixing crops) accounted for about 27 percent; and manure management accounted for about 14 percent of total emissions in the agriculture sector. While residue burning is practiced in Nevada, emissions from this activity were negligible.

Table 8-2: Nevada Agricultural Sector Emissions ($MMTCO_2eq$)

Sub-Sector	1990	1995	2000	2005	2010	2011	2012	2013
Enteric Fermentation	0.900	0.946	0.970	0.978	0.879	0.891	0.909	0.839
Manure Management	0.126	0.142	0.167	0.169	0.200	0.201	0.208	0.205
Ag Soils	0.457	0.461	0.505	0.489	0.479	0.477	0.446	0.392
Agricultural Residue Burning	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total Emissions	**1.484**	**1.550**	**1.642**	**1.636**	**1.558**	**1.570**	**1.563**	**1.436**

Figure 8-1 shows agriculture sector emissions from 1990 to 2013 highlighting the emissions of each of the above mentioned processes; note that agricultural residue burning emissions are not visible in Figure 8-1 because its contributions are negligible. Figure 8-2 shows the relative contributions of CH_4 and N_2O emissions of the agricultural sector in Nevada. CH_4 is the main gas contributing to agricultural sector GHG emissions and this is because enteric fermentation leads to CH_4 generation.

Figure 8-1: Agricultural Sector Emissions, 1990 – 2013 ($MMTCO_2eq$)

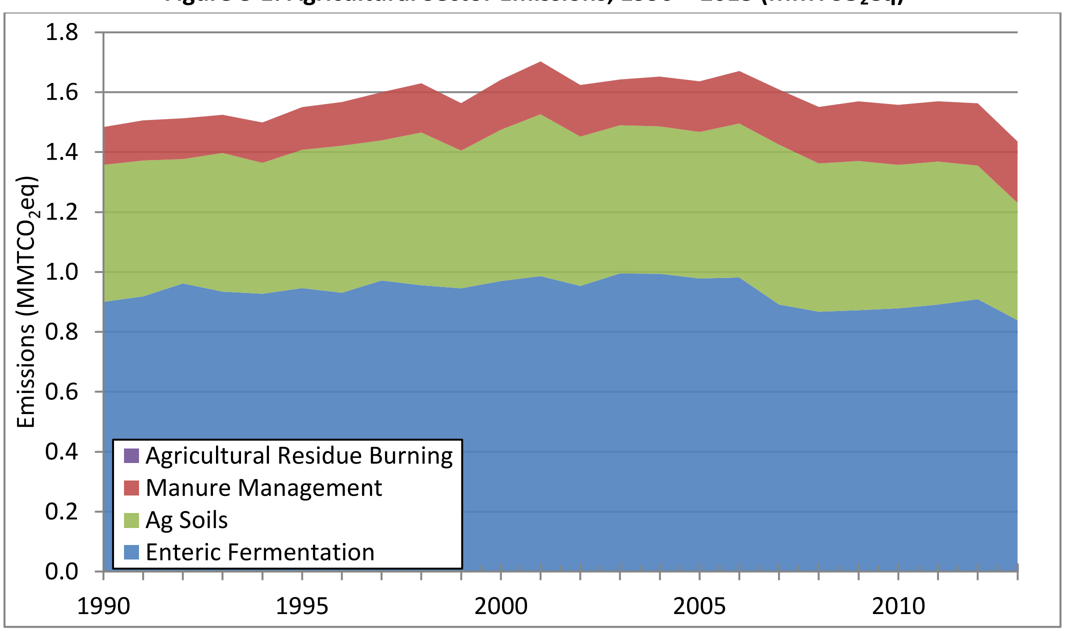
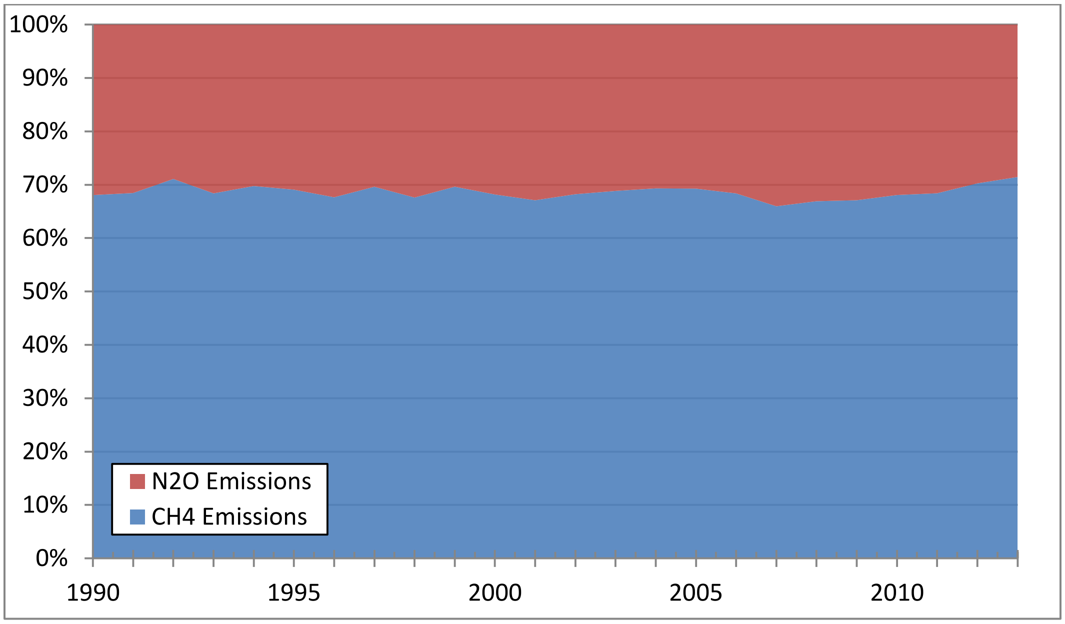


