New Mexico Greenhouse Gas Emissions Inventory and Forecast

October 27, 2020

Prepared for: Center for the New Energy Economy at Colorado State University
Prepared by: Energy and Environmental Economics, Inc. (E3)

Energy+Environmental Economics

New Mexico Greenhouse Gas (GHG) Emissions Inventory and Forecast

October 27, 2020

Prepared for Center for the New Energy Economy at Colorado State University:

Patrick Cummins, Senior Policy Advisor, Patrick.Cummins@colostate.edu

Prepared by Energy and Environmental Economics, Inc. (E3):

Sharad Bharadwaj

Rawley Loken

Tory Clark

Amber Mahone

© 2020 Copyright. All Rights Reserved.

Energy and Environmental Economics, Inc.

44 Montgomery Street, Suite 1500

San Francisco, CA 94104

415.391.5100

www.ethree.com

Project Contact: Amber Mahone, Partner

amber@ethree.com

Table of Contents

Figures

Tables

1. Introduction

In 2019, Governor Michelle Lujan Grisham issued an Executive Order for the State of New Mexico to join the United States Climate Alliance and set an economy-wide greenhouse gas (GHG) emissions target of 45% below 2005 levels by 2030 (EO 2019-003). In this Executive Order, Governor Lujan Grisham also established a Climate Change Task Force to evaluate policies and strategies to achieve the target, including increasing the ambition of the state Renewable Portfolio Standard (RPS), implementing Low Emission Vehicle (LEV) and Zero Emission Vehicle (ZEV) standards, updating building codes, and developing a comprehensive, statewide, enforceable regulatory framework to reduce oil and gas sector methane emissions and prevent waste from new and existing sources.[1] In 2019, the Climate Change Task Force published its first report detailing initial recommendations for policies and actions to reduce emissions across the state.[2]

This technical study is meant to provide data and metrics to help New Mexico analyze the scope of statewide GHG emissions and target policies to reduce emissions. The study was commissioned by Colorado State University's Center for the New Energy Economy (CNEE) at the request of the state. CNEE coordinated with the New Mexico Energy, Minerals, and Natural Resources Department and the New Mexico Environment Department to complete the study.

This study estimates GHG emissions for the 2005 baseline year and for 2018, the most recent year for which data are available for most source categories. The study forecasts emissions under the following scenarios:

1. Baseline, or business as usual: includes on the books state and federal policies as of 2018, but no new state policies;
2. Reference, or current policy: includes effects of emissions reductions from recently enacted and pending statewide policies; and
3. Mitigation: includes emission reductions from additional policies as necessary to achieve the state's 2030 carbon target

[1] Governor Lujan Grisham, "Executive Order 2019-003: Executive Order Addressing Climate Change and Energy Waste Prevention."

[2] New Mexico Interagency Climate Change Task Force, "New Mexico Climate Strategy: Initial Recommendations and Status Update."

2. Emissions inventory

This section gives an overview of the sectors within the New Mexico GHG Inventory, with estimates of 2005 and 2018 emissions. This study used the best available data to estimate historical emissions, and used emissions accounting protocols consistent with the Environmental Protection Agency (EPA) national inventory: these include using 100-year global warming potential (GWP) to calculate carbon dioxide equivalent ($CO2_e$) emissions, and using emissions factors sourced from the EPA.[3] There is a broad range of data sources included and detailed data sources are described in more detail in the sections that follow. In brief, key data sources include:

- Environmental Protection Agency (EPA) State Inventory Tool (SIT): a spreadsheet tool developed by EPA which is designed to help states develop GHG emissions inventories. This is published and revised periodically so this study used the most recent version of EPA SIT available as of August 2020, which was published in November, 2019;[4]
- Energy Information Agency (EIA) State Energy Data System (SEDS): a set of data series which EIA publishes that contain estimates of energy consumption by sector and state. This is published and revised periodically so this study used the most recent version of EIA SEDS available as of August 2020, which was published in June, 2020;[5]
- Western States Air Resources Council (WESTAR) Western Regional Air Partnership (WRAP) Oil and Gas Work Group: an inventory and forecast of oil and gas emissions and production by basin and state within the WESTAR geography.[6,7]

This section of the report also provides more detailed data tables and explanations of each sector's GHG inventory methodology. A brief summary of the emissions calculation methodology by sector is provided in Table 1, with emissions estimate by sector for 2005 and 2018 provided in Figure 1 and Table 2.

[3] Global warming potential is a measure of how much energy a GHG will absorb over a given period, relative to carbon dioxide; by definition carbon dioxide has a global warming potential of one. The United States primarily uses the 100-year global warming potential to measure the relative impact of different GHGs.

[4] U.S. Environmental Protection Agency, "State Inventory and Projection Tool."

[5] US Energy Information Administration, "State Energy Data System 2018 Consumption Technical Notes."

[6] Grant et al., "Revised Final Report: 2028 Future Year Oil and Gas Emission Inventory for WESTAR-WRAP States - Scenario #1: Continuation of Historical Trends.".

[7] WESTAR includes 15 state members (Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming) and four federal land management partners (US Fish and Wildlife, Bureau of Land Management, National Park Service, and US Forest Service)

Table 1. Emissions and calculation methodology by sector, 2005 and 2018

Sector	2005 calculation method	2018 calculation method
Electricity generation	E3 calculation based on emissions data for in-state generators. Data sources include EPA and EIA	
Transportation	Default EPA SIT outputs	Energy consumption from EIA SEDS, multiplied by fuel-specific emissions factors from EPA SIT**
Residential		
Commercial		
Industrial (non-oil-and-gas fuel combustion)	Direct SIT outputs net fossil fuel industry fuel consumption	EIA SEDS energy consumption with EPA SIT emission factors after removing fossil fuel industry energy consumption*
Industrial processes (Non-combustion emissions from non-oil-and-gas industry)	Default EPA SIT outputs*	
Agriculture	Default EPA SIT outputs*	
Coal mining & abandoned mines	Default EPA SIT outputs*	
Waste	Default EPA SIT outputs	
Natural & working lands	Default EPA SIT outputs*	
Oil & gas (fugitive emissions)	WESTAR 2014-2016 baseline emissions scaled by oil production + natural gas transmission and distribution emissions from SIT	
Oil & gas (fuel combustion)	WESTAR 2014-2016 baseline emissions scaled by oil production + downstream fossil fuel industry combustion emissions identified from SEDS	

*EPA SIT outputs not available for 2018. For emissions attributed to energy consumption, EPA SIT estimates emissions by multiplying fuel consumption (sourced from EIA SEDS) with fuel emissions factors. To estimate emissions in 2018, E3 used the same approach

**EPA SIT outputs not available for 2018 for all sectors, so for these sectors 2017 data were used

Figure 1. Statewide annual emissions, 2005 and 2018 (MMT CO_2e)

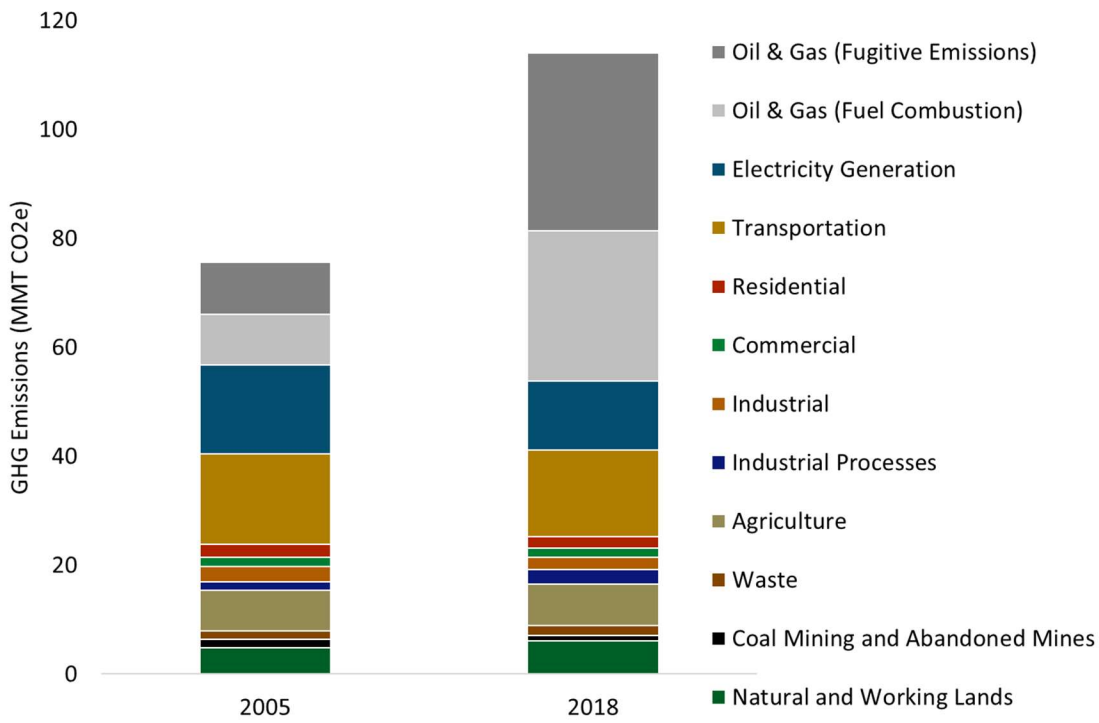


Table 2. Statewide annual emissions, 2005 and 2018

Sector	2005 (MMT CO_2e)	2018 (MMT CO_2e)
Electricity Generation	16.3	12.1
Transportation	16.5	15.8
Residential	2.4	2.2
Commercial	1.7	1.7
Industrial	2.8	2.1
Industrial Processes (Non-Combustion Emissions)	1.7	2.7
Agriculture	7.3	7.7
Coal Mining & Abandoned Mines	1.6	0.9
Waste	1.6	1.8
Natural & Working Lands	4.8	6.1
Subtotal	**56.7**	**53.2**
Oil & Gas (Fugitive Emissions)	9.6	32.7
Oil & Gas (Fuel Combustion)	9.3	27.7
Total	**75.6**	**113.6**

Residential and Commercial Buildings

This inventory attributes direct emissions from energy consumed in buildings to the residential or commercial sector.[8] Emissions from residential and commercial buildings are associated with fuel combustion on-site, primarily from natural gas and propane burned for space heating, water heating and cooking. Emissions associated with electricity consumption in buildings are attributed to the electricity sector.

To calculate emissions for residential and commercial buildings, E3 relied on the EPA State Inventory Tool, which provides estimates of emissions associated with sector-specific fuel combustion over time. These data were used to calculate emissions for 2005. As the SIT was not available for 2018 at the time of this study, E3 estimated emissions associated with residential and commercial buildings for 2018 by using the EIA SEDS, which estimates energy consumption by sector, along with fuel-specific emissions factors obtained from the SIT. This methodology is consistent with how the SIT calculates emissions by sector for historical years, so E3 expects the emissions estimate for residential and commercial buildings in EPA SIT 2018, when it is available, will be similar to the estimate produced here.

Table 3. Residential fossil fuel consumption and emissions

Fuel	2005 consumption (TBtu)	2005 emissions (MMT CO_2e)	2018 consumption (TBtu)	2018 emissions (MMT CO_2e)
Hydrocarbon Gas Liquids (Propane)	7.49	0.46	4.4	0.25
Natural Gas	34.06	1.81	35.6	1.89
Total Emissions		**2.36**		**2.18**

Notes and data sources:

2005 fuel consumption from EPA SIT

2018 fuel consumption from EIA SEDS

2018 emissions calculated by multiplying fuel specific emissions factors from EPA with EIA SEDS consumption data. This methodology is consistent with how EPA SIT calculates emissions by sector for historical years.

[8] This inventory relies on SIT and SEDS data on energy consumption by sector; SEDS uses a variety of survey data to estimate energy consumption by sector, defining the residential sector as including living quarters for private households, while the commercial sector consists of service-providing facilities and equipment of businesses, governments, and other private and public organizations, including institutional living quarters.

Table 4. Commercial fossil fuel consumption and emissions

Fuel	2005 consumption (TBtu)	2005 emissions (MMT CO_2e)	2018 consumption (Tbtu)	2018 emissions (MMT CO_2e)
Hydrocarbon Gas Liquids (Propane)	1.52	0.09	1.60	0.10
Natural Gas	24.78	1.32	26.85	1.42
Distillate Fuel	3.66	0.27	0.73	0.05
Motor Gasoline	0.12	0.01	1.85	0.13
Total Emissions		**1.71**		**1.71**

Notes and data sources:

Emissions factors from EPA SIT

2005 fuel consumption from EPA SIT

2018 fuel consumption from EIA SEDS

2018 emissions calculated by multiplying fuel specific emissions factors from EPA with EIA SEDS consumption data. This methodology is consistent with how EPA SIT calculates emissions by sector for historical years.

Gasoline sold at the pump includes a blend of motor gasoline (containing emissions such as above) and ethanol (6.5% blend by energy and treated as GHG-free in this analysis).

Transportation

Emissions associated with the transportation sector within New Mexico are calculated according to the same methodology as those from the residential and commercial buildings sectors. E3 relied on the SIT for emissions from 2005 and used SEDS data along with SIT emissions factors to estimate emissions for 2018.[9] The 2005 EPA SIT data provides separate estimates for CO_2, CH_4 and N_2O emissions from mobile sources, and categorizes transportation CO_2 emissions as coming from natural gas or all petroleum sources. To be consistent with the EPA SIT categorization of transportation emissions, Table 5 includes CO_2 emissions estimates for natural gas and petroleum fuels, and CH_4 and N_2O emissions for all transportation related mobile sources. The 2018 EPA SIT is not available, so for creating this inventory E3 use an emissions factor by fuel, which is inclusive of CO_2, CH_4, and N_2O emissions, and multiply this emissions factor by fuel with fuel consumption data from EIA SEDS. EIA SEDS does not aggregate transportation fuels into a "petroleum" category. Table 5 thus includes emissions estimate for 2005 using categories consistent with EPA SIT summary outputs in 2005, and includes emissions estimate for 2018 using categories consistent with EIA SEDS fuel categories.

This methodology accounts for greenhouse gas emissions associated with combustion of all gasoline and diesel sold within the state. E3 did not perform any adjustments to account for either fuel sold in-state but used to drive miles outside the state or fuel sold outside state boundaries but consumed by drivers within the state. This is a standard approach to estimating transportation emissions within states, so this methodology is used here.

Some state inventories only include aviation emissions associated with domestic or intra-state air travel,[10] while others include GHG emissions associated with all jet fuel sold within the state. This methodology takes the latter approach, where emissions from all jet fuel sold within the state are counted within the state's inventory. Aviation is a relatively minor portion of the transportation emissions within New Mexico and thus this assumption is not likely to significantly change results.

[9] SEDS uses a variety of survey data to estimate energy consumption by sector and defines the transportation sector as consisting of all vehicles whose primary purpose is in transporting people or goods; energy demand from vehicles whose primary purpose is not transportation (e.g., cranes and construction equipment, farming vehicles, forklifts) is classified in the sector of the vehicles' primary use. Some state inventories (such as New York) consider natural gas consumed by transmission operators within other sectors, but the default SEDS and SIT approach is to consider natural gas consumed by transmission operators within the transportation sector, so E3 use this allocation methodology within this report. Note that fugitive emissions from natural gas in the pipeline system are considered within the "oil and gas" sector, but gas combustion from pipeline transmission operators are considered within the Transportation sector

[10] For example California considers intra-state travel, New York estimates non-international travel, Washington considers all aviation fuel sold within state

Table 5. Transportation fossil fuel consumption and emissions

Fuel	2005 consumption (TBtu)	2005 emissions (MMT CO_2e)	2018 consumption (TBtu)	2018 emissions (MMT CO_2e)
Natural Gas	20.43	1.08	10.27	0.56
Motor Gasoline	114.88	8.16	109.4	7.84
Jet Kerosene	12.94	0.94	7.65	0.59
Diesel	68.37	5.06	92.25	6.86
Lubricants*	1.04	0.08		
CH4 and N2O Emissions**	-	1.20		
Total Emissions		**16.53**		**15.85**

Notes and data sources:

Emissions factors from EPA SIT

2005 fuel consumption from EPA SIT

2018 fuel consumption from EIA SEDS

2018 emissions calculated by multiplying fuel specific emissions factors from EPA with EIA SEDS consumption data. This methodology is consistent with how EPA SIT calculates emissions by sector for historical years

Gasoline sold at the pump includes a blend of motor gasoline (containing emissions such as above) and ethanol (6.5% blend by energy and treated as GHG-free in this analysis)

*Due to the very small emissions impact, lubricants consumption was not included in the 2018 inventory estiamte

**EPA SIT calculates CH_4 and N_2O emissions associated with fuel combustion separately from direct CO_2 emissions. These emissions are calculated simultaneously in the 2018 inventory accounting methodology and are included in the emissions values shown in the far-right column

Industrial (fuel combustion emissions from non-oil-and-gas industries)

The largest industry within New Mexico is the oil and gas sector. All emissions from the oil and gas sector (from energy combustion and fugitive emissions) are calculated separately in this analysis (see following section). This section discusses emissions from fuel combustion for all non-oil-and-gas industries.

As seen in Table 6, a significant share of natural gas fuel use which EIA categorizes as industrial is used as lease fuel or plant fuel for oil and gas operations; the emissions associated with these natural gas end uses are categorized within the oil and gas sector in this inventory.

Table 6. Natural gas use by category: 2005 and 2018

EIA Category	2005 (Tbtu)	2018 (Tbtu)	Inventory categorization
Natural Gas Lease and Plant Fuel Consumption	80.18	86.84	Categorized as Industrial in SEDS, as Oil and Gas within this inventory analysis
Natural Gas Lease Fuel Consumption	*43.36*	*41.42*	
Natural Gas Plant Fuel Consumption	*36.82*	*45.42*	
Natural Gas Pipeline and Distribution Use*	20.39	10.27	Categorized as Transportation in SEDS and within this inventory
Natural Gas Delivered to Consumers	128.31	184.39	Categorized within Residential, Commercial, Industry or Electricity Generation as appropriate
Natural Gas Total Consumption	**228.88**	**281.50**	

Notes and data sources:

* The EIA categorizes natural gas used by pipeline and distribution system operators (such as pipeline gas consumed within compressor stations) within the Transportation sector. As the 2005 and 2018 GHG inventories use EIA and EPA data, and the EPA SIT tool relies on EIA data for energy use by sector, to maintain consistency in this report E3 also categorizes natural gas used by pipeline and distribution system operators as within the Transportation sector.

Data source: EIA Natural Gas Annual 2005, 2018

Table 7 shows the industrial fuel consumption emissions used within this study. It includes the industrial sector emissions as associated with the default EPA and EIA data, and shows the reduced industrial sector emissions after subtracting the fuel demand associated with oil and gas industry from the default EPA or EIA data.

Table 7. Industrial fuel consumption emissions from non-oil-and-gas industries

Industrial sector emissions	2005	2018
Industrial sector emissions from EPA (2005) or EIA SEDS[11] data (2018)	7.89 MMT CO_2e	7.71 MMT CO_2e
Industrial sector emissions - non-oil-and-gas-industries	**2.76 MMT CO_2e**	**2.13 MMT CO_2e**
Notes and data sources: Methodology to calculate industrial sector emissions: Begin with default industrial data from EPA SIT / SEDS and remove natural gas and petroleum fuel consumption associated with the oil and gas industry. For natural gas, this includes natural gas reported as lease fuel and plant fuel by EIA. For petroleum, this includes demand for fuels that are primarily used in refining like petroleum coke and still gas. 2005 emissions from EPA SIT 2018 emissions calculated by multiplying fuel specific emissions factors from EPA with EIA SEDS consumption data. This methodology is consistent with how EPA SIT calculates emissions by sector for historical years.		

[11] SEDS defines the industrial sector as all facilities and equipment used for producing, processing, or assembling goods, and considers the industrial sector to encompass manufacturing; agriculture, forestry, fishing, hunting; mining, including oil and gas extraction; and construction. As noted above, energy use and emissions from oil and gas extraction are categorized within the "Oil and Gas" sector in this inventory.

Oil and Gas

To estimate greenhouse gas emissions from the oil and gas sector, this analysis relies on a variety of data sources, primarily the Western Regional Air Partnership (WRAP) oil and gas working group, which estimated annual emissions by gas for a variety of western states, including New Mexico, in 2014-2016.[12] The methodology used in this analysis to estimate oil and gas emissions for 2005 and 2018 is described in Table 8. Note this methodology includes an estimate of emissions from both fuel combustion and fugitive emissions associated with oil and gas activities. While the total amount of emissions from fugitive sources is smaller than from fuel combustion emissions in terms of tons per gas, the high global warming potential of these fugitive emissions (primarily methane) means that fugitive emissions are the largest source of total emissions in terms of CO_2 equivalent.

Table 8. Oil and gas sector 2005 and 2018 GHG emissions summary (MMT CO_2e)

Category	Methodology summary	2005	2018
Fuel combustion emissions included within WRAP inventory (upstream/midstream)	*Scale WRAP 2014-2016 fuel combustion emissions to 2005 using ratio of 2005 historic oil production to 2014-2016 oil production from WRAP inventory, assuming emissions per barrel produced are constant.* $$GHG_{2005} = GHG_{2014-2016} * \frac{AnnualOilProduction_{2005}}{AnnualOilProduction_{2014-2016}}$$ *Scale WRAP 2014-2016 fuel combustion emissions to 2018 by multiplying oil production in 2018 by an emissions intensity per barrel calculated by taking linear interpolation of WRAP forecast which includes 2016 and 2023 values (i.e., E3 interpolated the WRAP GHG per barrel factors for New Mexico from the 2014-2016 inventory and the WRAP 2023 estimate, and found an emissions per barrel value lower in 2018 than in 2016, but are not as low as WRAP forecast projects in 2023).* $$GHG_{2018} = AnnualOilProduction_{2018} * GHGPerBarrel_{2018}$$	*7.94*	*26.68*
Fuel combustion emissions from sources not captured by WRAP inventory (downstream)	*E3 estimated downstream fuel combustion emissions related to the oil sector captured within SEDS by allocating industrial demand for fuels primarily associated with the refining industry (e.g. petroleum coke, still gas) to the Industry Oil and Gas sector in PATHWAYS. Downstream fuel combustion used in the natural gas pipeline systems was taken directly from EIA and is captured in the Transportation sector of PATHWAYS, in line with the EIA SEDS methodology.*	*0.97*	*0.97*
Fuel Combustion Emissions	**Sum of scaled WRAP and SEDS/SIT**	**8.91**	**27.64**

[12] Grant et al., "Revised Final Report: 2028 Future Year Oil and Gas Emission Inventory for WESTAR-WRAP States - Scenario #1: Continuation of Historical Trends."

Fugitive methane emissions included within WRAP inventory	*Scale WRAP 2014-2016 fugitive methane emissions to 2005 and 2018 using the same methodology as that used in the scaling for the "Fuel combustion emissions included within WRAP inventory" category above.*	*8.61*	*30.22*
Non-fuel combustion CO_2 emissions included within WRAP inventory		*0.87*	*1.93*
WRAP emissions included within WRAP inventory		*0.04*	*0.13*
Natural gas transmissions & distribution fugitive emissions	*Use EPA SIT data on natural gas fugitive emissions from pipeline transmission and distribution systems*	*0.40*	*0.47*
Fugitive Emissions	**Sum of WRAP scaled and EPA SIT data**	**9.92**	**32.74**
Grand Total Emissions	**Sum of fugitive and fuel combustion emissions**	**18.83**	**60.40**

The WRAP inventory estimates annual GHG emissions by gas and by source for a baseline representing average production over 2014-2016. Table 9 shows the emissions by basin and fuel from this database. Note these emissions are in units of tons per gas, and have not been scaled by GWP factors to estimate the CO_2e.

Table 9. GHG emissions by basin, 2014-2016 baseline (t/yr)

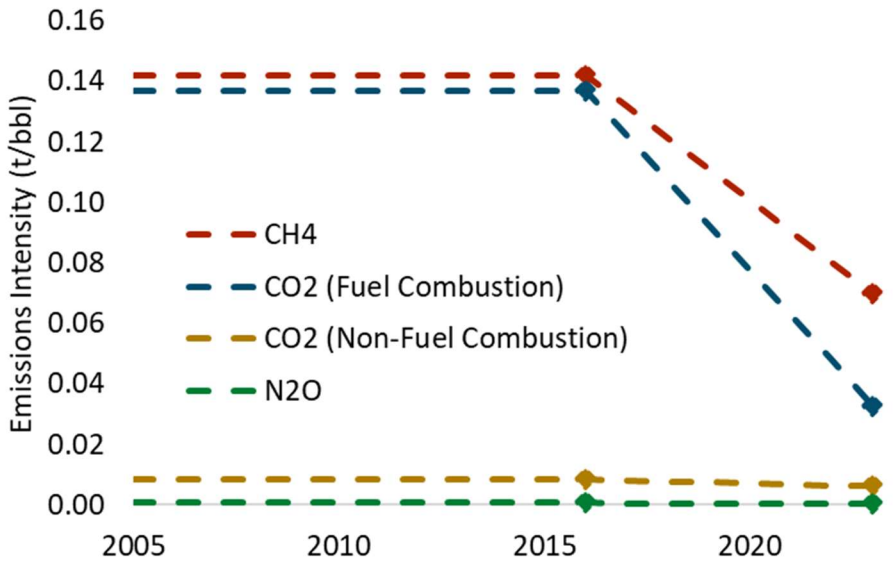
Basin	CO_2 (t/yr)	CH_4 (t/yr)	N_2O (t/yr)
San Juan	10,697,190	408,462	154
Permian	8,638,737	294,141	154
Pedregosa Basin	291,546	21	8
Basin-And-Range Province	289,521	30	8
Orogrande Basin	265,543	41	7
Raton	7,976	2,318	0
Estancia Basin	7,592	1	0
Sierra Grande Uplift	5,830	49	0
Grand Total	**20,203,936**	**705,063**	**331**
Notes and data sources: Data from WESTAR WRAP emissions inventory			

To estimate emissions in 2005 and 2018, E3 scaled the 2014-2016 WRAP emissions by a scaling factor for both combustion and non-combustion emissions.[13] When estimating emissions 2005, E3 assumed the emissions intensity of crude production (emissions of GHG per barrel of output) were identical to the 2014-2016 WRAP data (as displayed in Figure 2) and multiplied emissions

[13] See Table 28 for the source to emissions category which E3 used to estimate the proportion of CO_2 emissions which should be categorized as fuel combustion vs fugitive emissions.

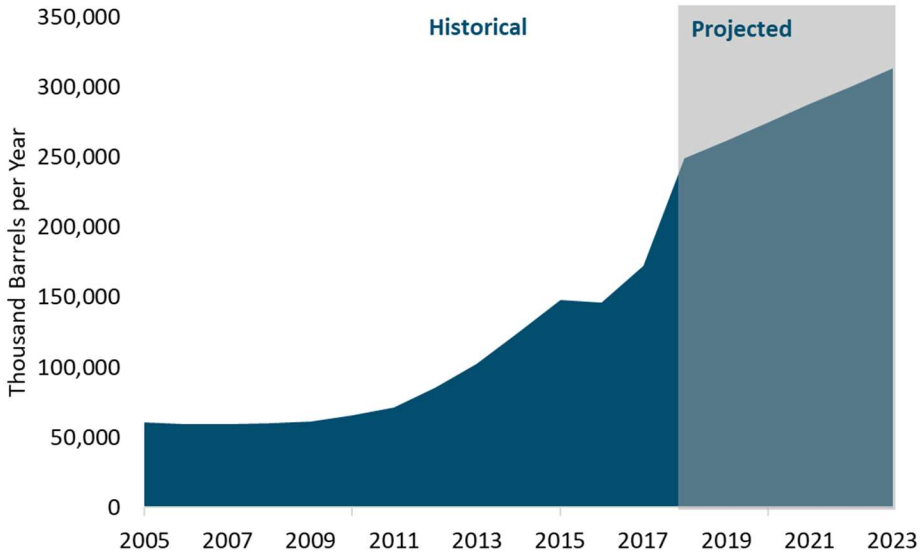
intensity with historical crude production (as displayed in Figure 3). When scaling emissions to 2018, E3 assumed a declining emissions intensity of production between the 2014-2016 starting point from WRAP inventory and the 2023 estimate from the WRAP baseline forecast. This emissions intensity was multiplied by statewide oil production for 2018 (as displayed in Figure 3). Figure 4 shows the resulting oil and gas sector emissions values.

Figure 2. Greenhouse gas intensity of oil production



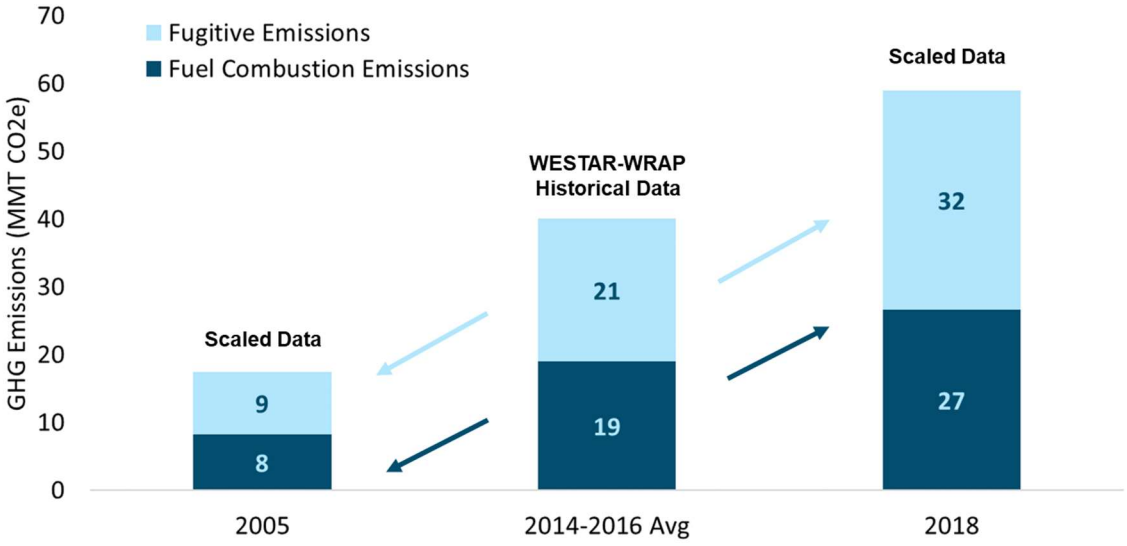
Source: 2014-2016 from WRAP inventory. The 2014-2016 values are assumed constant when back-casting to 2005. 2023 emissions intensities values sourced from WRAP baseline forecast, and 2016-2023 is a linear trendline

Figure 3. New Mexico oil production, historical and projected



Source: 2005-2018 production from EIA, 2018-2023 forecast from WESTAR WRAP. Note this forecast was produced prior to the COVID-19 economic slowdown.

Figure 4. New Mexico upstream/midstream oil and gas sector emissions: 2005 (E3 estimated), 2014-2016 average (WRAP inventory), 2018 (E3 estimated)



Industrial Processes

(Non-combustion emissions from non-oil-and-gas industries)

E3 sourced data to estimate emissions from industrial processes, excluding non-combustion emissions from the oil and gas sector from EPA SIT; these data are reported in Table 10.

Table 10. GHG emissions from industrial processes by gas

Category	2005 (MMT CO_2e)	2018 (MMT CO_2e)
Carbon Dioxide Emissions	**0.998**	**0.628**
Cement Manufacture	*0.673*	*0.591*
Lime Manufacture	*0.295*	-
Limestone and Dolomite Use	*0.011*	*0.023*
Soda Ash	*0.017*	*0.013*
Aluminum Production, CO2	-	-
Iron & Steel Production	-	-
Ammonia Production	-	-
Urea Consumption	*0.002*	*0.001*
Nitrous Oxide Emissions	**-**	**-**
Nitric Acid Production	-	-
Adipic Acid Production	-	-
HFC, PFC, SF6 and NF3 Emissions	**0.661**	**2.118**
ODS Substitutes	*0.661*	*0.983*
Semiconductor Manufacturing	-	*1.134*
Magnesium Production	-	-
Electric Power Transmission and Distribution Systems	-	-
HCFC-22 Production	-	-
Aluminum Production, PFCs	-	-
Total Emissions	**1.659**	**2.746**

Notes and data sources:

Emissions for 2005 are direct outputs from EPA SIT estimate of historical 2005 emissions; emissions for 2018 are EPA SIT estimate of 2017 emissions, as EPA SIT is not available for 2018.

Agriculture, coal mining, forestry, waste, and wastewater

A variety of non-combustion emissions from agriculture, land-use change and forestry, waste, and wastewater are present in New Mexico. E3 used data from the EPA SIT to estimate emissions from these sectors. When necessary, E3 converted emissions factors between methane and carbon dioxide equivalent, using gas-specific conversion factors from the IPCC Fifth Assessment Report (AR5) for the emissions cited in the tables below.[14,15]

Table 11. Agriculture emissions by sector

Category	2005 (MMT CO_2e)	2018 (MMT CO_2e)
Enteric Fermentation	3.66	3.76
Manure Management	2.07	2.48
Agricultural Soil Management	1.61	1.46
Rice Cultivation	-	-
Liming	-	-
Urea Fertilization	0.01	0.01
Burning of Agricultural Crop Waste	0.00	0.00
Total	**7.35**	**7.70**
Notes and data sources: Emissions for 2005 are direct outputs from EPA SIT estimate of historical 2005 emissions; emissions for 2018 are EPA SIT estimate of 2017 emissions, as EPA SIT is not available for 2018.		

Table 12. Coal mining and abandoned mines emissions

Category	2005 (MMT CO_2e)	2018 (MMT CO_2e)
Coal Mining	1.59	0.93
Abandoned Coal Mines	0.02	0.01
Vented	-	-
Sealed	*0.02*	*0.01*
Flooded	-	-
Total	**1.61**	**0.95**
Notes and data sources: Emissions for 2005 are direct outputs from EPA SIT estimate of historical 2005 emissions; emissions for 2018 are EPA SIT estimate of 2017 emissions, as EPA SIT is not available for 2018.		

[14] IPCC, "Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change."

[15] Gas-specific conversion factors are needed to convert emissions in raw tons into a carbon dioxide equivalent basis. To perform this conversion, we use the 100-year global warming potential to convert measure the relative impact of different greenhouse gases.

Table 13. Land-use change and forestry emissions and sequestration

Category	2005 (MMT CO2e)	2018 (MMT CO2e)
Forest Carbon Flux	**2.83**	**3.81**
Aboveground Biomass	*0.36*	*0.86*
Belowground Biomass	*0.13*	*0.18*
Dead Wood	*(1.73)*	*(1.30)*
Litter	*0.33*	*0.33*
Soil Organic Carbon	*1.49*	*1.49*
Total Wood products and landfills	*2.25*	*2.25*
Urban Trees	**(0.18)**	**(0.19)**
Landfilled Yard Trimmings and Food Scraps	**(0.07)**	**(0.07)**
Grass	*(0.00)*	*(0.00)*
Leaves	*(0.02)*	*(0.02)*
Branches	*(0.02)*	*(0.02)*
Landfilled Food Scraps	*(0.02)*	*(0.02)*
Forest Fires	**-**	**-**
CH_4	-	-
N_2O	-	-
N_2O from Settlement Soils	**0.02**	**0.01**
Agricultural Soil Carbon Flux	**2.18**	**2.50**
Total	**4.78**	**6.06**

Notes and data sources:

Emissions for 2005 are direct outputs from EPA SIT estimate of historical 2005 emissions; emissions for 2018 are EPA SIT estimate of 2017 emissions, as EPA SIT is not available for 2018.

Table 14. Waste emissions by category

Category	2005 (MMT CO_2e)	2018 (MMT CO_2e)
Estimated CH_4* Emissions	**1.51**	**1.76**
Municipal Solid Waste (MSW) Generation	*1.41*	*1.65*
Industrial Generation	*0.10*	*0.12*
Avoided CH_4 Emissions	-	-
Flare	-	-
Landfill Gas-to-Energy	-	-
Oxidation at MSW Landfills	0.14	0.16
Oxidation at Industrial Landfills	0.01	0.01
Total	**1.36**	**1.59**

Notes and data sources:

*There is significant uncertainty associated with estimating CH_4 emissions from landfills, as emissions are impacted by characteristics that vary by landfill (e.g., temperature, rainfall, waste composition, soil cover). The EPA SIT estimates CH_4 emissions associated with landfills, but labels them as "Potential CH_4" to highlight the uncertainty of estimating CH_4 emissions from landfill waste streams.

MSW Generation = municipal waste streams sent to landfills

Industrial Generation = industrial waste streams sent to landfills

2005 and 2018 data from EPA SIT

Table 15. Wastewater emissions for New Mexico

Category	2005 (MMT CO_2e)	2018 (MMT CO_2e)
Municipal CH_4	0.17	0.19
Municipal N_2O	0.05	0.06
Industrial CH_4	0.00	0.00
Fruits & Vegetables	-	-
Red Meat	*0.00*	*0.00*
Poultry	-	-
Pulp & Paper	-	-
Total	**0.22**	**0.24**

Notes and data sources:

2005 and 2018 data from EPA SIT

Electricity Generation

To calculate emissions from electricity generation, E3 considered emissions from all in-state generating units. Note that, as Table 16 shows, the default EIA data on in-state generation and in-state emissions show much higher generation and emissions levels than this analysis. This is because the EIA data include emissions and generation from the Four Corners power plant which is a tribal source on the Navajo Nation. Four Corners is not included in this analysis because it does not fall under state authority and most of the power from the plant is not consumed in New Mexico.

High quality historical data on dispatch of in-state and out-of-state plants for New Mexico electricity use requires additional research beyond the scope of this study. Therefore, this analysis is based on in-state generation. Note that since 2005, retail sales of electricity in New Mexico have not varied more than 6% above or below generation from in-state units; thus, taking a simplified approach of relying on high quality historical data of in-state emissions is a reasonable proxy for emissions attributable to the New Mexico electricity sector.