Figure 8-2: Relative Contributions of CH_4 and N_2O of Agricultural Sector Emissions, 1990 – 2013

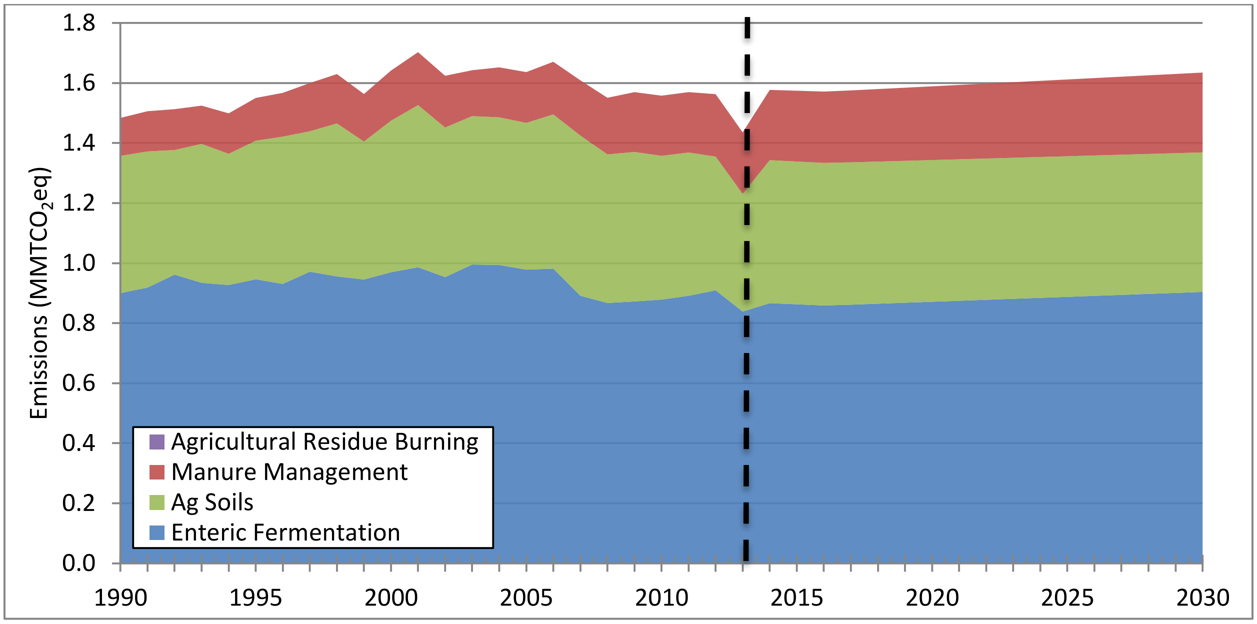


8.3 Projected Emissions

Projected emissions in this sector were based on the assumption that growth in this sector would largely resemble recent historical trends in changes to livestock populations, agricultural soils, and agricultural residue burning. The methods presented in the SIT were applied to forecasted livestock populations in order to estimate emissions. Emissions from both enteric fermentation and manure management are dependent on livestock populations. Forecasted changes to livestock populations based on post-recession totals show that there will be very little growth in Nevada's population of livestock. Forecasting the emissions from the agricultural soils and agricultural residue burning sub-sectors shows similar results. The data from these forecasts show a relatively insignificant source of CO_2 emissions in the state will grow by roughly 12 percent by 2030. This increase equates to less than half of a percent of Nevada's 2030 emissions.

The projections show that total GHG emissions from the agricultural sector will increase by about 200,000 metric tons of CO_2eq in 2030 (versus 2013 figures). Agricultural sector emissions are not projected to surpass the maximum total emissions that this sector achieved in 2001. Overall, these projections show that this sector will continue to be a minor contributor of GHGs in the state. Figure 8-3 shows the historical and projected emissions from the agricultural sector. The vertical dashed line marks the end of historical emissions and the beginning of the projections.