Table 16. Summary of generation, sales, and emissions data for 2005 and 2018

Category	Units	2005	2018
EIA In-State Generation	GWh	35,136	32,674
Generation from in-state units	GWh	19,520	25,028
Retail sales	GWh	20,639	24,030
EIA In-state emissions	MMT CO2e	30.9	19.7
Emissions from in-state units	**MMT CO2e**	**16.3**	**12.1**
Notes and data sources: EIA in-state generation, retail sales data, ownership of out of state units from EIA Forms 906/920, 860, 923[16] Generation from in-state units from EPA Emissions & Generation Resource Integrated Database (eGRID) data[17]			

[16] U.S. Energy Information Administration, "A Guide to EIA Electric Power Data."

[17] Abt Associates, "The Emissions & Generation Resource Integrated Database: Technical Support Document for EGRID with Year 2018 Data."

3. Emissions forecast methodology and framework

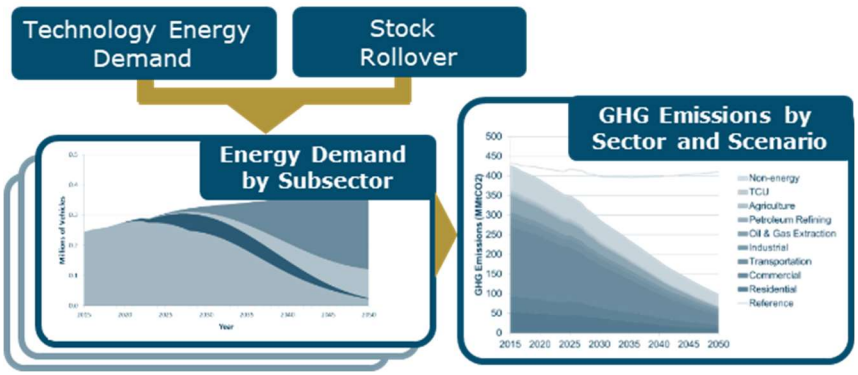
Model framework

To characterize economy-wide greenhouse gas emissions in New Mexico, E3 analyzed economy-wide decarbonization using the PATHWAYS model. E3's PATHWAYS model is an economy-wide representation of infrastructure, energy use, and emissions within a specified geography. E3 developed PATHWAYS in 2008 to help policymakers, businesses, and other stakeholders analyze trajectories to achieving deep decarbonization of the economy, and the model has since been improved over time in projects analyzing jurisdictions across North America; recent examples include working with the California Energy Commission, with the New York State Energy Research and Development Authority, and with the Colorado Energy Office .

E3 aligned the GHG emissions within the New Mexico PATHWAYS model with the inventory accounting methodology described previously in this report. In brief, this includes emissions associated with energy use in residential and commercial buildings, transportation, and industry; electricity generation from in-state generators; non-combustion emissions associated with industrial processes, agriculture, and waste processing; and emissions associated with oil and gas production and extraction.

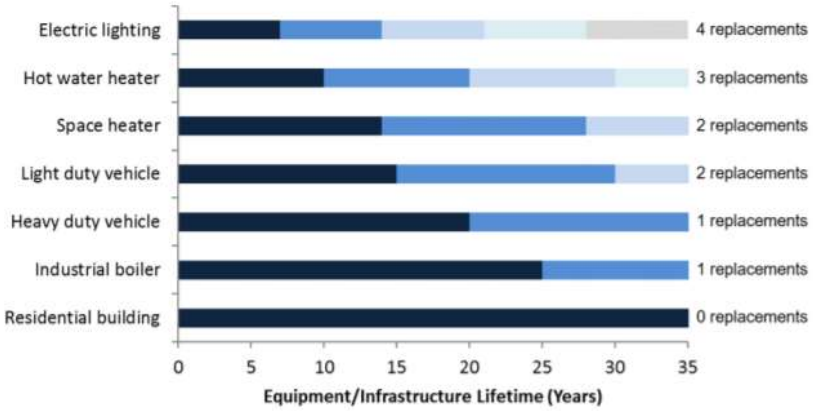
E3 developed a NM PATHWAYS model of bottom-up energy and emissions within all sectors of the economy, benchmarked to the 2018 inventory described in the previous section, and developed economy-wide emissions scenarios through 2050. The PATHWAYS model characterizes bottom-up and user-defined emissions accounting scenarios to analyze questions around possible energy and climate policies. PATHWAYS includes both supply and demand sectors to capture interactions between the sectors, and the focus is on comparing user-defined policy and market adoption scenarios and to track physical accounting of energy flows within all sectors of the economy.

Figure 5. Illustration of PATHWAYS model framework



A key feature of PATHWAYS is a characterization of stock rollover in major equipment categories (specifically in buildings and transportation fleets). A stock rollover approach tracks infrastructure turnover of energy consuming device while accounting for changes in performance, such as improved efficiency over time. This tracks the time lag between changes in annual sales of new devices and change in device stocks over time explicitly. Different technologies will have different lifetimes, which are captured by this approach. For example, some technologies, such as lightbulbs, might have lifetimes of just a few years while others, such as building shell systems, might have lifetimes on the order of decades. By tracking these lifetimes, using PATHWAYS a user can determine the pace necessary to achieve economy-wide greenhouse gas emissions goals while capturing potential path dependencies.

Figure 6. Illustrative device lifetimes for stock rollover methodology in PATHWAYS



A second key feature of the PATHWAYS model is its ability to link sectors. This enables PATHWAYS to identify where aggressive action in one sector can enable emissions reductions elsewhere. For instance, the treatment of the electricity sector is explicitly tied to the carbon savings associated with electric vehicles.

Overview of emissions forecasting approaches

E3 used a variety of modeling approaches to forecast greenhouse gas emissions in each sector. Greenhouse gas emissions from consumption of fuel for energy demand were analyzed using either (1) stock rollover, in which an explicit accounting of rollover appliances and equipment were calculated and used to account for energy and GHG emissions; or (2) total energy by fuel, in which the total energy consumption was directly modeled.

In calculating energy demands, E3 benchmarked energy consumption within New Mexico to state level data from the EIA SEDS, which reports fuel consumption by economic sector and fuel in each state. E3 performed a bottom-up based accounting of the appliances and vehicles in the state and relied on a variety of federal data on appliance and vehicle efficiencies, as well as usage patterns,

to benchmark residential; commercial; and transportation energy demands. The stock rollover approach was used when quality infrastructure data were available from public data sources; otherwise E3 used a total energy approach, in which there is no explicit turnover calculations within the modeling framework.

For other sectors in which energy demand were not specified, E3 input the GHG emissions directly in each year, but adjusted these to account for the effects of various policies, such as waste and ozone pre-cursor reductions for oil and gas or land use change emissions from forests.

Table 17. NM PATHWAYS emissions forecast methodology by sector

Sector	Emissions forecast methodology
Electricity Generation	Estimate effects of electric sector policies on total generation mix and calculate emissions rate of electricity generation. Apply emissions rate to forecasts of statewide load to estimate total emissions for electricity.
Transportation	Use combination of stock rollover and total energy approaches to estimate demand for various fuels and estimate emissions from these fuels. This approach considers the reduced emissions from electrification or efficiency, as well as the increased load these measures might create.
Residential	
Commercial	
Industrial (non-oil-and-gas fuel combustion)	
Industrial Processes (Non-combustion emissions)	Hydrofluorocarbon (HFC) emissions reductions modeled, but other non-combustion emissions held constant over time
Agriculture	Hold flat in Baseline scenario, with scenario-dependent reductions in Reference and Mitigation scenario as described in Table 19
Coal Mining & Abandoned Mines	Assume coal mining emissions are reduced in line with reduced coal for electricity generation, but abandoned mine reductions are modeled using SIT methodology
Waste	Hold flat in Baseline scenario, with scenario-dependent reductions in Reference and Mitigation scenario as described in Table 19
Natural & Working Lands	
Oil & Gas (Fugitive Emissions)	WESTAR WRAP "continuation of historical trends" forecast through 2023 as primary data source, with estimated effects of NSPS rollback for Baseline and additional mitigation from New Mexico methane rules in the Reference and Mitigation scenarios
Oil & Gas (Fuel Combustion)	

Table 18. Forecast of key energy service demand drivers by sector

Sector	Key driver	Compound annualized growth rate [%]	Data source
Residential	Household growth	0.8%	UNM Geospatial and Population Studies for residential population growth, with historical relationship between population growth and household growth rate from EIA data[18]
Commercial	Commercial square feet	1%	EIA Annual Energy Outlook (AEO) 2018[19]
Industry	Energy growth	Varies by fuel (from 0% to .98% per year)	EIA AEO 2018
Oil and gas	Production	Variable (4.6% annual growth from 2018-2023, then 0% growth after 2023)	WESTAR WRAP forecast for production through 2023, and held constant beyond
On-road transportation	Vehicle-miles traveled (VMT)	0.6% light duty vehicles 1.2% medium duty and heavy duty vehicles	EIA AEO 2018
Off-road transportation	Energy growth	Varies by fuel (from -0.2% to 1.0% per year)	EIA AEO 2018
Electricity Generation	Electric load growth	Varies by scenario (from .58% to 2.6% per year averaged 2020-2050)	Built up from energy demands in Buildings, Industry, Transportation

Emissions forecast for key sectors without a stock rollover approach: oil and gas, electricity generation

Oil and gas

Forecasting emissions from oil and gas extraction is difficult as total emissions are closely related to production levels, which can be highly variable on an annual or even monthly basis. This analysis relies on data from the WESTAR-WRAP Oil and Gas Working Group, which estimated oil and gas production and associated emissions for a 2014-2016 baseline and for 2023. In addition to relying on data from the WESTAR-WRAP study, E3 also estimated a range of potential that could be achieved as a co-benefit of the draft oil and natural gas ozone precursor rules being promulgated by the state.[20] The scenario-specific assumptions and results for this analysis are discussed later in this report.

[18] University of New Mexico Geospatial and Population Studies, "New Mexico Population Projections."

[19] U.S. Energy Information Administration, "Annual Energy Outlook 2018."

[20] New Mexico Environment Department, Oil and Natural Gas Regulation for Ozone Precursors: Preliminary Draft.

Electricity generation

Electrification is one of the core decarbonization strategies modeled in the deep decarbonization scenario. While this report estimates emissions from electricity generation considering load growth and the state's clean electricity targets, E3 did not run a detailed capacity expansion and electricity dispatch model for this analysis. E3 estimated future generation by assuming existing units run at 2018 levels until their scheduled retirement, with renewables added to meet RPS or clean electricity requirements. E3 estimated future generation and emissions on an annual basis using a spreadsheet tool that considers the impacts of the ETA, scheduled plant retirements, and what generating resources are eligible for addition. We discuss the scenario-specific assumptions and results for this analysis later in this report.

Scenario development

This study includes analysis of three statewide emissions trajectory scenarios through 2050.

- **Baseline Scenario:** a business as usual scenario showing a forecast for emissions within the state without taking into consideration the effect of specific energy or emissions reductions policies passed since 2018.
- **Reference Scenario (current policies):** a scenario showing the effect of currently passed and anticipated emissions reductions measures based on the directives of EO 2019-003. This includes the Energy Transition Act and efficient building codes (passed and adopted); and clean cars, HFC measures, and a regulatory framework to reduce emissions from the oil and gas sector.
- **Mitigation Scenario (deep decarbonization):** a scenario that represents the scale of effort necessary to achieve the state's 2030 carbon target, with a level of effort in each sector commensurate with similar deep decarbonization analyses performed in other states such as California and Colorado. This scenario includes electrification of most space and water heating within buildings, as well as electrifying most light-duty vehicles. The modeling also includes increased adoption of electric and hydrogen vehicles in medium-duty vehicles (MDVs) and heavy-duty vehicles (HDVs), and industrial electrification of feasible industrial processes. This scenario is not meant to reflect a specific action plan for the state, but rather representative pathways that highlight the scale of transformation necessary to reach decarbonization goals.

Because of the significant role oil and gas plays in the overall GHG emissions trajectory for the state, this study includes two sets of forecasts for each scenario: one showing economy-wide emissions from all sectors, and one without the oil and gas sector in order to more easily see the progress made in other sectors.

Table 19. Key assumptions for PATHWAYS measures by scenario

Sector	Strategy	Expressed as	Baseline	Reference	Mitigation
Buildings	Building Shell Efficiency	Efficient shell sales share*	No incremental efficiency beyond current shells	100% of new and retrofit building shells meet IECC 2018 building codes	*Same as Reference*
	Building Electrification	Electric heat pump sales share	None	None	65% sales of heat pumps for space heating and water heating by 2030; 90% by 2040
	Appliance Efficiency (non-HVAC)	Efficient appliance sales share	None	100% efficient sales for lighting by 2030	100% efficient sales for all appliances by 2030
Industry	Efficiency	Efficiency increase relative to baseline projection	None	None	15% by 2030, 20% by 2050
Transportation	Corporate Average Fuel Economy (CAFE) Standards	Light Duty Vehicle (LDV) fuel economy	CAFE extension (MY2021-2026 extension)	*Same as Baseline*	*Same as Baseline*
	Smart Growth	LDV VMT reduction relative to Reference**	None	*Same as Baseline*	8.4% by 2030
	Aviation Efficiency	Efficiency increase relative to Reference	None	None	10% by 2030, 40% by 2050
	Vehicle Electrification	Zero Emission Vehicle (ZEV) sales share	LDV ZEV sales consistent with EIA AEO 2019: 6% by 2030, 12% by 2050	LDV ZEV sales consistent with low emission vehicle program (LEV): 22% by 2030	LDV: 70% by 2030, 100% by 2035 MDV/HDV: 40% by 2030; 100% by 2040
Zero Emissions Fuels***	Bioenergy Availability	Feedstocks supply	None	*Same as Baseline*	Population weighted share of US waste and residues (from DOE Billion Ton Study)
	Biofuels Blend	Share of conventional fuel use met with biofuels	6.5% ethanol blend for gasoline	*Same as Baseline*	25% renewable diesel blend by 2030;

Sector	Strategy	Expressed as	Baseline	Reference	Mitigation
					100% renewable diesel blend by 2050
Clean Electricity	Clean Electricity Generation	Share of renewable/zero-emission generation	20% RPS by 2020	50% RPS by 2030; 100% clean electricity by 2045	50% RPS by 2030, with no increase in natural gas generation; 100% clean electricity by 2045
Non-combustion (Industrial Processes, Agriculture, Waste)	Industrial Processes	Hydrofluorocarbon (HFC) reductions	None	17% reduction by 2030; 29% by 2050 (based on downscaling of EPA SNAP rules)	30% reduction by 2030; 85% by 2050 (phase down in line with Kigali Amendment)[21]
	Natural and Working Lands	Reduction in forest/soil emissions	None	*Same as Baseline*	50% reduction by 2030
	Waste	Methane emissions captured	None	*Same as Baseline*	20% captured by 2030; 60% captured by 2050
	Agriculture	Methane and nitrous oxide reductions	None	*Same as Baseline*	9% reduction in CH_4 and NOx emissions from enteric fermentation and manure management by 2030; 3% reduction in NOx from soil management by 2030
Oil and Gas	Equipment improvements	Reduced fuel combustion and methane emissions	2020 Federal NSPS Rules	2016 Federal NSPS Rules + 60% reduced fugitive CH_4 emissions intensity by 2030 (also show 30%-90% range in graphics)	2016 Federal NSPS Rules + 90% reduced fugitive CH_4 emissions intensity by 2030

[21] U.S. Environmental Protection Agency, "Recent International Developments under the Montreal Protocol."

Sector	Strategy	Expressed as	Baseline	Reference	Mitigation
Notes and acronyms:					
*Building shell improvements (such as deep retrofits of homes) decrease demand for space heating and air conditioning. E3 calculated the stock rollover of building shells with a 40-year lifetime. Efficient building shells reduce AC demand by 20% and space heating demand by 50%, with an additional 34% reduction in the Commercial Other subsector. These values are benchmarked to the estimated impacts of New Mexico adopting 2018 IECC from an analysis conducted by Pacific Northwest National Laboratory.[22,23]					
**LDV VMT reductions sourced from potential VMT reductions achievable through work from home policies.[24] It is deeply uncertain how VMT can be reduced through smart growth, work from home, and other policies but this initial estimate is used to get a sense of scale for how much is required to achieve New Mexico's ambitious climate targets.					
*** For more information on the bioenergy assumptions used within this study see the Appendix.					
IECC: International Energy Conservation Code					
SNAP: Significant New Alternatives Policy					
LDV: Light duty vehicle					
MDV/HDV: Medium duty vehicle / heavy duty vehicle					
VMT: Vehicle miles traveled					
RPS: Renewable Portfolio Standard					
NSPS: New Source Performance Standard[25]					

4. Emissions forecast results

Figure 7 and Figure 8 show statewide emissions by sector in 2018. The emissions by sector are benchmarked to the inventory results discussed in previous sections, but these graphics include a breakdown of emissions by subsector from the more detailed NM PATHWAYS model representation. For example, the transportation sector includes an estimate of emissions by passenger vehicles, freight trucks, and other. E3 estimated these within the PATHWAYS framework from local and state data on VMT by vehicle type as well as vehicle population data.[26]

[22] Taylor, "Preliminary Cost Effectiveness of the Residential 2018 IECC for the State of New Mexico."

[23] US Department of Energy "State Code Adoption Tracking Analysis"

[24] Chong, "COVID-19, Commuting, and Clean Air: A Look at Pandemic-Era Mobility and Transportation Emissions in California."

[25] U.S. Environmental Protection Agency, Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources Review.

[26] Pickrell, Pace, and Wishart, "Development of VMT Forecasting Models for Use by the Federal Highway Administration"; Tang, Tianjia PhD., "The Future of Travel Demand."

Figure 7. New Mexico GHG emissions in 2018, by sector and subsector

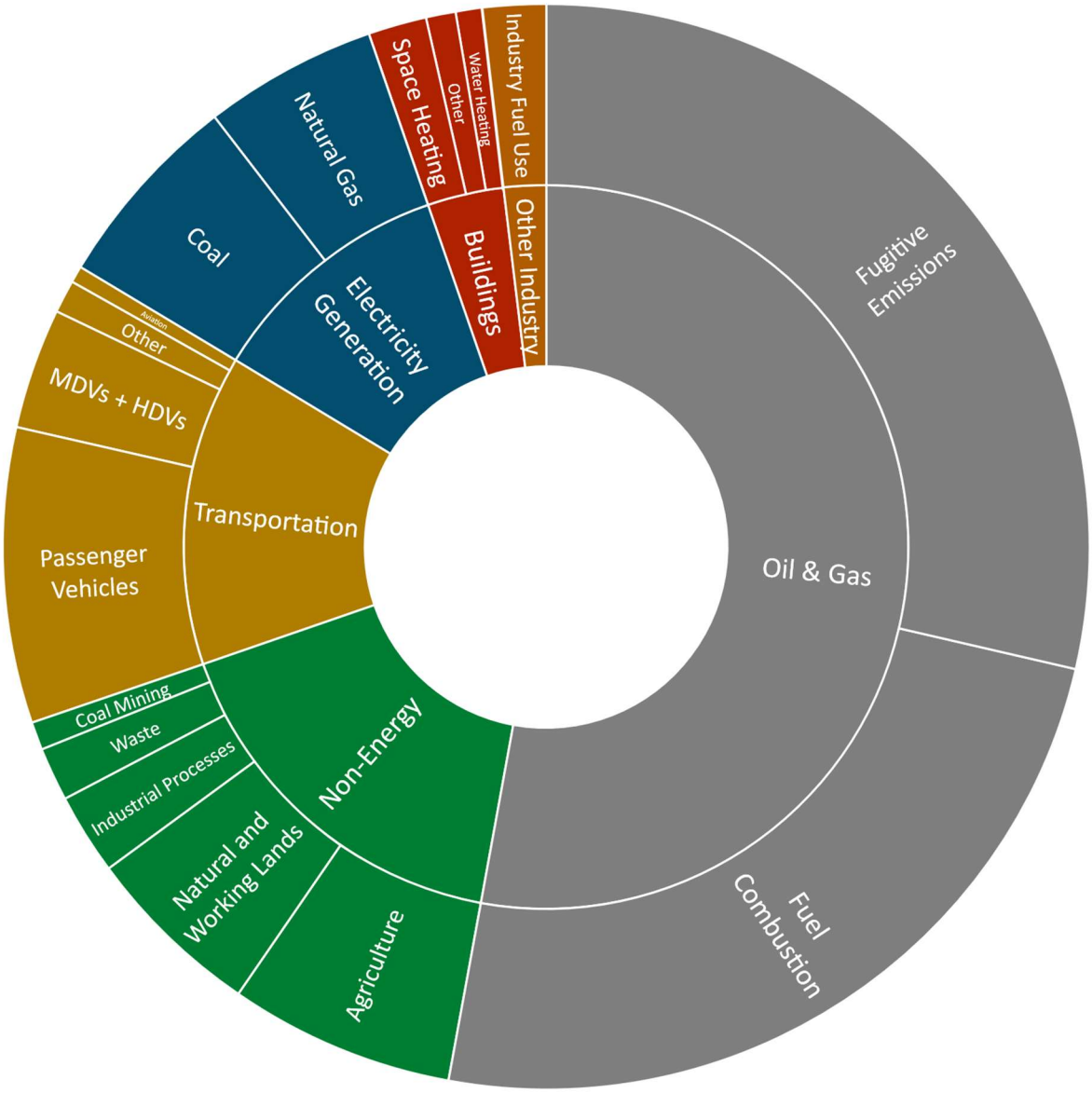


Figure 8. New Mexico GHG emissions in 2018: without oil and gas, by sector and subsector

Results through 2030

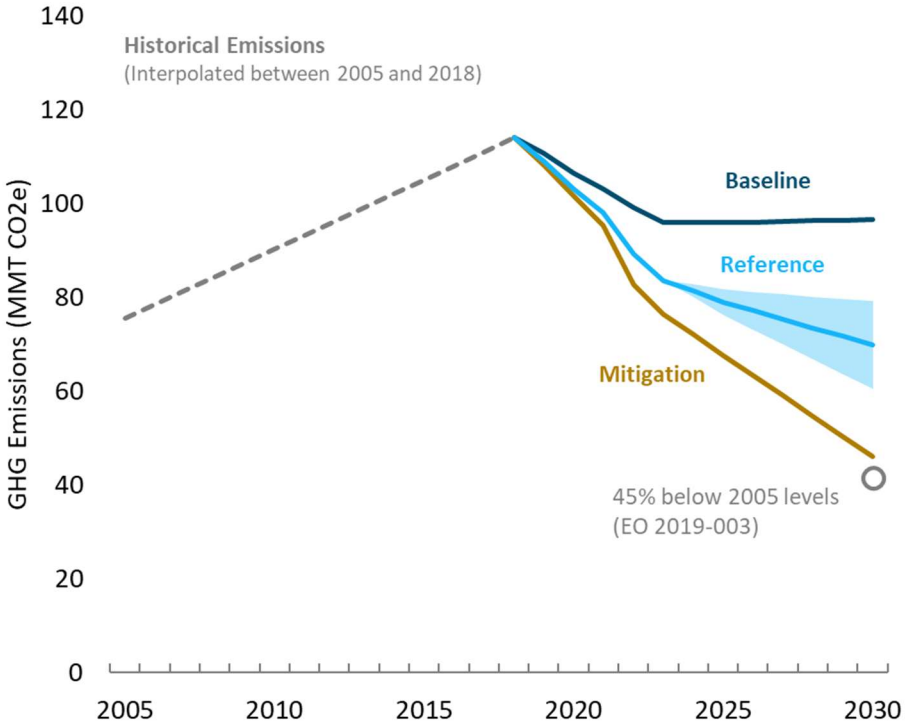
This section includes the results of the economy-wide emissions forecasting analysis through 2030: it includes emissions by scenario; the effect of key policies on emissions reductions in the Reference scenario; emissions by sector in the Reference and Mitigation scenarios.

Economy-wide emissions result

Figure 9 shows annual economy-wide emissions for three scenarios through 2030, as well as a marker showing the 45% by 2030 target set by EO 2019-003.[27] The Reference scenario achieves significant emissions reductions relative to the Baseline, and even further reductions are achieved from the Mitigation case relative to the Reference, though there still remains a small gap between the Mitigation scenario and the 2030 emissions target. The Baseline scenario sees emissions increase by 28% by 2030 relative to 2005 levels; the Reference scenario sees a range of emissions, from 5% increase relative to 2005 to 20% reduction in emissions levels by 2030 relative to 2005 levels depending on uncertainty around oil and gas emissions reductions achievable via state policies; the Mitigation scenario achieves 39% emissions reductions by 2030 relative to 2005 levels.

[27] The 45% by 2030 target calculated here is relative to the 2005 emissions inventory as shown in Table 2.

Figure 9. Baseline, Reference, and Mitigation case emissions forecast through 2030, including oil and gas sector emissions



Note the uncertainty band around the Reference scenario, which includes a range of emissions reductions achievable in the oil and gas sector depending on the effects of state policies. The central estimate includes a 60% reduction in fugitive CH_4 emissions intensity from oil and gas sector by 2030, while the low and high bands show 30% and 90% reductions in fugitive CH_4 emissions intensities in oil and gas by 2030.

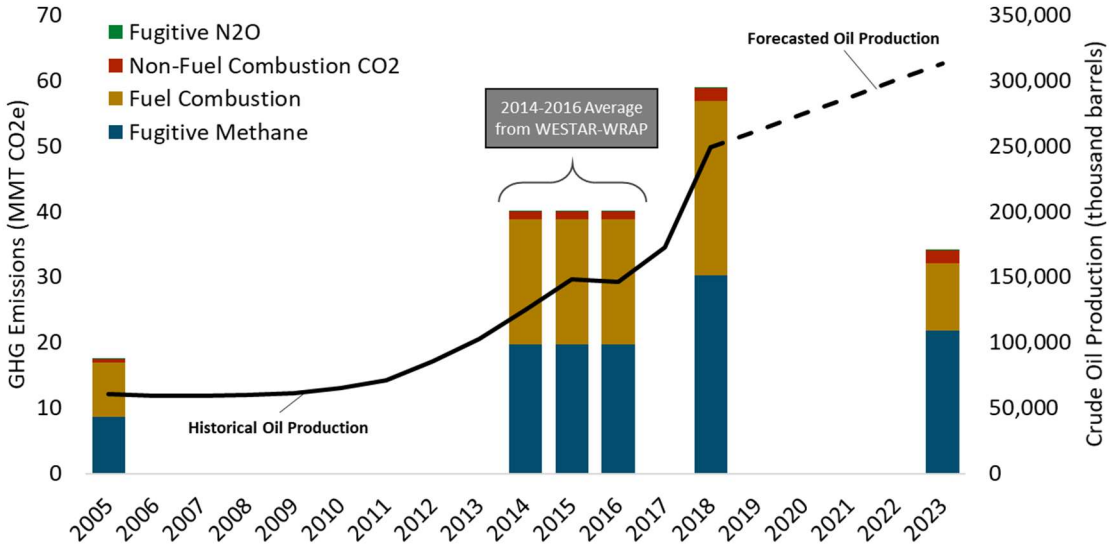
All scenarios see a significant rise in emissions from 2005 to 2018, as well as a significant drop from 2018 to 2023, driven primarily by the New Source Performance Standards (NSPS) for the oil and gas sector. The next section discusses oil and gas emissions and key drivers for emissions reductions over time, before turning to the rest of the economy.

Oil and Gas emissions results

Figure 10 shows the emissions modeled within the oil and gas sector through 2023. This study estimates a significant rise in emissions from 2005 to 2018, driven primarily by the increase in oil production within the state. Between 2018 and 2023 E3 forecast a significant decrease in emissions in the Reference scenario, due to the expected impacts of regulatory programs like the EPA New Source Performance Standards (NSPS) and federal off-road diesel engine tier standards. These emissions forecasts were based on the WESTAR-WRAP "Continuation of Historical Trends"

forecast.[28] The WESTAR-WRAP forecast assumes changes to production and associated emissions through 2023. Due to the uncertainties of forecasting future production, E3 held these oil and gas production and emissions values constant after 2023, except for scenarios where there are impacts from additional oil and gas regulations.

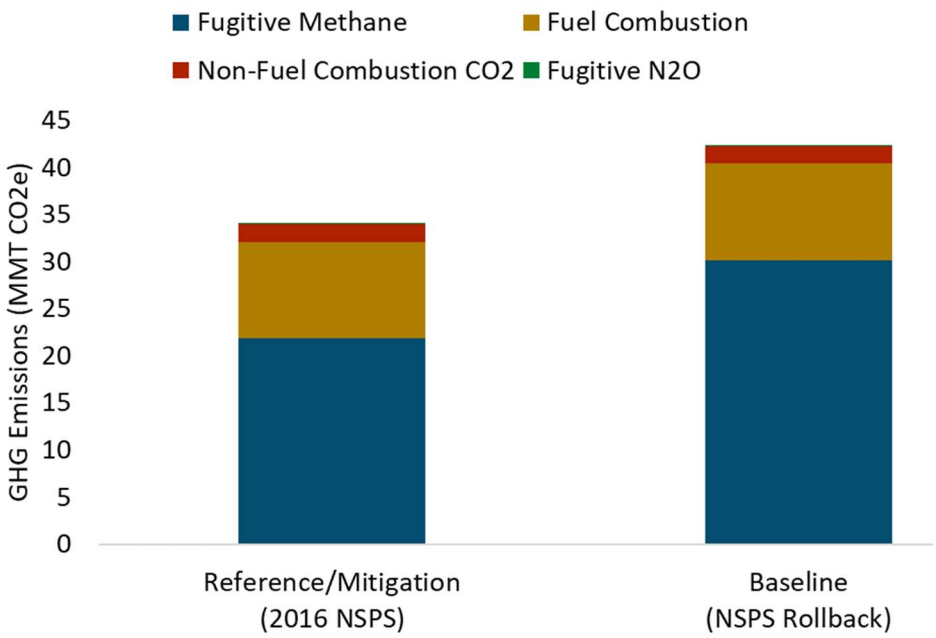
Figure 10. Oil & gas sector emissions reductions through 2023



Since the publication of the WESTAR-WRAP report, the EPA has rolled back key subparts of NSPS that affect emissions from the oil and gas sector. E3 have used the expected foregone emissions reductions from the final rules as detailed in the EPA's Regulatory Impact Analysis to estimate an increase in oil & gas emissions in 2023 in the Baseline scenario. However, in the Reference and Mitigation scenarios the full benefits of the rolled-back NSPS rules are assumed. The difference in emissions in 2023 is shown in Figure 11 below.

[28] Grant et al., "Revised Final Report: 2028 Future Year Oil and Gas Emission Inventory for WESTAR-WRAP States - Scenario #1: Continuation of Historical Trends."

Figure 11. Oil & gas sector emissions in 2023 by scenario



The Reference and Mitigation forecasts estimate further emissions reductions beyond 2023 by including the effect of the proposed state rules to target waste and ozone precursors. These rulemakings are ongoing, so this analysis shows benefits ranging from 30% to 90% reduction in oil and gas methane emissions relative to 2023.

Figure 12 shows the effect of the various policies modeled within the Reference scenario. The next section includes further disaggregation of the emissions reductions achieved through the "Non-Oil and Gas Reductions" wedge, but this figure focuses on emissions reductions achievable through federal and state policies targeting the oil and gas sector. The estimated impact of the NSPS rollback on oil and gas sector emissions is included as a "Federal Regulation Uncertainty" wedge.

Figure 12. Reference Scenario emissions reductions by measure through 2030

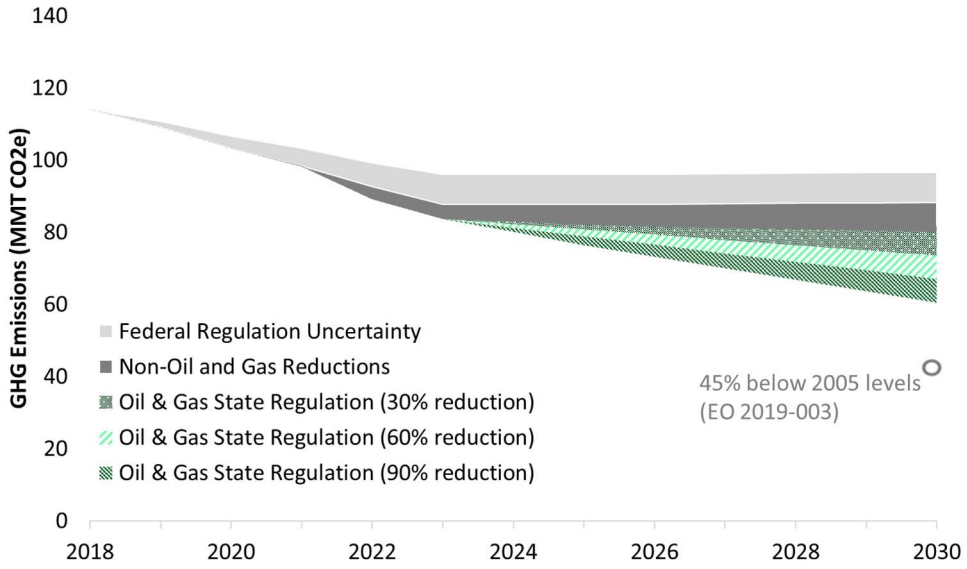


Table 20. Reference Scenario emissions reductions by measure: 2030 reduction snapshot (MMT CO2e)

Measure	2030 Reduction (MMT CO_2e)
Federal Regulation Uncertainty	8.34
Non-Oil and Gas Reductions	8.11
Oil & Gas State Regulation (30% reduction in fugitive CH_4 emissions from waste/ozone precursor rule relative to 2023)	6.53
Oil & Gas State Regulation (60% reduction in fugitive CH_4 emissions from waste/ozone precursor rule relative to 2023)	13.05
Oil & Gas State Regulation (90% reduction in fugitive CH_4 emissions from waste/ozone precursor rule relative to 2023)	19.58

Results from electricity, buildings, transportation, and other sectors

Figure 13 shows emissions by scenario, with a focus on all sectors of the economy except the oil and gas sector. As before, significant emissions reductions are attributed to Reference scenario policies, as well as further emissions reductions in the Mitigation scenario. The Baseline scenario excluding oil and gas sees emissions increase by 6% by 2030 relative to 2005 levels; the Reference scenario achieves a 20% reduction in emissions levels by 2030 relative to 2005 levels; the Mitigation scenario achieves 45% emissions reductions by 2030 relative to 2005 levels, a level consistent with the 45% emissions target set in EO 2019-003.

Note the specific policies included within the Mitigation scenario are included in Table 19, above. This Mitigation scenario includes aggressive mitigation policies broadly consistent with the level of effort seen in similar economy-wide mitigation targets as seen in states such as California, Colorado, or New York; these include measures such as building and transportation electrification,

low-carbon fuels, significant energy efficiency and conservation measures.[29] The Mitigation scenario included in this report is meant to provide a sense of scale for what sorts of policies might be necessary to achieve economywide decarbonization, but is not a least-cost optimization or a specific action plan for the State.

Figure 13. Baseline, Reference, and Mitigation case emissions forecast, excluding oil and gas sector emissions, through 2030

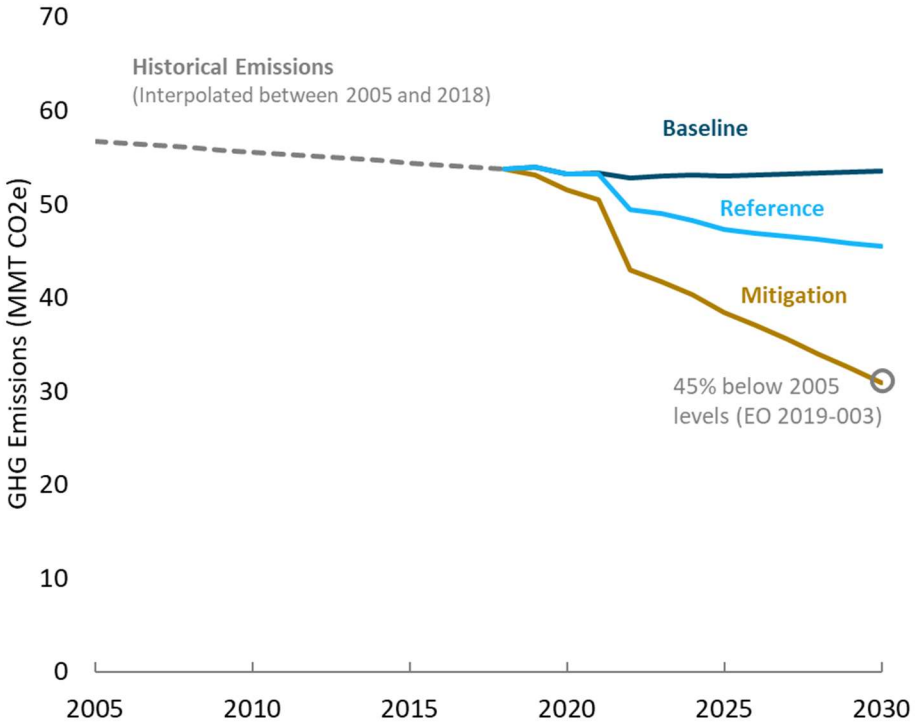


Figure 14 shows in more detail the level of emissions reductions achieved by Reference scenario policies. The Energy Transition Act (ETA) is the source of the majority of emissions reductions from non-oil-and-gas sectors. The significant drop in emissions in the 2022 time frame is associated with retirement of the San Juan coal generating station, while continued decreases in emissions through 2030 are associated with replacement of natural gas generation with zero carbon renewable generation, consistent with achieving the ETA's target of 50% renewable electricity by 2030.

[29] California Air Resources Board, "California's 2017 Climate Change Scoping Plan"; Energy and Environmental Economics Inc., "Pathways to Deep Decarbonization in New York State"; Mahone et al., "Deep Decarbonization in a High Renewables Future: Updated Results from the California PATHWAYS Model."