Figure 8-3: Historical and Projected Emissions for the Agricultural Sector, 1990 – 2030 ($MMTCO_2eq$)



9. Fossil Fuel Industry Sector Emissions

9.1 Overview

This section reports CH_4 emissions from all phases of natural gas and oil systems in Nevada.[35] Natural gas emissions are associated with production, transmission, venting, and distribution; oil emissions are associated with production, refining, and transport. Emissions associated with energy production from fossil fuel combustion and energy consumption by these processes are included in Section 3: Electricity Generation and in Section 5: Residential, Commercial, and Industrial. The methodologies in the SIT were used to estimate GHG emissions. The sources of the dataset used to estimate fossil fuel industry GHG emissions are summarized in Table 9-1. In 2013, the most recent year with a full inventory of emissions, fossil fuels industry emissions accounted for 2 percent of gross emissions in the state.

Table 9-1: Sources Used to Estimate Fossil Fuel Industry GHG Emissions

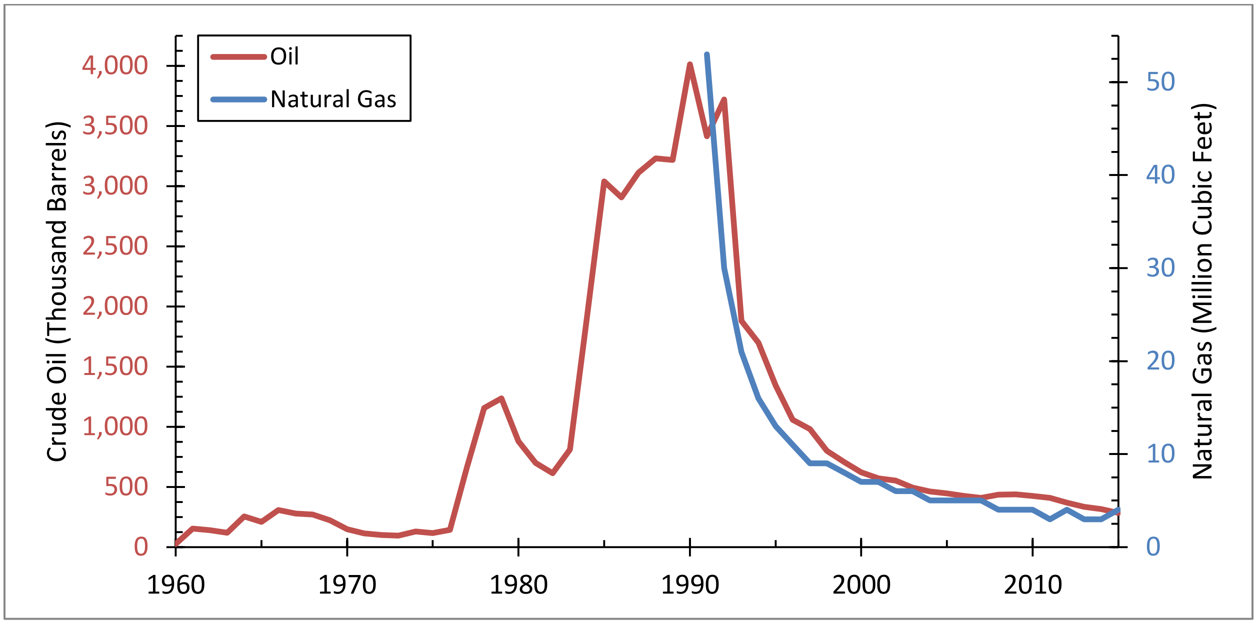
Process	Source	Reference
Emission factors	- SIT	
Natural gas production	- Nevada Oil Patch, a bi-monthly production report published by the State of Nevada Commission on Mineral Resources - US EIA State Energy Data System	http://minerals.nv.gov/Programs/Oil_and_Gas/Forms_Report/ http://www.eia.gov/state/seds/
Natural gas processing	- US EIA	http://www.eia.gov/
Natural gas transmission	- U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) –Annual Reports	http://phmsa.dot.gov/pipeline/library/data-stats
Natural gas distribution	- U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) –Annual Reports	http://phmsa.dot.gov/pipeline/library/data-stats
Oil Production	- Nevada Oil Patch, a bi-monthly production report published by the State of Nevada Commission on Mineral Resources - US EIA State Energy Data System	http://minerals.nv.gov/Programs/Oil_and_Gas/Forms_Report/ http://www.eia.gov/state/seds/
Oil Refined	- US EIA	http://www.eia.gov/dnav/pet/pet_pnp_unc_dcu_r50_a.htm
Oil Transported	Assumed to be equal to oil refined	

9.2 Historical Emissions

Natural gas and oil production in Nevada peaked in the early 1990's. Natural Gas production peaked in 1991, the EIA's first year of recorded commercial production, at 53 million cubic feet. Oil production in Nevada peaked in 1990 when the state produced just more than 4 million barrels which was 0.15 percent of 1990 US production (2.68 billion barrels). From 2011 to 2015 production in the industry has been relatively stagnant with natural gas production averaging roughly 9,300 cubic feet per day and oil production averaging roughly 936 barrels per day. Figure 9-1 below shows historical production of natural gas and oil in Nevada.