Figure 14. 2030 Reference Scenario emissions reductions by measure relative to the Baseline Scenario, excluding oil and gas, through 2030

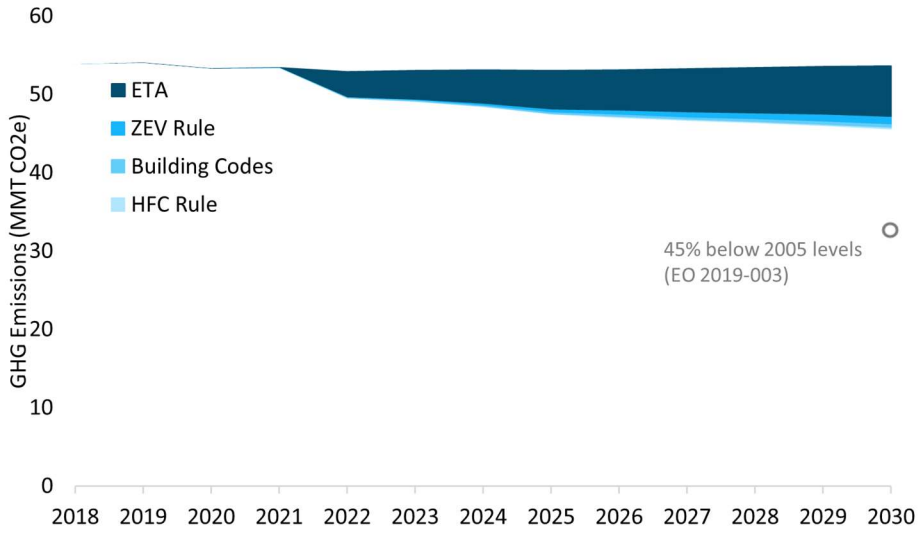


Table 21. Reference Scenario emissions reductions by measure relative to the Baseline Scenario, excluding oil and gas: 2030 reduction

Measure	2030 Reduction (MMT CO_2e)
ETA	6.49
ZEV Rule	0.97
Building Codes	0.47
HFC Rule	0.18

Figure 15 shows the growth in electricity sales in the Reference and Mitigation scenarios through 2030. Note this is a forecast of electricity sales, not of generation; this figure does not include the effects of transmission and distribution losses, which are captured in the generation graphics.

Figure 16 shows the impacts of the ETA on electricity generation with a comparison of generation sources by scenario for the Reference and Mitigation scenarios. It is important to note this electricity accounting framework assumes existing fossil units are run at their 2018 generation levels until plant retirement, and any incremental generation necessary to meet load is provided by either renewables or natural gas fired generation. In the Reference scenario E3 assume incremental renewables sufficient to ensure 50% RPS standard in 2030, whereas in the Mitigation scenario all incremental generation is met by renewables, with no incremental natural gas generation. A sophisticated capacity expansion, electricity dispatch, and electric reliability model was not run for this analysis.

Figure 15. Electricity sales by sector, Reference and Mitigation scenarios: 2018-2030

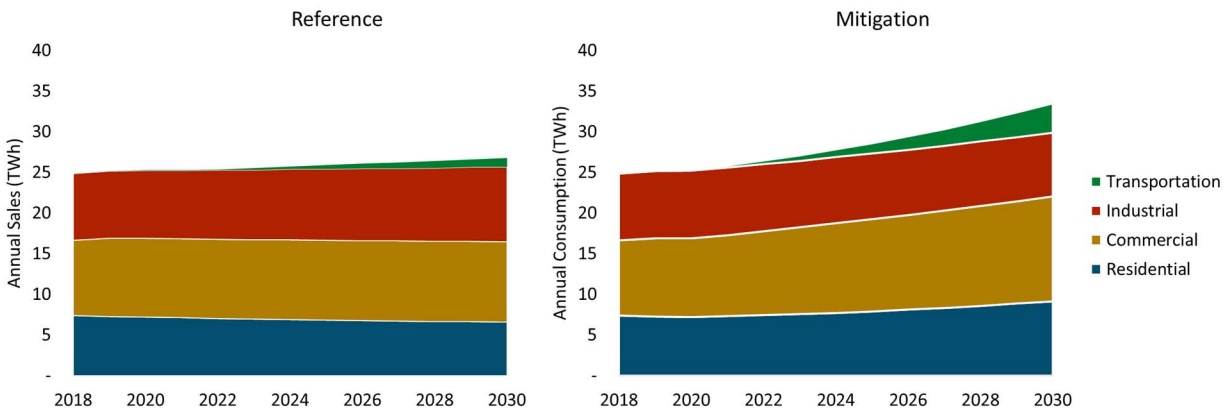


Figure 16. Electricity generation by source, Reference and Mitigation scenarios (2020,2030)

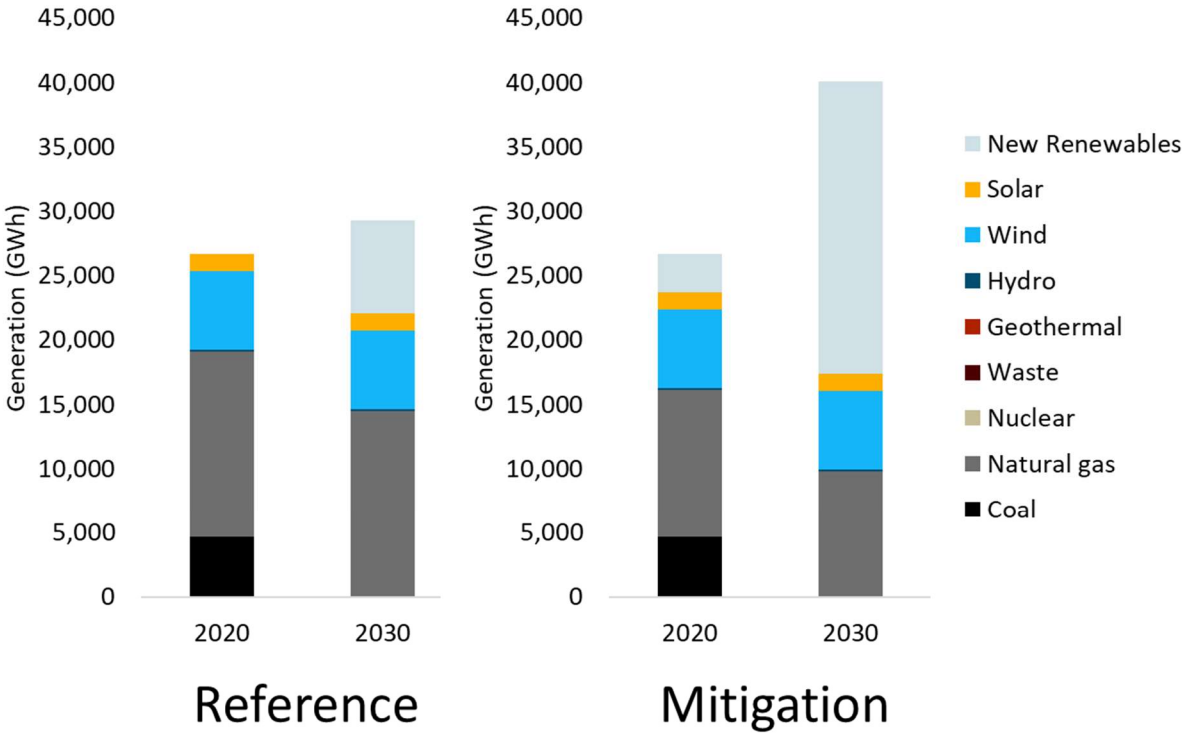
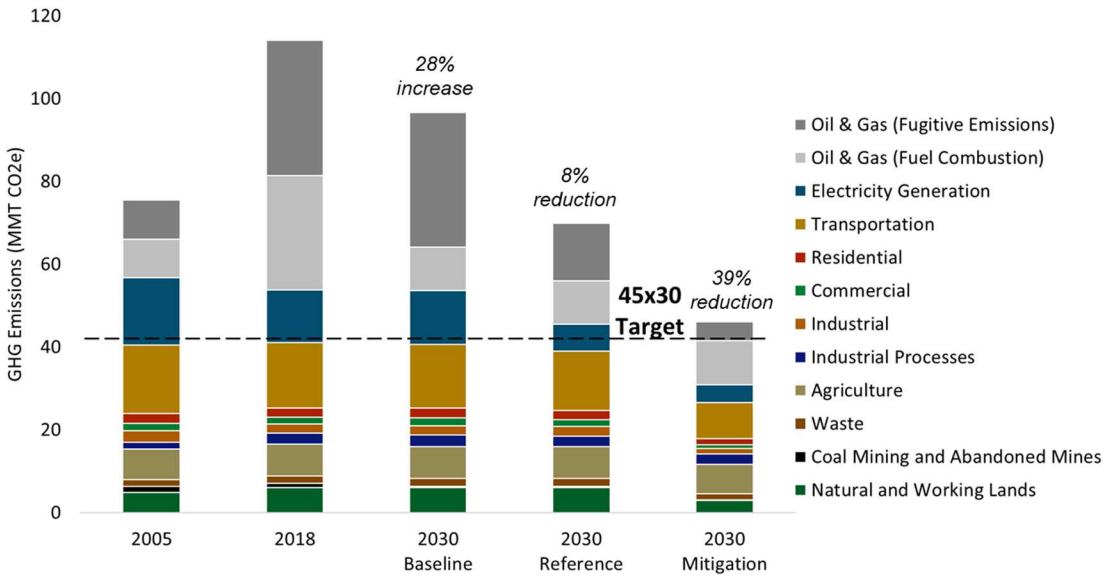


Figure 17 and Table 22 provide a comparison of emissions by sector in 2030 compared to 2005 and 2018, while Figure 18 shows a comparison of emissions by sector through 2030 for the Reference and Mitigation scenarios.

Figure 17. Economywide emissions: 2005, 2018, 2030 emissions by sector



Note: As shown in Figure 9 we include a range of fugitive CH_4 emissions reductions in the Reference scenario. Figure 17, Table 22, and Figure 18 show the central estimate of 60% reduction in fugitive CH_4 emissions intensity from oil and gas sector by 2030 in the Reference scenario.

Table 22. Economywide emissions: 2005, 2018, 2030 emissions by sector

Sector	2005 (MMT $CO2_e$)	2018 (MMT $CO2_e$)	2030 Baseline (MMT $CO2_e$)	2030 Reference (MMT $CO2_e$)	2030 Mitigation (MMT $CO2_e$)
Natural and Working Lands	4.8	6.1	6.1	6.1	2.9
Coal Mining and Abandoned Mines	1.6	0.9	0.2	0.2	0.1
Waste	1.6	1.8	1.9	1.9	1.5
Agriculture	7.3	7.6	7.6	7.6	7.0
Industrial Processes	1.7	2.7	2.8	2.6	2.5
Industrial	2.8	2.1	2.3	2.3	1.3
Commercial	1.7	1.7	1.9	1.7	0.9
Residential	2.4	2.2	2.4	2.1	1.5
Transportation	16.5	15.8	15.4	14.4	8.7
Electricity Generation	16.3	12.6	12.9	6.4	4.3
Oil & Gas (Fuel Combustion)	9.3	27.7	10.5	10.5	10.5
Oil & Gas (Fugitive Emissions)	9.6	32.7	32.5	13.9	4.6
Total	**75.5**	**114.0**	**96.6**	**69.9**	**46.0**

Figure 18. Economywide emissions by sector: Reference and Mitigation scenarios through 2030

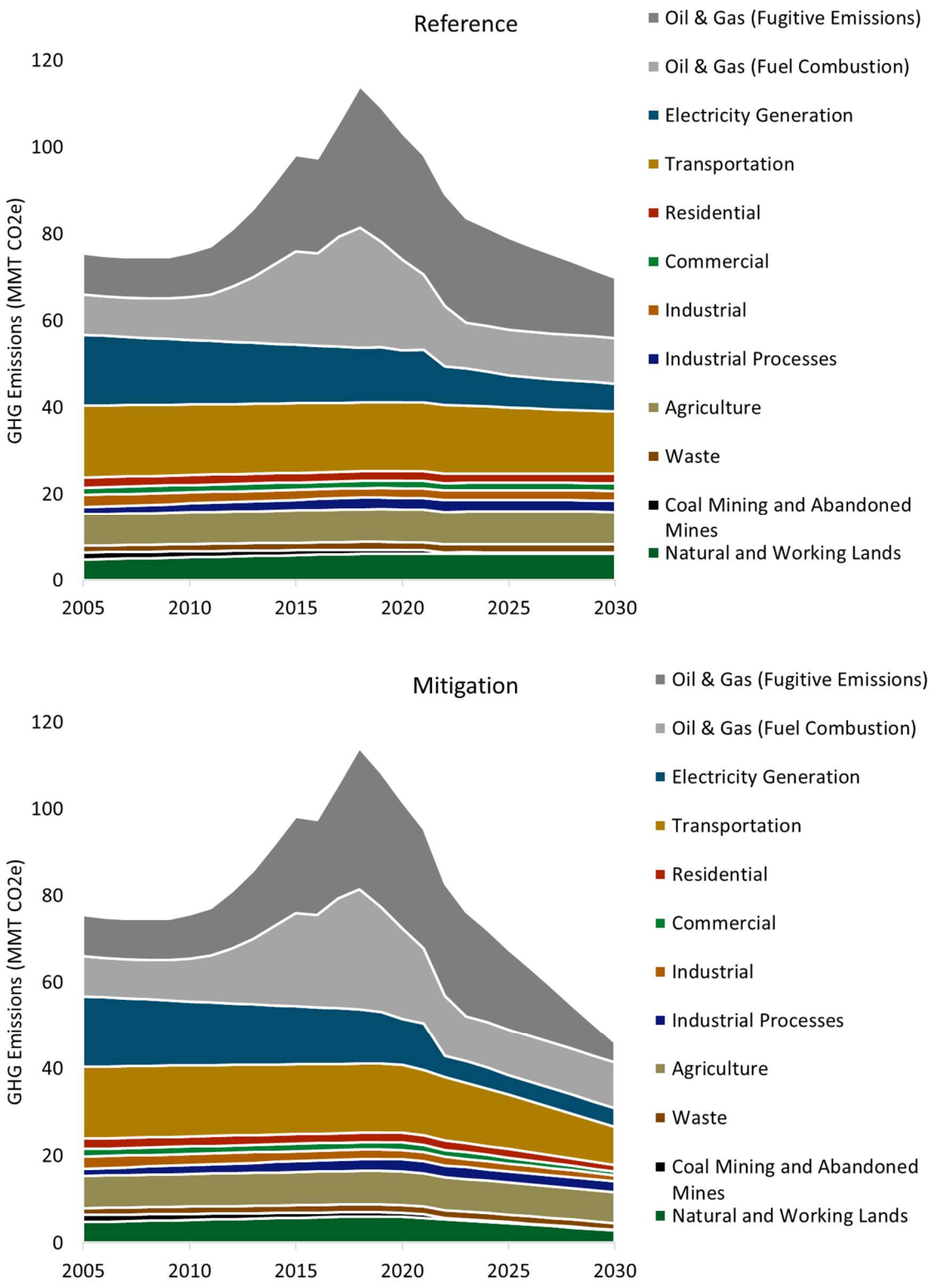
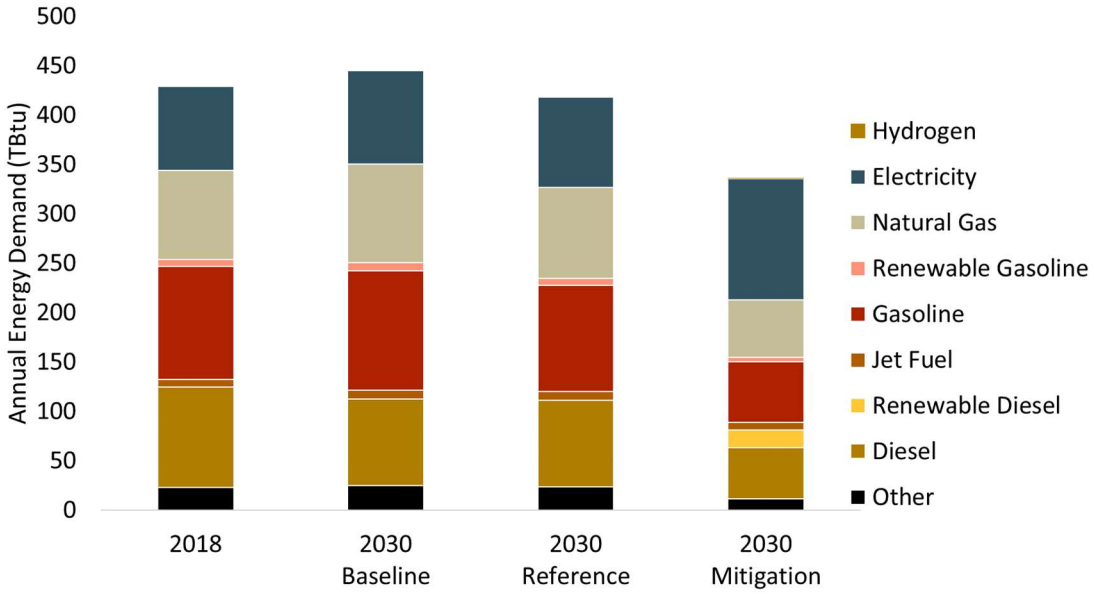


Figure 19 also highlights the impact of energy efficiency and electrification technologies on energy demand. The Baseline scenario shows an increase in energy demand in 2030 relative to 2018, driven by population and economic growth. The Reference scenario includes energy efficiency measures and shows a reduction relative to the Baseline, to return to about the level of energy demand as 2018. The Mitigation scenario includes incremental efficiency over the Reference with a significant decrease in energy demand relative to the Reference scenario by 2030, as well as a shift towards low carbon fuels as the Mitigation scenario includes use of renewable diesel as a strategy to decarbonize transportation fuels.

Figure 19. Economywide annual energy demand by fuel, excluding oil and gas: sectors: 2018 and 2030

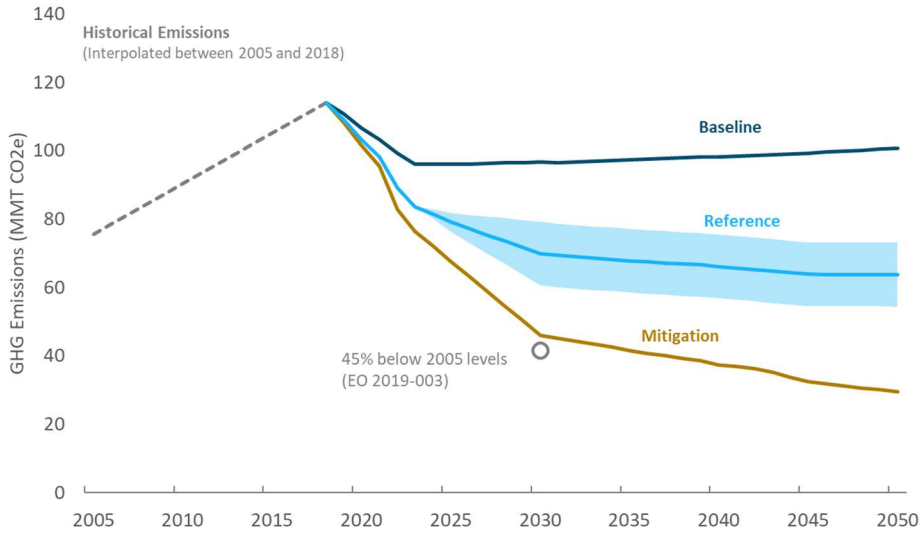


Results through 2050

Economy-wide emissions results

Figure 20 shows annual economy-wide emissions for the three scenarios through 2050. The Baseline scenario sees emissions continue to rise after 2023, while the Reference and Mitigation scenarios both see continued emissions reductions through 2050. The Reference scenario achieves a range of 3% to 28% reductions by 2050 relative to 2005, while the Mitigation scenario achieves 61% reductions by 2050 relative to 2005.

Figure 20. Baseline, Reference, and Mitigation case emissions forecast through 2050



Note the uncertainty band around the Reference scenario, which includes a range of emissions reductions achievable in the oil and gas sector depending on the effects of state policies. The central estimate includes a 60% reduction in fugitive emissions intensity from oil and gas sector by 2030, while the low and high bands show 30% and 90% reductions in fugitive emissions intensities in oil and gas by 2030.

Oil and Gas emissions results

Figure 21 shows the emissions modeled for the oil and gas sector through 2050. Beyond 2030 E3 assumed no change in oil production, emissions intensity of production, or in fugitive methane emissions. This results in a constant oil and gas GHG emissions beyond 2030. This is unlikely to play out, but without reliable forecasts of oil and gas production estimates it is difficult to estimate oil and gas emissions so far into the future.

Figure 21. Oil & Gas sector emissions reductions through 2050

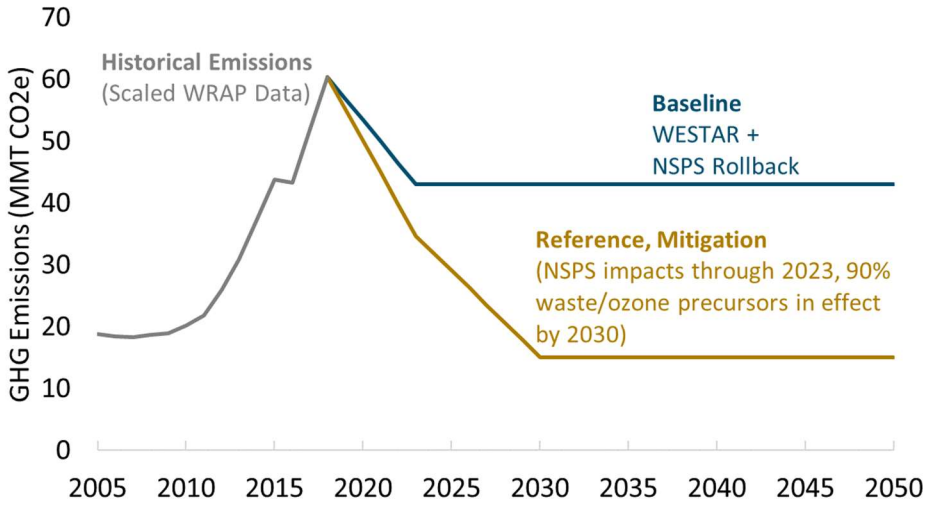


Figure 22 shows the emissions reductions achieved by the various policies modeled within the Reference scenario. The next section disaggregates emissions reductions from policies outside of the oil and gas sector, but this figure focuses on emissions reductions achievable through federal and state policies targeting the oil and gas sector. As described above, the oil and gas reductions are held constant beyond 2030, with only the "Non-Oil and Gas Reductions" wedge changing in size.

Figure 22. Reference Scenario emissions reductions by measure through 2050

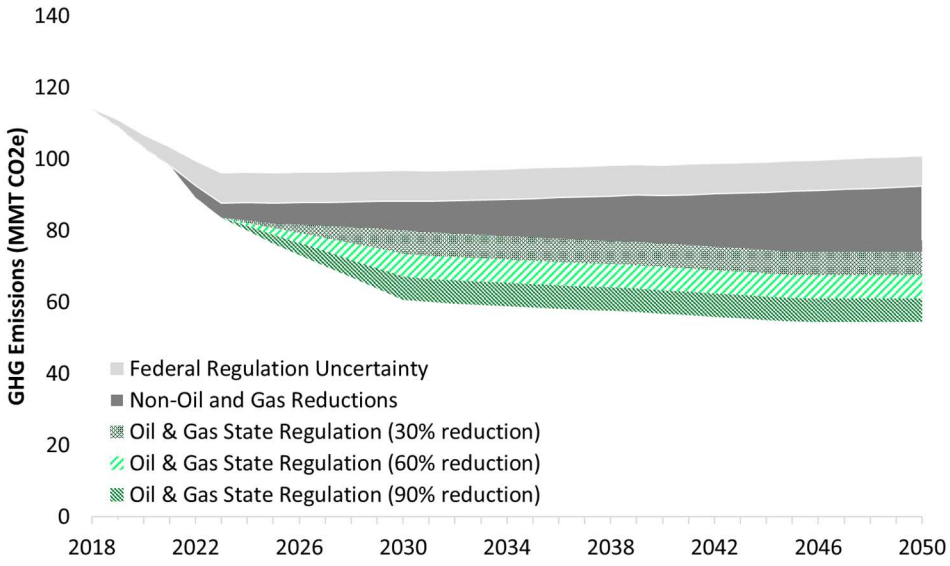


Table 23. Reference Scenario emissions reductions by measure: 2050 reduction

Measure	2050 Reduction (MMT CO_2e)
Federal Regulation Uncertainty	8.34
Non-Oil and Gas Reductions	18.44
Oil & Gas State Regulation (30% reduction in fugitive CH_4 emissions from waste/ozone precursor rule relative to 2023)	6.53
Oil & Gas State Regulation (60% reduction in fugitive CH_4 emissions from waste/ozone precursor rule relative to 2023)	13.05
Oil & Gas State Regulation (90% reduction in fugitive CH_4 emissions from waste/ozone precursor rule relative to 2023)	19.58

Results from electricity, buildings, transportation, and other sectors

Figure 23 shows emissions by scenario, with a focus on all sectors of the economy excluding the oil and gas sector. As before, significant emissions reductions are attributed to Reference scenario policies, as well as further emissions reductions in the Mitigation scenario. The Mitigation scenario included in this report is meant to provide a sense of scale for what sorts of policies might be necessary to achieve economywide decarbonization, but is not meant to be prescriptive. Note that New Mexico has a target for 2030 emissions, set by EO 2019-003, but does not have a 2050 target.

Note the specific policies included within the Mitigation scenario are described in Table 19, above. This Mitigation scenario includes aggressive mitigation policies such as building and transportation electrification, low-carbon fuels, significant energy efficiency and conservation measures.

Figure 23. Baseline, Reference, and Mitigation case emissions forecast, no oil and gas, through 2050

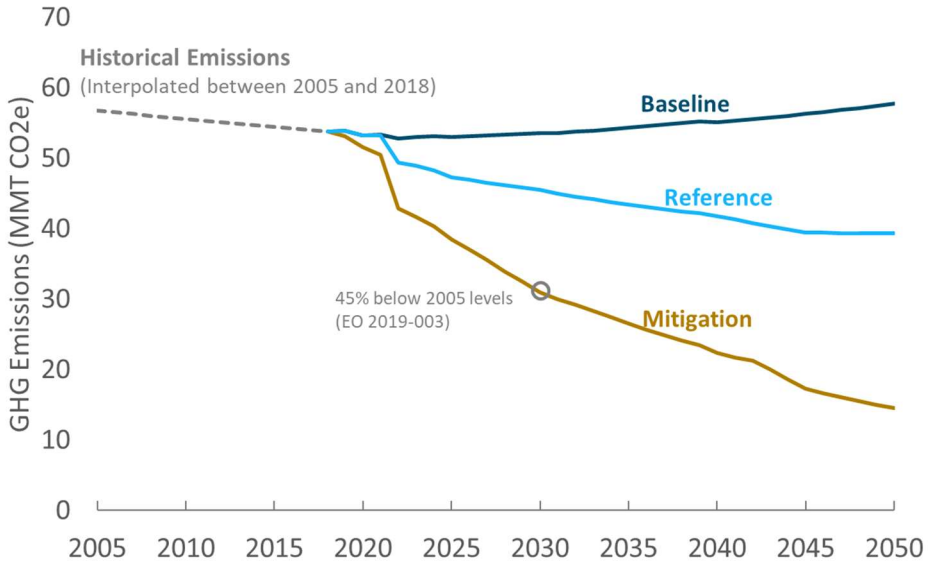


Figure 24 shows in more detail the level of emissions reductions achieved by Reference scenario policies. As can be seen in this figure, the Energy Transition Act (ETA) is source of the majority of emissions reductions from non-oil-and-gas sectors.

Figure 24. Reference Scenario emissions reductions by measure, no oil and gas, through 2050

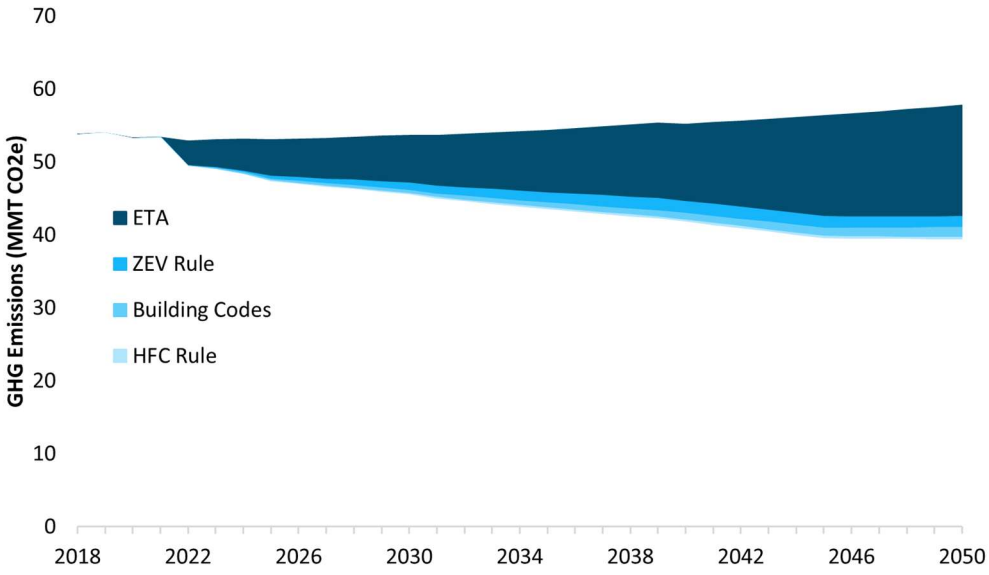


Table 24. Reference Scenario Emissions reductions by measure, no oil and gas: 2050 reduction

Measure	2050 Reduction (MMT CO_2e)
ETA	15.27
ZEV Rule	1.48
Building Codes	1.37
HFC Rule	0.33

Figure 25 shows the growth in electricity sales in the Reference and Mitigation scenarios through 2050. Note this is a forecast of electricity sales, not of generation; this figure does not include the effects of transmission and distribution losses, which are captured in the generation graphics.

Figure 26 shows the impacts of the ETA on electricity generation with a comparison of generation sources by scenario for the Reference and Mitigation scenarios.

The ETA requires investor-owned utilities to deliver 80% renewable energy generation by 2040, and 100% carbon-free (not necessarily renewable) by 2045, while rural co-ops must meet this target by 2050.[30] In the electricity accounting performed for this study, E3 assumed that the 80% RPS requirement as part of the ETA would continue to be binding in 2050, such that in 2050 the state's generation portfolio could be met by up to 20% carbon-free resources, which are not necessarily new renewable generation. A full capacity expansion and electricity dispatch model was outside the scope of this analysis, so E3 do not comment explicitly on the reliability or least cost pathways of achieving deeply decarbonized electricity generation. Various studies have been undertaken to identify challenges and solutions for decarbonization of the electricity generation sector.[31] These studies are not reviewed here but note that the accounting methodology E3 used in forecasting emissions for electricity generation in this study is agnostic as to the source of decarbonized electricity. New carbon-free resources could include wind, solar, battery storage, nuclear power, fossil units with carbon capture and storage (CCS), hydrogen, or renewable natural gas. Other more detailed analyses have found that at very high levels of renewable electricity, some form of firm dispatchable capacity is required to maintain a reliable and cost-effective electricity system.

[30] New Mexico Interagency Climate Change Task Force, "New Mexico Climate Strategy: Initial Recommendations and Status Update."

[31] Ribera and Sachs, "Pathways to Deep Decarbonization"; Mahone et al., "Deep Decarbonization in a High Renewables Future: Updated Results from the California PATHWAYS Model"; Energy and Environmental Economics Inc., "Pathways to Deep Decarbonization in New York State"; Jenkins, Luke, and Thernstrom, "Getting to Zero Carbon Emissions in the Electric Power Sector."

Figure 25. Electricity sales by sector, Reference and Mitigation scenarios: 2018 -2050

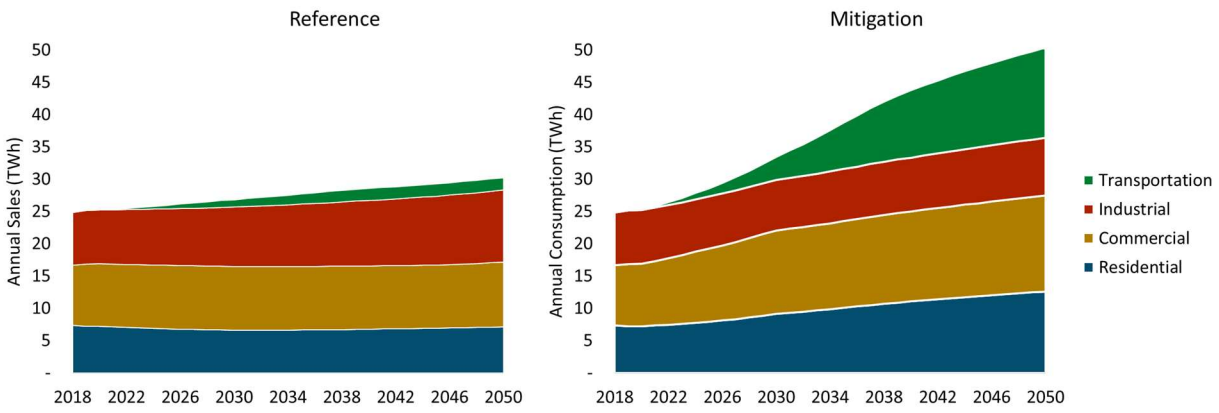


Figure 26. Electricity generation by source, Reference and Mitigation scenarios (2020,2030,2040,2050)

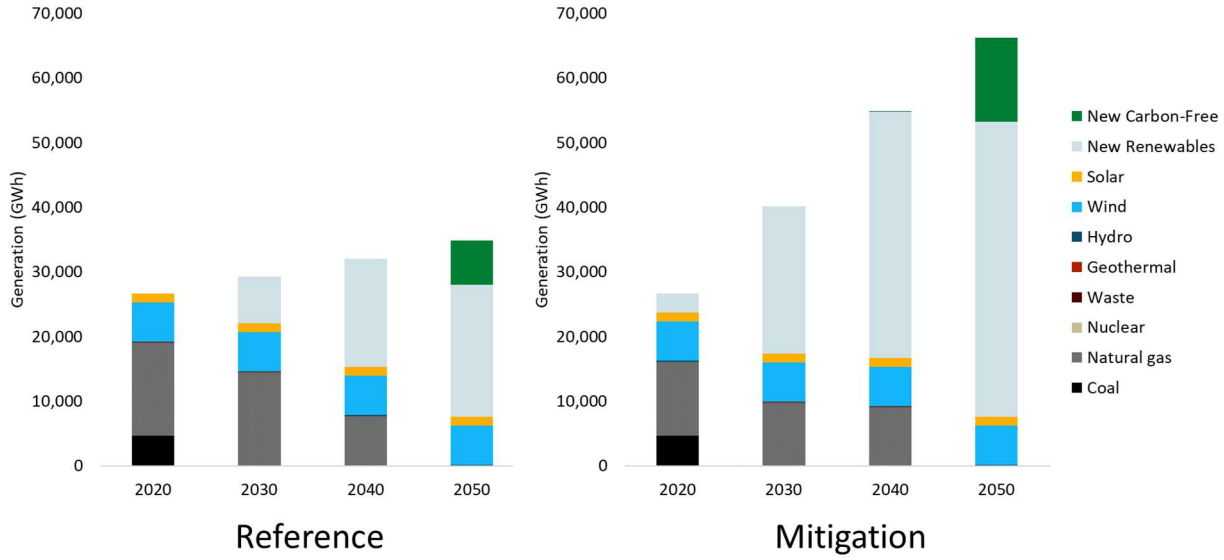
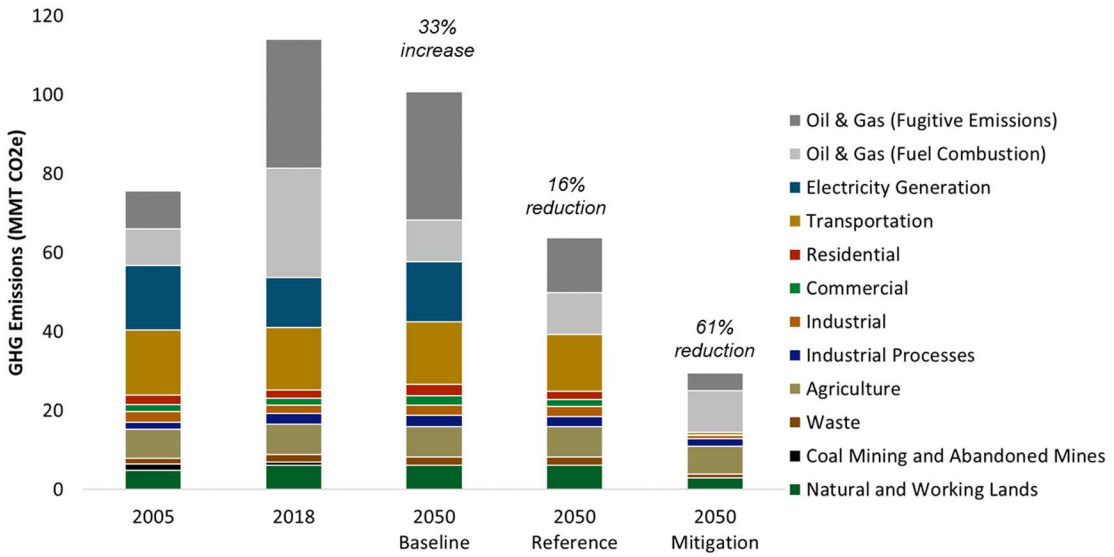


Figure 27 and

Table 25 provide a comparison of emissions by sector in 2050 compared to 2005 and 2018, while Figure 28 shows a comparison of emissions by sector through 2050 for the Reference and Mitigation scenarios.