[35] Note that there is no coal production in Nevada; its emissions would otherwise be included in this section.

Figure 9-1: EIA Historical Energy Production Estimates for Nevada, 1960 – 2015 [36]



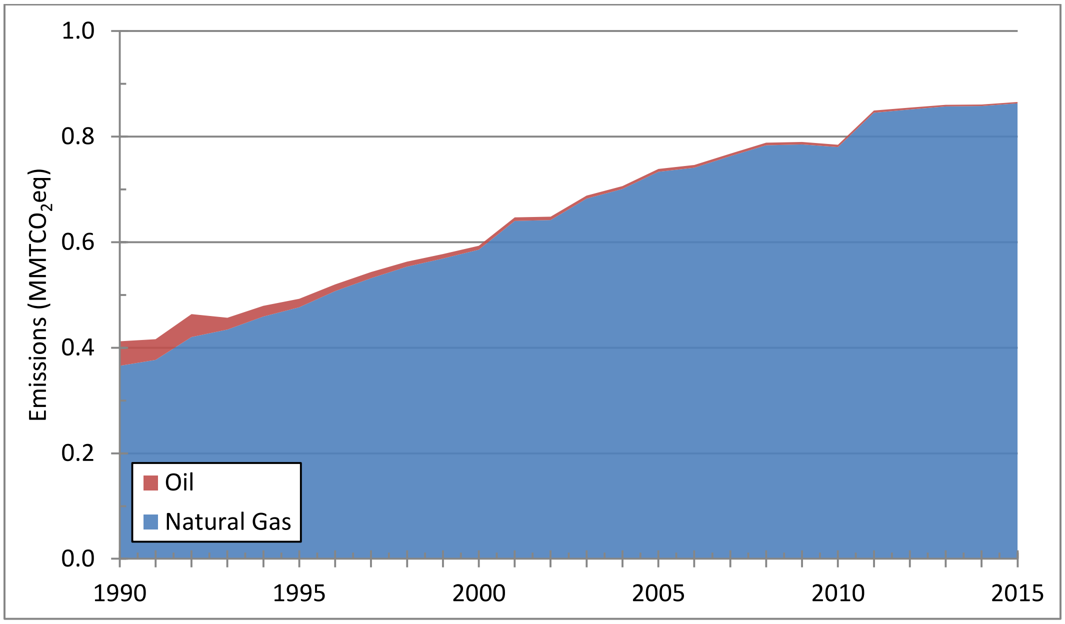
Due to the absence of a coal industry in Nevada and the limited natural gas and oil production that does take place in the state, emissions from production, processing, transmission, and distribution represent a very small fraction of the state's overall GHG emissions. Historically, emissions from the fossil fuel industry have represented less than 2.2 percent of total emissions across all sectors, with the relative contribution of natural gas in the sector increasing from 88.7 percent in 1990 to 99.7 percent in 2015. Table 9-2 shows the fossil fuel industry emissions with natural gas broken down by production, transmission, and distribution. Historical natural gas and oil emissions from 1990 to 2015 are illustrated in Figure 9-2.

Table 9-2: Nevada Fossil Fuel Industry Emissions (MMTCO2eq)

Sub-Sector	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Total Natural Gas	0.366	0.477	0.586	0.733	0.780	0.845	0.851	0.857	0.858	0.863
Production	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.001
Transmission	0.206	0.260	0.287	0.353	0.332	0.393	0.396	0.401	0.400	0.400
Distribution	0.158	0.215	0.298	0.379	0.447	0.451	0.454	0.456	0.457	0.462
Oil	0.046	0.016	0.007	0.005	0.004	0.004	0.004	0.003	0.003	0.003
Total Emissions	**0.412**	**0.493**	**0.593**	**0.739**	**0.785**	**0.849**	**0.855**	**0.860**	**0.861**	**0.866**

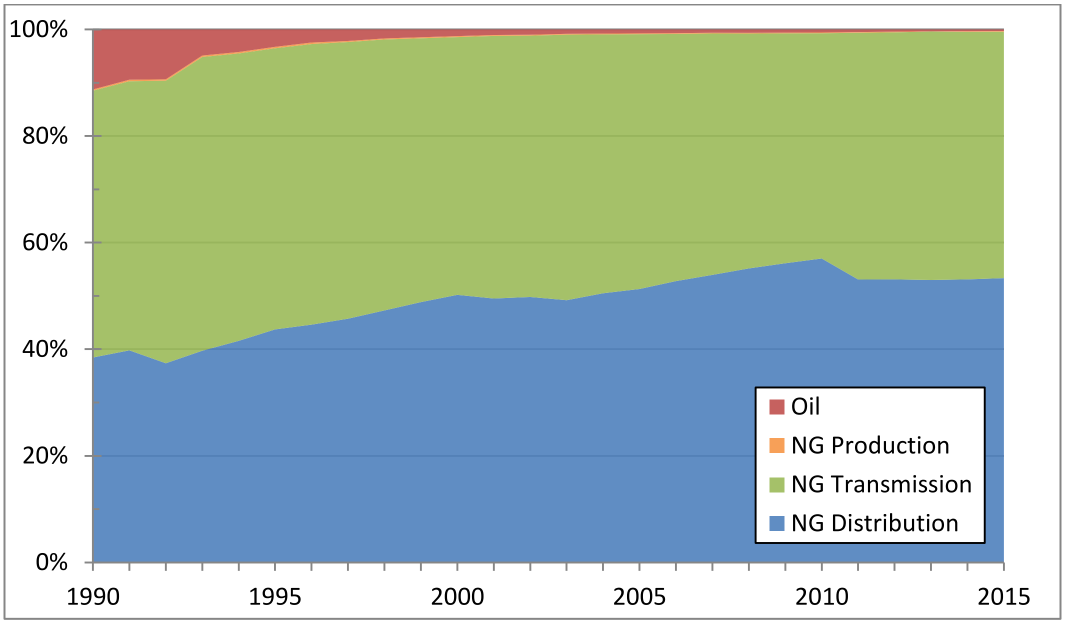
[36] US EIA State Energy Data System, http://www.eia.gov/state/seds/ (accessed September 23, 2016).

Figure 9-2: Nevada Fossil Fuel Industry Emissions, 1990 - 2015 ($MMTCO_2eq$)



Transmission and distribution of natural gas are the major sources of GHG emissions in the sector. This is due largely to the transportation and distribution of natural gas in the state that is not directly related to natural gas produced within the state. Nevada is both a net importer of natural gas (and oil for that matter) and also a "throughway" of natural gas from where it is produced to where it is inevitably used. Figure 9-3 looks at the relative contributions of emissions from the natural gas and oil sub-sectors to highlight just how large a share of the emissions of the fossil fuel industry sector come from the transmission and distribution of natural gas.

Figure 9-3: Relative Contributions of Fossil Fuel Industry Emissions, 1990 – 2015