Figure 27. Economywide emissions: 2005, 2018, 2050 emissions by sector



Note: As shown in Figure 20 we include a range of fugitive CH_4 emissions reductions in the Reference scenario. Figure 27 ,

Table 25, and Figure 28 show the central estimate of 60% reduction in fugitive CH_4 emissions intensity from oil and gas sector by 2030, and held constant through 2050 in the Reference scenario.

Table 25. Economywide emissions: 2005, 2018, 2050 emissions by sector

Sector	2005 ($MMT CO2_e$)	2018 ($MMT CO2_e$)	2050 Baseline ($MMT CO2_e$)	2050 Reference ($MMT CO2_e$)	2050 Mitigation ($MMT CO2_e$)
Natural and Working Lands	4.8	6.1	6.1	6.1	2.9
Coal Mining and Abandoned Mines	1.6	0.9	0.0	0.0	0.0
Waste	1.6	1.8	2.2	2.2	0.9
Agriculture	7.3	7.6	7.6	7.6	7.0
Industrial Processes	1.7	2.7	2.9	2.6	1.9
Industrial	2.8	2.1	2.6	2.6	0.9
Commercial	1.7	1.7	2.4	1.7	0.0
Residential	2.4	2.2	2.8	2.1	0.1
Transportation	16.5	15.8	15.9	14.5	0.7
Electricity Generation	16.3	12.6	15.3	0.0	0.0
Oil & Gas (Fuel Combustion)	9.3	27.7	10.5	10.5	10.5
Oil & Gas (Fugitive Emissions)	9.6	32.7	32.5	13.9	4.6
Total	**75.5**	**114.0**	**100.8**	**63.7**	**29.6**

Figure 28. Economywide emissions by sector: Reference and Mitigation scenarios through 2050

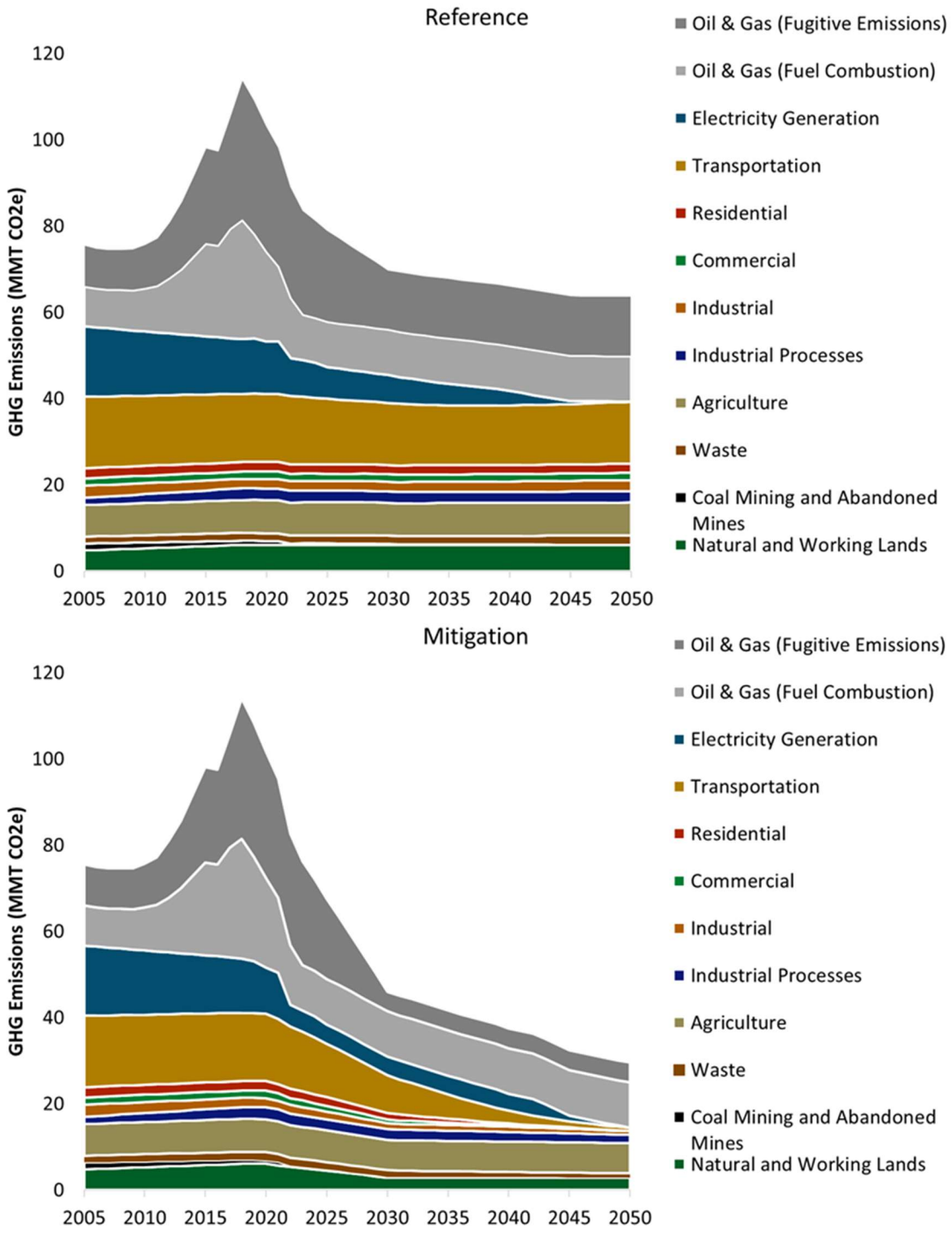
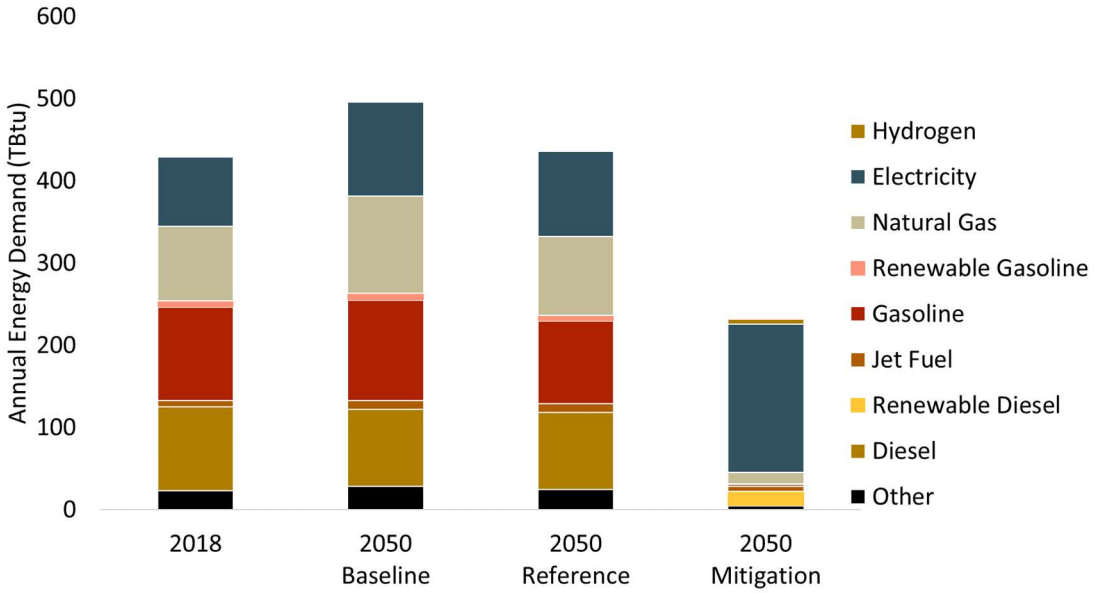


Figure 29 shows the impact of energy efficiency measures in the Reference scenario, as the gap between the Baseline and the Reference scenario continues to grow from 2030 through 2050. However, the Mitigation scenario shows a dramatic reduction in energy demand relative to the Reference scenario. This is due to both increased energy efficiency measures, as well as the fuel switching of various fossil fuel demands (such as space heating and vehicles) to electricity. Electric vehicles and heat pump space heaters are significantly more efficient than the fossil replacements, reaching efficiencies of three times or more relative to their counterparts, and therefore electrification of fossil energy demands acts as an efficiency measure.

Figure 29. Economywide annual energy demand by fuel, no oil and gas: 2018 and 2050



5. Conclusion

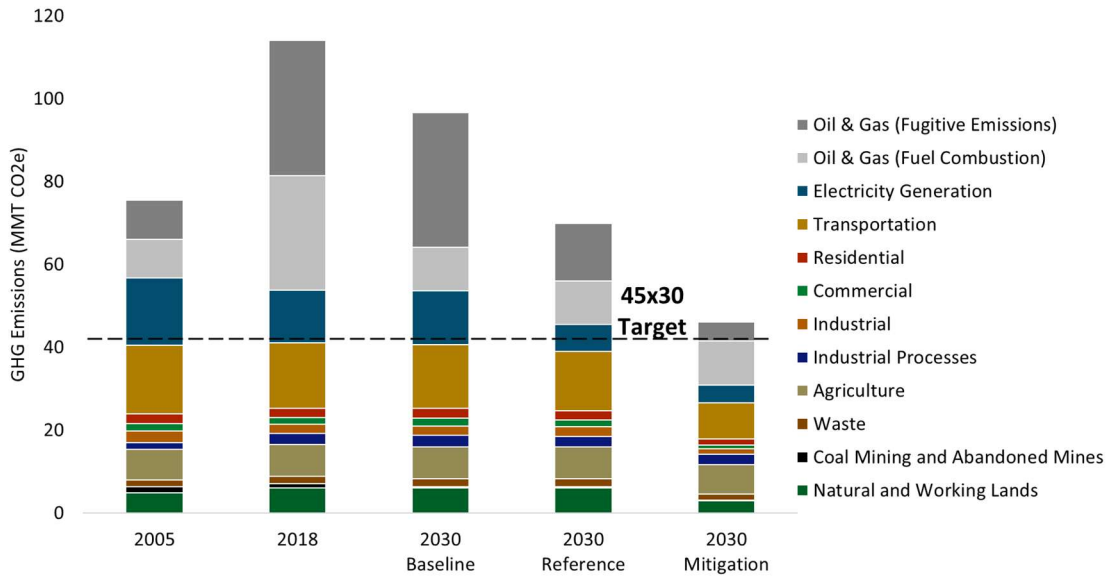
This report has estimated greenhouse gas emissions in New Mexico for 2005 and 2018, and has produced an analysis of emissions in the state for 2030 and 2050 under three scenarios: one business as usual scenario representing federal but no state energy and climate policies (Baseline), one scenario represent current state policies (Reference), and one illustrative scenario representing deep decarbonization measures (Mitigation). Key conclusions are discussed below.

Oil and gas production dominates the emissions inventory. Data collection and data verification in the oil and gas sector is a challenge. Further study is needed to confirm sources of oil and gas emissions, emission reductions from state and federal policies, and forecasts under varying scenarios of both production and policy, as well as to identify strategies which can reduce emissions associated with fuel consumption and methane leakage. Federal action in the oil and gas sector, or lack thereof, can produce significant swings in oil and gas production and emissions forecasts.

Current policies are key to moving towards deep decarbonization targets economywide. Key existing policies are the ETA, which drives significant electricity sector decarbonization, adoption of zero-emission vehicles, more stringent building codes, HFC reductions, and waste and volatile organic compound rules reducing fugitive emissions in oil and gas. Within the past two years since Governor Lujan-Grisham signed EO 2019-003, the State has implemented or made strides towards policies that move significantly towards the 2030 carbon target.

Existing statewide policies are not sufficient to meet 2030 carbon goals, and additional policy action is necessary. Although current policies put the State on a path to achieving significant carbon reductions by 2030, as seen in Figure 30 the Reference Scenario does not achieve the 2030 carbon target: this scenario is above the 2030 target by 28 MMT CO_2e. There is a 14 MMT CO_2e gap between the target and Reference Scenario emissions in 2030 even when considering an accounting framework which discounts oil and gas emissions.

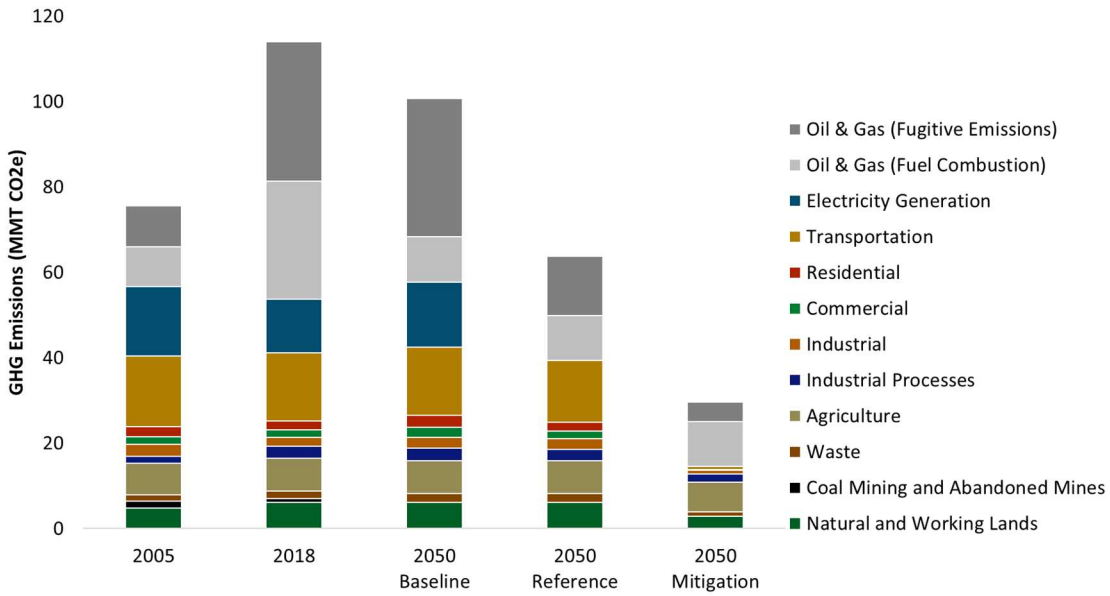
Figure 30. Economywide emissions by sector: 2005, 2018, 2030



Given the significant role of the oil and gas sector, targeting only energy combustion emissions, even with aggressive action, is not sufficient to achieve the 2030 target. The illustrative mitigation measures assume the state pursues additional action in vehicle electrification, building efficiency and electrification, and advanced biofuels. As seen in Figure 30, these measures achieve significant decarbonization through the 2030 time frame, but are not quite sufficient to achieve a 45% reductions relative to 2005 levels. Further reductions outside of buildings, transportation and electricity generation are needed, primarily in oil and gas production but also in other non-energy sources such as agriculture and natural and working lands.

To achieve further deep decarbonization beyond the 45% by 2030 target, aggressive action must be pursued across all sectors. The Mitigation scenario includes ambitious and broad decarbonization measures across the economy, including electrification and energy efficiency in buildings and industry; electric vehicles in transportation; advanced renewable biofuel usage; full decarbonization of the electricity generation sector by 2050; and significant land use emissions reductions. With these measures in place the Mitigation scenario achieves further decreases in economywide emissions by 2050, as Figure 31 shows. However, other sources of emissions remain, primarily from oil and gas combustion and methane emissions; industrial process and waste emissions; natural and working lands; and agriculture.

Figure 31. Economywide emissions by sector: 2005, 2018, 2050



The state needs to intensify and accelerate mitigation measures which are in place to be on a pathway to economy-wide deep decarbonization. This could include measures such as earlier saturation of electric vehicles, early retirement of fossil fuel consuming equipment, pursuing further building shell weatherization, or increasing VMT reductions due to further densification or mass transit.

While New Mexico has a challenge in achieving deep decarbonization, current state policies show the potential to significantly reduce greenhouse gas emissions in the state. By continuing to expand these state policies and pursue more aggressive mitigation across the economy, New Mexico is well positioned to move towards deep decarbonization targets economywide.

6. Appendix

Energy and emissions benchmarking

Table 26 shows a detailed breakdown of energy use and emissions as categorized within the PATHWAYS modeling framework. Within each sector, PATHWAYS models energy demand by analyzing demand for specific energy services, which are represented by the subsectors below. These subsectors were aggregated into end use categories within the pie charts shown in Figure 7 and Figure 8, and the data underlying those are shown in Table 27.

Table 26. New Mexico GHG emissions and energy consumption by sector and end use: 2018

Subsector modeled in PATHWAYS	Sector	End Use categorized in pie charts	GHG Emissions (MMT CO2e)	Final Energy Consumption (TBtu)
Commercial Air Conditioning	Buildings	AC + Ventilation	0.01	2.17
Commercial Cooking	Buildings	Other	0.07	1.87
Commercial Other	Buildings	Other	0.83	35.03
Commercial Space Heating	Buildings	Space Heating	0.61	11.57
Commercial Water Heating	Buildings	Water Heating	0.21	3.95
Commercial General Service Lighting	Buildings	Lighting	-	0.89
Commercial High Intensity Discharge Lighting	Buildings	Lighting	-	0.04
Commercial Linear Fluorescent Lighting	Buildings	Lighting	-	2.31
Commercial Refrigeration	Buildings	Other	-	3.64
Commercial Ventilation	Buildings	AC + Ventilation	-	2.96
Industry Oil and Gas	Oil & Gas	Fuel Combustion	27.65	515.89
Industry Other	Other Industry	Industry Fuel Use	2.13	61.18
Residential Building Shell	Buildings	Other	-	-
Residential Clothes Washing	Buildings	Other	-	0.17
Residential Dishwashing	Buildings	Other	-	0.76
Residential Exterior Lighting	Buildings	Lighting	-	0.38
Residential Freezing	Buildings	Other	-	0.63
Residential General Service Lighting	Buildings	Lighting	-	2.30
Residential Linear Fluorescent Lighting	Buildings	Lighting	-	0.39
Residential Reflector Lighting	Buildings	Lighting	-	0.52
Residential Refrigeration	Buildings	Other	-	2.45
Residential Room Air Conditioning	Buildings	AC + Ventilation	-	0.40
Residential Central Air Conditioning	Buildings	AC + Ventilation	0.04	10.79
Residential Clothes Drying	Buildings	Other	0.02	1.97
Residential Cooking	Buildings	Other	0.04	1.38
Residential MF SH	Buildings	Space Heating	0.11	2.04

Subsector modeled in PATHWAYS	Sector	End Use categorized in pie charts	GHG Emissions (MMT CO2e)	Final Energy Consumption (TBtu)
Residential Other	Buildings	Other	0.06	11.15
Residential SF SH	Buildings	Space Heating	1.25	26.11
Residential Water Heating	Buildings	Water Heating	0.67	14.66
Transportation Aviation	Transportation	Aviation	0.59	7.64
Transportation Buses	Transportation	MDVs + HDVs	0.03	0.38
Transportation HDV	Transportation	MDVs + HDVs	1.74	23.40
Transportation Long LDV	Transportation	Passenger Vehicles	6.86	99.06
Transportation MDV	Transportation	MDVs + HDVs	2.35	31.55
Transportation Other	Transportation	Other	1.09	17.99
Transportation Short LDV	Transportation	Passenger Vehicles	3.20	47.44
Agriculture	Non-Energy	Agriculture	7.64	-
BECCS	Non-Energy	BECCS	-	-
Coal Mining and Abandoned Mines	Non-Energy	Coal Mining	0.95	-
Industrial Processes	Non-Energy	Industrial Processes	2.75	-
Natural Gas and Oil Systems	Oil & Gas	Fugitive Emissions	32.65	-
Natural and Working Lands	Non-Energy	Natural and Working Lands	6.06	-
Solid Waste	Non-Energy	Waste	1.59	-
Wastewater	Non-Energy	Waste	0.24	-
Electricity Generation	Electricity Generation	Distillate	0.00	-
Electricity Generation	Electricity Generation	Natural Gas	5.90	-
Electricity Generation	Electricity Generation	Coal	6.74	-

Table 27. New Mexico energy and emissions by sector: 2018

Sector Labels	End Use Labels	GHG Emissions (MMT CO2e)	Final Energy Consumption (Tbtu)
Buildings	AC + Ventilation	0.04	16.32
Buildings	Lighting	-	6.84
Buildings	Space Heating	1.96	39.72
Buildings	Water Heating	0.88	18.62
Buildings	Other	1.01	59.05
Other Industry	Industry Fuel Use	2.13	61.18
Transportation	Aviation	0.59	7.64
Transportation	MDVs + HDVs	4.11	55.33
Transportation	Passenger Vehicles	10.06	146.50
Transportation	Other	1.09	17.99
Non-Energy	Agriculture	7.64	-
Non-Energy	BECCS	-	-
Non-Energy	Coal Mining	0.95	-
Non-Energy	Industrial Processes	2.75	-
Non-Energy	Natural and Working Lands	6.06	-
Non-Energy	Waste	1.83	-
Electricity Generation	Distillate	0.00	-
Electricity Generation	Natural Gas	5.90	-
Electricity Generation	Coal	6.74	-
Oil & Gas	Fuel Combustion	27.65	515.89
Oil & Gas	Fugitive Emissions	32.65	-

WRAP emissions categorization

As discussed in the oil and gas inventory section above, E3 categorized WRAP emissions by source as either fuel combustion or non-fuel combustion sources. The categorization of WRAP source description to either fuel combustion or non-fuel combustion is found in Table 28.