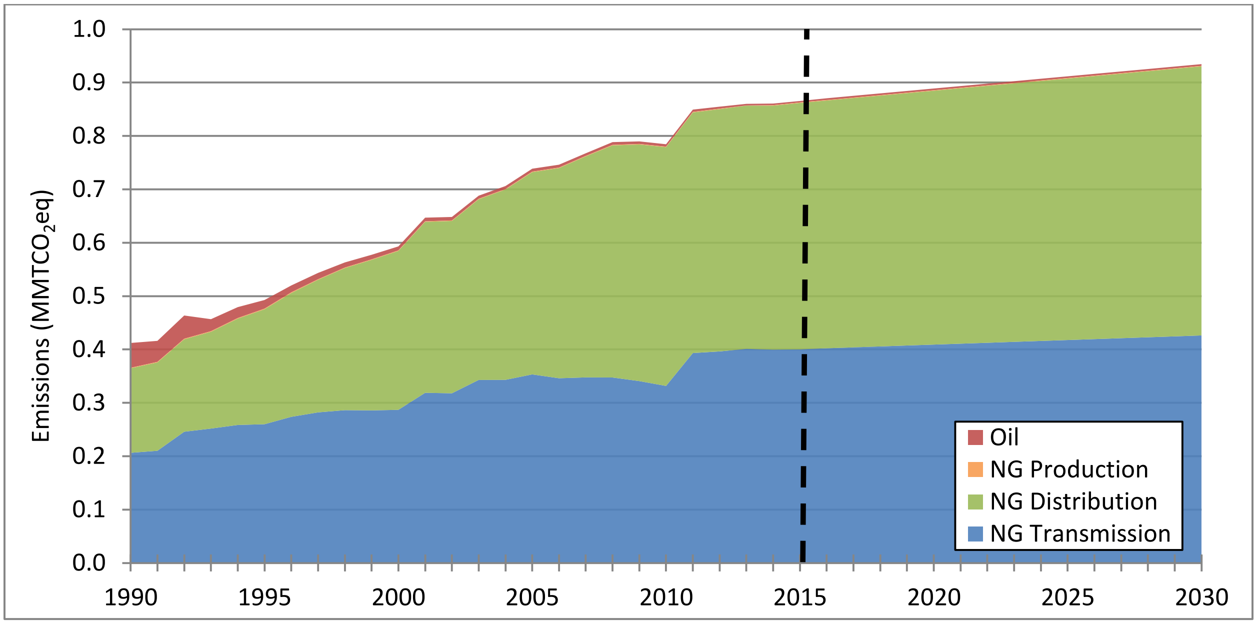


9.3 Projected Emissions

Projected emissions in this sector were based on the assumption that natural gas and oil emissions would not significantly change in Nevada before 2030. The methods presented in the SIT were applied to estimates of changes in the natural gas and oil sectors in order to project emissions through 2030. Emissions from natural gas production were held constant to their 2015 levels; these emissions have largely gone unchanged over the past 20 years and it is not expected that they will significantly change in the next 15 years. Natural gas transmission emissions were based on forecasting growth in the transmission pipeline mileage in the state. Natural gas distribution emissions estimates were calculated based on forecasting growth in the plastic distribution pipeline and an historical average of the protected steel distribution pipeline. Oil production, refining, and transport emissions estimates were held constant to the most recent 5 year historical average (2011 to 2015).

Based on these assumptions, total GHG emissions from the fossil fuel industry will increase by about 75,000 $MTCO_2eq$ by 2030. Overall, these projections show that this sector will continue to be a minor contributor of GHGs in the state. Figure 9-4 illustrates the historical and projected emissions from the fossil fuel industry. The vertical dashed line marks the end of historical emissions and the beginning of the projections.

Figure 9-4: Historical and Projected Emissions for the Fossil Fuel Industry, 1990 – 2030 ($MMTCO_2eq$)



10. Land Use, Land Use Change, and Forestry

10.1 Overview

This section includes GHG emissions from land use, land use change, and forestry activities. Temperate forests in the Northern hemisphere are in general CO_2 sinks, as their net carbon flux balance (i.e., carbon emissions minus carbon sequestration) is negative, hence actively contributing to offset anthropogenic GHG emissions. The strength of these sinks, per unit of area, depends on many factors, such as forest species composition, climate variability, and the occurrence of perturbations like wildfires and diseases. Other natural ecosystem types (e.g., grasslands, shrublands, wetlands) also contribute to the overall carbon flux balance, but the current scientific consensus is that they are, on average, close to carbon neutral. The main approach adopted to estimate carbon (in the form of CO_2) sequestration in forests relies on estimating the magnitude of distinct carbon pools (i.e., the total amount of carbon found in each pool, or stock, such as aboveground biomass, soil, roots, etc.) in the forest ecosystems and their change through time (i.e. the net change of carbon in all pools of a forest, which is equated to carbon flux between the forest ecosystem and the atmosphere, or other compartments of the biosphere). The USDA-Forest Service collects, manages, analyzes and makes available such data through the Forest Inventory and Analysis program (FIA).[37] In this respect, a positive change in overall carbon stocks per unit of area of a forest indicates net carbon uptake (i.e., CO_2) from the atmosphere. However, carbon stocks can change as a result of land use change (i.e., cause an increase or decrease of forested areas), or logging and wildfire events, which both decrease the amount of forest carbon stocks.

Land use and land use change only marginally contribute to GHG emissions in Nevada. Nevertheless, wildfires and prescribed fires (wildland fires) can significantly contribute to the annual carbon balance of the forests and other natural ecosystems. It is important to note that the carbon released by fires in forests and other natural ecosystems is not accounted in the GHG inventory. This is because the loss of carbon from forests is already accounted for by either the carbon-pool inventory approach (in forests), or because it balances an equivalent amount of carbon previously sequestered through photosynthesis (in other natural ecosystems). CH_4 and N_2O are also released during fires and they need to be included in the GHG inventory as emissions.

The SIT provides methodologies and emission factors to estimate net GHG emissions from the forestry sector. Historical data on the areas affected by fires in Nevada were obtained from the National Interagency Fire Center (NIFC).[38]

10.2 Historical Emissions

Forests in Nevada covered approximately 3,100,000 hectares in 2006[39], equivalent to 11% of Nevada's land. Figure 10-1 shows land cover in Nevada, of note is Nevada's largely undeveloped state (nearly 85 percent of the State is federally owned).

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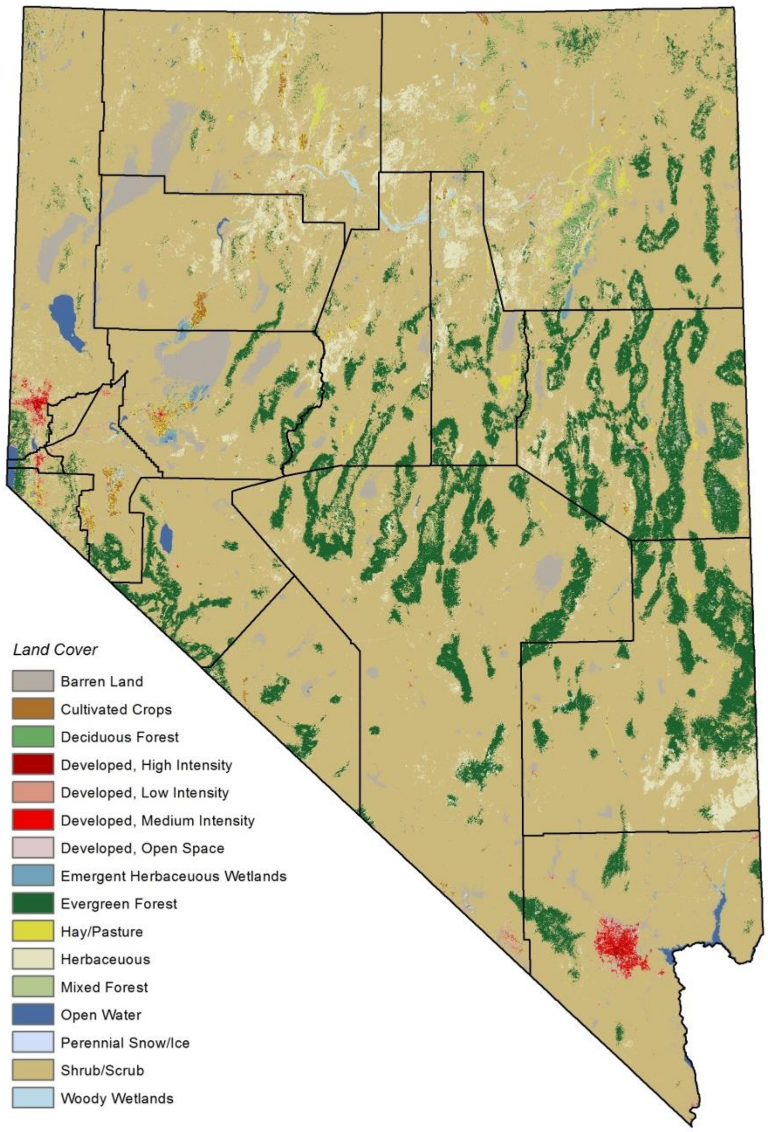
[37] http://www.fia.fs.fed.us/ (accessed September 2016).
[38] http://www.nifc.gov/ (accessed September 2016).

Figure 10-1: Land Cover in Nevada



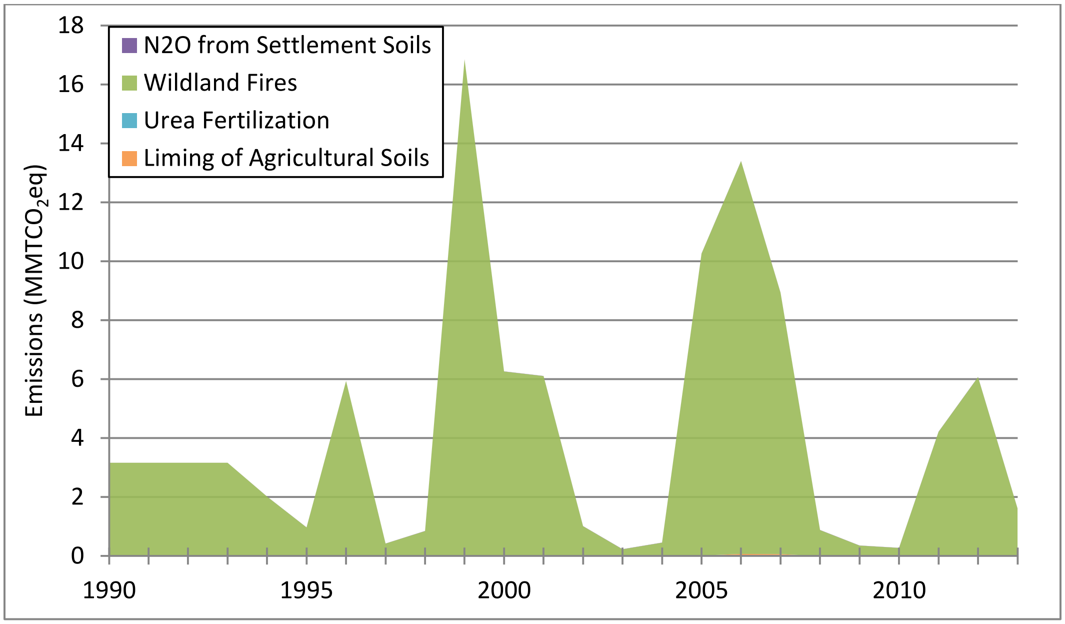
Emissions from wildland fires and CO_2 uptake by forests are the two main factors contributing to total sector emissions. Table 10-1 lists sector emissions as well as CO_2 uptake and wildfire emissions for select years. Forest uptake was relatively constant across the 1990 to 2013 time period, with estimates ranging between 6 and 9 $MMTCO_2eq$ sequestered from the atmosphere every year. Wildfire emissions were extremely variable as they depend entirely on the intensity of the fire season and total acres burned, with emissions ranging from as little as 0.353 $MMTCO_2eq$ in 2009 to 16.853 $MMTCO_2eq$ emitted in 1999. Figure 10-2 shows the relative contributions of land use, land use change, and forestry sub-sector emissions in two separate charts, one showing GHG emissions and the other showing CO_2 sinks.