Table 28. E3 categorization of WRAP source description as fuel combustion vs. non-fuel combustion

WRAP Source Description	E3 Category
Artificial Lift	Fuel Combustion
Artificial Lift Engines	Fuel Combustion
Blowdown Flaring	Non-Fuel Combustion
Casinghead Gas Flaring	Non-Fuel Combustion
Casinghead Gas Venting	Non-Fuel Combustion

WRAP Source Description	E3 Category
CBM Fired 2Cycle Lean Burn Compressor Engines 50 To 499 HP	Fuel Combustion
CBM Fired 4Cycle Lean Burn Compressor Engines 50 To 499 HP	Fuel Combustion
CBM Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP	Fuel Combustion
CBM Well Completion: All Processes	Non-Fuel Combustion
CBM Well Heaters	Fuel Combustion
CBM Well Truck Loading	Non-Fuel Combustion
CBM Well Venting - Blowdowns	Non-Fuel Combustion
Completions	Non-Fuel Combustion
Condensate tank	Non-Fuel Combustion
Condensate tank flaring	Non-Fuel Combustion
Condensate Tanks	Non-Fuel Combustion
Dehydrator	Fuel Combustion
Dehydrator Flaring	Non-Fuel Combustion
Dehydrators	Fuel Combustion
Drill Rigs	Fuel Combustion
Fracing	Fuel Combustion
Fugitives: Connectors	Non-Fuel Combustion
Fugitives: Flanges	Non-Fuel Combustion
Fugitives: Open Ended Lines	Non-Fuel Combustion
Fugitives: Other	Non-Fuel Combustion
Fugitives: Valves	Non-Fuel Combustion
Gas Well Completion: All Processes	Non-Fuel Combustion
Gas Well Dehydrators	Fuel Combustion
Gas Well Heaters	Fuel Combustion
Gas Well Pneumatic Devices	Fuel Combustion
Gas Well Pneumatic Pumps	Fuel Combustion
Gas Well Truck Loading	Non-Fuel Combustion
Gas Well Venting - Blowdowns	Non-Fuel Combustion
Hydraulic Fracturing Engines	Fuel Combustion
Initial completion Flaring	Non-Fuel Combustion
Lateral Compressors 4 Cycle Lean Burn	Fuel Combustion
Lateral Compressors 4 Cycle Rich Burn	Fuel Combustion
Mud Degassing	Non-Fuel Combustion
Natural Gas Fired 2Cycle Lean Burn Compressor Engines 50 To 499 HP	Fuel Combustion
Natural Gas Fired 4Cycle Lean Burn Compressor Engines 50 To 499 HP	Fuel Combustion
Natural Gas Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP	Fuel Combustion
Nonpoint Compressor Engines	Fuel Combustion
Nonpoint Fugitives	Non-Fuel Combustion
Nonpoint Heaters	Fuel Combustion

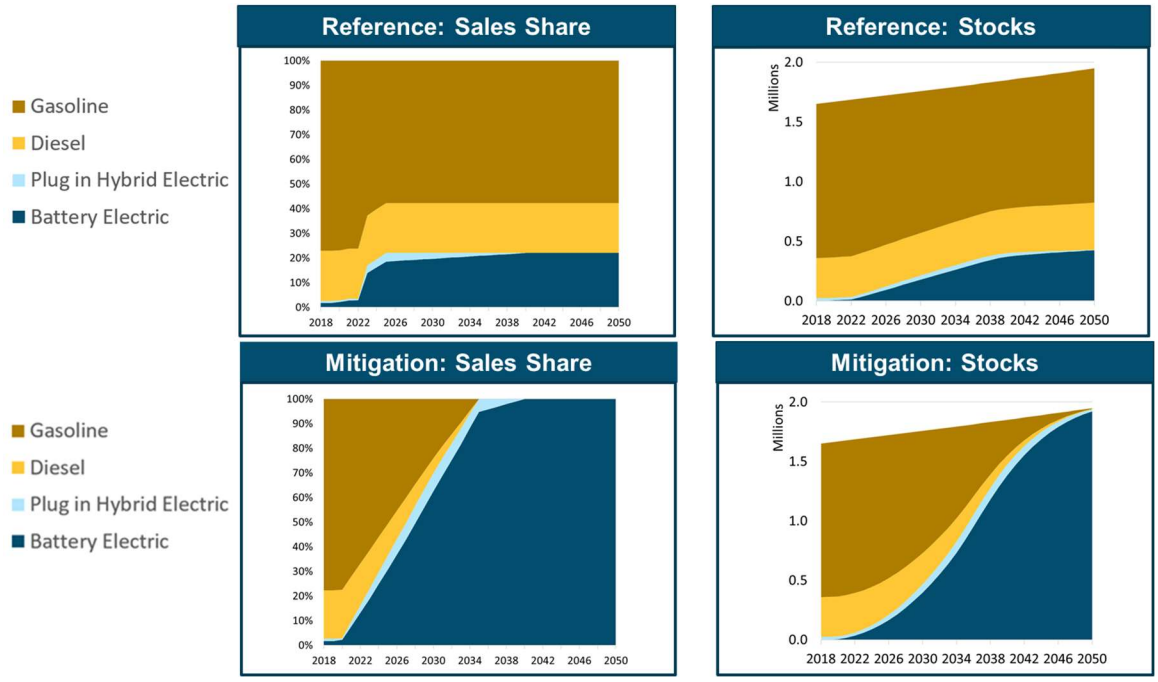
WRAP Source Description	E3 Category
Oil Tank	Non-Fuel Combustion
Oil Tank Flaring	Non-Fuel Combustion
Oil Tanks	Non-Fuel Combustion
Oil Well Completion: All Processes	Non-Fuel Combustion
Oil Well Heaters	Fuel Combustion
Oil Well Pneumatic Devices	Fuel Combustion
Oil Well Pneumatic Pumps	Fuel Combustion
Oil Well Tanks - Flashing & Standing/Working/Breathing	Non-Fuel Combustion
Oil Well Truck Loading	Non-Fuel Combustion
Pneumatic Devices	Fuel Combustion
Pneumatic Pumps	Fuel Combustion
Produced water	Non-Fuel Combustion
Refracing	Non-Fuel Combustion
Storage Tanks: Condensate	Non-Fuel Combustion
Tank Truck/Railcar Loading: Condensate	Non-Fuel Combustion
Tank Truck/Railcar Loading: Crude Oil	Non-Fuel Combustion
Total: All Processes	Non-Fuel Combustion
Truck Loading	Non-Fuel Combustion
Venting - blowdowns	Non-Fuel Combustion
Venting - initial completions	Non-Fuel Combustion
Water Pump Engines	Fuel Combustion
Water Tank Flaring	Non-Fuel Combustion
Water Tank Venting	Non-Fuel Combustion
Well Venting	Non-Fuel Combustion
Well-head Engines	Fuel Combustion
Workover rigs	Fuel Combustion
4-cycle Lean Burn	Fuel Combustion
4-cycle Rich Burn	Fuel Combustion
Amine Units	Non-Fuel Combustion
Fixed Roof Tank, Condensate, working+breathing+flashing losses	Non-Fuel Combustion
Fugitive Emissions	Non-Fuel Combustion
Internal Floating Roof Tank, Condensate, working+breathing+flashing	Non-Fuel Combustion
Midstream Unclassified	Non-Fuel Combustion
Other Not Classified	Non-Fuel Combustion
Point Source Compressor Engines	Fuel Combustion
Point Source Dehydrators	Fuel Combustion
Point Source Flares	Non-Fuel Combustion
Point Source Fugitives	Non-Fuel Combustion
Point Source Heaters	Fuel Combustion

WRAP Source Description	E3 Category
Point Source Tank Losses	Non-Fuel Combustion
Point Source Venting	Non-Fuel Combustion
Turbine	Fuel Combustion
(blank)	Fuel Combustion

Light duty vehicle stocks and sales graphics

Figure 32 shows the stocks and sales of light duty vehicles, to illustrate the stock rollover approach within PATHWAYS. Note the delay between increased sales share of electric vehicles in the Mitigation case, which achieve nearly 100% EV sales by 2035, while it takes almost until 2050 to reach a similar penetration of EV stock due to the time it takes for vehicles to naturally retire. One way to accelerate this process would be to pursue accelerated retirements, such as equipment buybacks, but E3 have not analyzed that approach in this study.

Figure 32. Light duty vehicle (LDV) stocks and sales shares through 2050



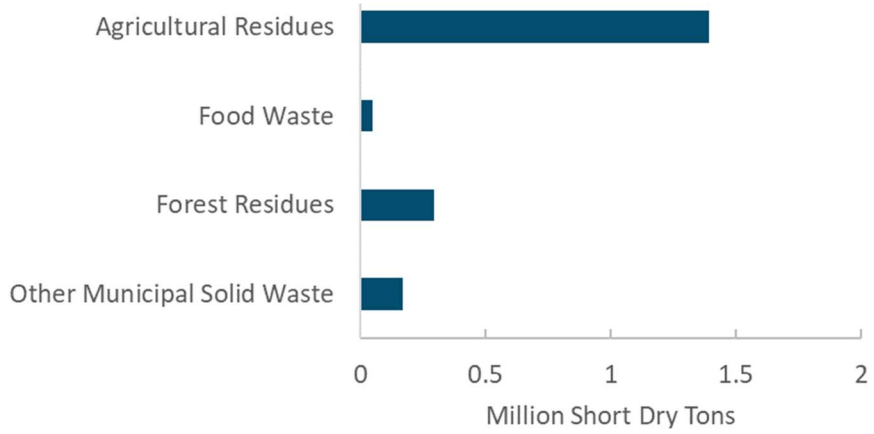
Advanced renewable biofuels

In addition to electrification as a decarbonization pathway, advanced renewable biofuels were included as low carbon fuel options. To analyze availability of low-carbon biofuels feedstock, E3 relied on a US Department of Energy report on biomass availability within the United States, the *2016 Billion-Ton Report.*[32] This report provides county level estimates of sustainable potential biomass production for a variety of feedstocks, including agricultural, forestry, and waste streams.

In this analysis E3 assumed that New Mexico would have access to its population-weighted share of the total national feedstock supply of wastes and residues. This approach assumes that all US states begin transitioning to developing advanced biofuels with these resources, and thus New Mexico has access to a nationwide advanced biofuels market, as opposed to being limited to in-state feedstocks solely.

Figure 33 shows New Mexico's population-weighted share of national estimated biomass feedstock supply in 2050. E3 chose to limit available feedstocks to wastes and residues like agricultural residues, food waste, forest residues, municipal solid waste, and manure, since these typically have fewer concerns about land-use constraints and competition with food crop than purpose-grown energy crops.

Figure 33. Projected New Mexico share of national available feedstocks in 2050



To calculate the optimal portfolio of biofuels, E3 has developed a model which generates biofuel supply curves that determine the availability and cost of renewable liquid and gaseous fuels. The model optimizes the selection of combinations of feedstocks and conversion pathways. The model adds preparation, process, transportation, and delivery costs to feedstock cost curves to achieve supply curves by feedstock and conversion pathway. To obtain biofuel demand, E3 applied the percentage biofuel penetration targets to aggregate calculated final energy demand.

[32] Langholtz et al., "2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy."

7. Bibliography

Abt Associates. "The Emissions & Generation Resource Integrated Database: Technical Support Document for EGRID with Year 2018 Data." Washington, DC, 2020. https://www.epa.gov/sites/production/files/2020-01/documents/egrid2018_technical_support_document.pdf.

California Air Resources Board. "California's 2017 Climate Change Scoping Plan." Sacramento, CA, 2017. https://ww2.arb.ca.gov/sites/default/files/classic//cc/scopingplan/scoping_plan_2017.pdf.

Chong, Hoyu. "COVID-19, Commuting, and Clean Air: A Look at Pandemic-Era Mobility and Transportation Emissions in California." Riverside, CA, 2020. https://ucreconomicforecast.org/wp-content/uploads/2020/08/Mobility_Emissions_COVID19_CEFD_White_Paper_August_2020.pdf.

Energy and Environmental Economics Inc. "Pathways to Deep Decarbonization in New York State." San Francisco, CA, 2020. https://climate.ny.gov/-/media/CLCPA/Files/2020-06-24-NYS-Decarbonization-Pathways-Report.pdf.

Grant, John, Rajashi Parikh, Amnon Bar-Ilan, and Ramboll Corporation. "Revised Final Report: 2028 Future Year Oil and Gas Emission Inventory for WESTAR-WRAP States - Scenario #1: Continuation of Historical Trends." Novato, California, 2020. https://www.wrapair2.org/pdf/WRAP_OGWG_2028_OTB_RevFinalReport_05March2020.pdf.

Grisham, Michelle Lujan. "Executive Order 2019-003: Executive Order Addressing Climate Change and Energy Waste Prevention." Santa Fe, NM: Governor of State of New Mexico, 2019. https://www.env.nm.gov/wp-content/uploads/sites/24/2018/05/EO_2019-003.pdf.

IPCC. "Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change." Geneva, Switzerland, 2014. https://www.ipcc.ch/report/ar5/syr/.

Jenkins, Jesse D., Max Luke, and Samuel Thernstrom. "Getting to Zero Carbon Emissions in the Electric Power Sector." *Joule*. Elsevier Inc., 2018. https://doi.org/10.1016/j.joule.2018.11.013.

Langholtz, B M H J, L M Stokes, Eaton, U.S. Department of Energy, M. H. Langholtz, B. J. Stokes, and L. M. Eaton. "2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy." *Oak Ridge National Laboratory*, 2016. https://www.energy.gov/sites/prod/files/2016/12/f34/2016_billion_ton_report_12.2.16_0.pdf.

Mahone, Amber, Zachary Subin, Jenya Kahn-Lang, Douglas Allen, Vivian Li, Gerritt De Moor, Nancy Ryan, and Snuller Price. "Deep Decarbonization in a High Renewables Future: Updated Results from the California PATHWAYS Model." San Francisco, CA, 2018. https://www.ethree.com/wp-content/uploads/2018/06/Deep_Decarbonization_in_a_High_Renewables_Future_CEC-

500-2018-012-1.pdf.

New Mexico Environment Department. Oil and Natural Gas Regulation for Ozone Precursors: Preliminary Draft, Pub. L. No. 20.2.50 (2020). https://www.env.nm.gov/new-mexico-methane-strategy/wp-content/uploads/sites/15/2020/07/Draft-Ozone-Precursor-Rule-for-Oil-and-Natural-Gas-Sector-Version-Date-7.20.20.pdf.

New Mexico Interagency Climate Change Task Force. "New Mexico Climate Strategy: Initial Recommendations and Status Update," 2019. https://www.climateaction.state.nm.us/documents/reports/NMClimateChange_2019.pdf.

Pickrell, Don, David Pace, and Jacob Wishart. "Development of VMT Forecasting Models for Use by the Federal Highway Administration," 2018. https://www.fhwa.dot.gov/policyinformation/tables/vmt/vmt_model_dev.cfm.

Ribera, Teresa, and Jeffrey Sachs. "Pathways to Deep Decarbonization," 2015.

Tang, Tianjia PhD., PE. "The Future of Travel Demand," n.d. https://www.nap.edu/resource/25334/interstate/assets/meeting2/1 Demographics and VMT Panel/TangTianjia.pdf.

Taylor, Z. Todd. "Preliminary Cost Effectiveness of the Residential 2018 IECC for the State of New Mexico," 2019.

U.S. Energy Information Administration. "A Guide to EIA Electric Power Data." Washington, DC, 2018. https://www.eia.gov/electricity/data/guide/pdf/guide.pdf.

———. "Annual Energy Outlook 2018." Washington, DC, 2018. https://www.eia.gov/outlooks/archive/aeo18/.

U.S. Environmental Protection Agency. Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources Review, Pub. L. No. 40 CFR Part 60 subpart OOOO, subpart OOOOa (2020). https://www.epa.gov/sites/production/files/2020-08/documents/frn_oil_and_gas_review_2060-at90_final_20200812_admin_web.pdf.

———. "Recent International Developments under the Montreal Protocol." Accessed August 20, 2020. https://www.epa.gov/ozone-layer-protection/recent-international-developments-under-montreal-protocol.

———. "State Inventory and Projection Tool." Washington, DC: State Energy and Environment Program, U.S. Environmental Protection Agency, 2019. https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool.

University of New Mexico Geospatial and Population Studies. "New Mexico Population Projections." Accessed August 15, 2020. https://gps.unm.edu/pru/projections.

US Energy Information Administration. "State Energy Data System 2018 Consumption Technical Notes." Washington, DC, 2020. https://www.eia.gov/state/seds/sep_use/notes/use_technotes.pdf.