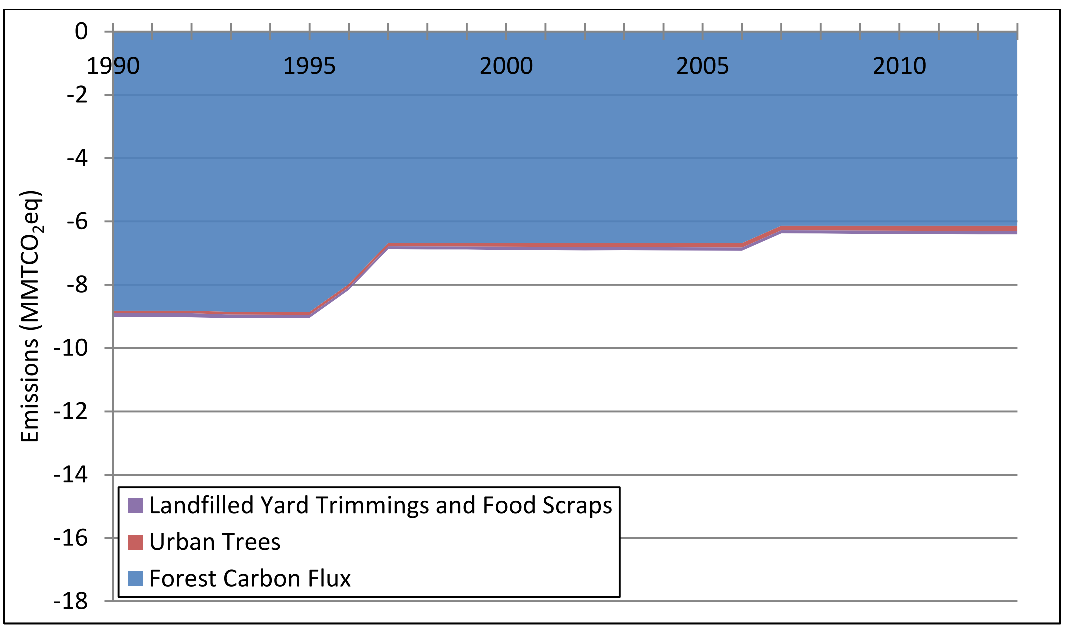
[39] Multi-Resolution Land Characteristics Consortium, MRLC, http://www.mrlc.gov/nlcd2006.php (accessed October 2016).

Table 10-1: Land Use, Land Use Change, and Forestry Sector Emissions ($MMTCO_2eq$)

Sub-Sector	1990	1995	2000	2005	2010	2011	2012	2013
Forest Carbon Flux	-8.820	-8.858	-6.682	-6.682	-6.134	-6.134	-6.134	-6.134
Wildland Fire Emissions	3.164	0.970	6.262	10.246	0.274	4.214	6.071	1.613
CH_4 Emissions	2.723	0.835	5.390	8.819	0.236	3.627	5.225	1.388
N_2O Emissions	0.441	0.135	0.872	1.428	0.038	0.587	0.846	0.225
Other Sub-Sectors	-0.196	-0.185	-0.216	-0.216	-0.261	-0.264	-0.266	-0.268
Total Emissions	**-5.851**	**-8.073**	**-0.635**	**3.349**	**-6.121**	**-2.183**	**-0.329**	**-4.788**

Figure 10-2: Land Use, Land Use Change, and Forestry Sector Emissions Sources and Emissions Sinks, 1990 - 2013 ($MMTCO_2eq$)





10.3 Projected Emissions

Very little is known about the effects of climate variability on a 10 to 20 year time scale and the effects that it has on forest productivity and the ability that forests have to offset anthropogenic GHG emissions. Also, disturbances to forests (e.g., wildfires and disease) are highly unpredictable and can strongly alter forest dynamics and productivity. For these reasons, no reliable or recommended methods are provided by the SIT to estimate sector emissions. Due to this limitation, projections for the sector were estimated by averaging 1990 to 2013 emissions and applying that average to the 2014 to 2030 period. It is estimated that, on average, the land use, land use change, and forestry sector will sequester 3.179 $MMTCO_2eq$ per year for the 2014 to 2030 period.