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)

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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)

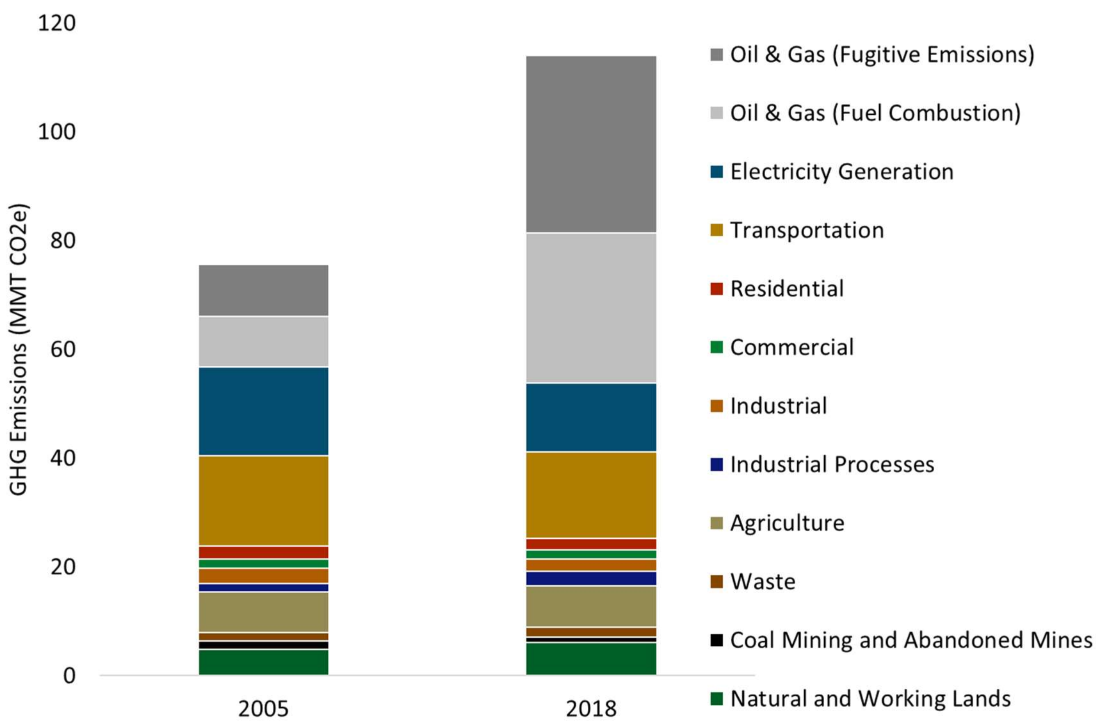


Table 2. Statewide annual emissions, 2005 and 2018

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)

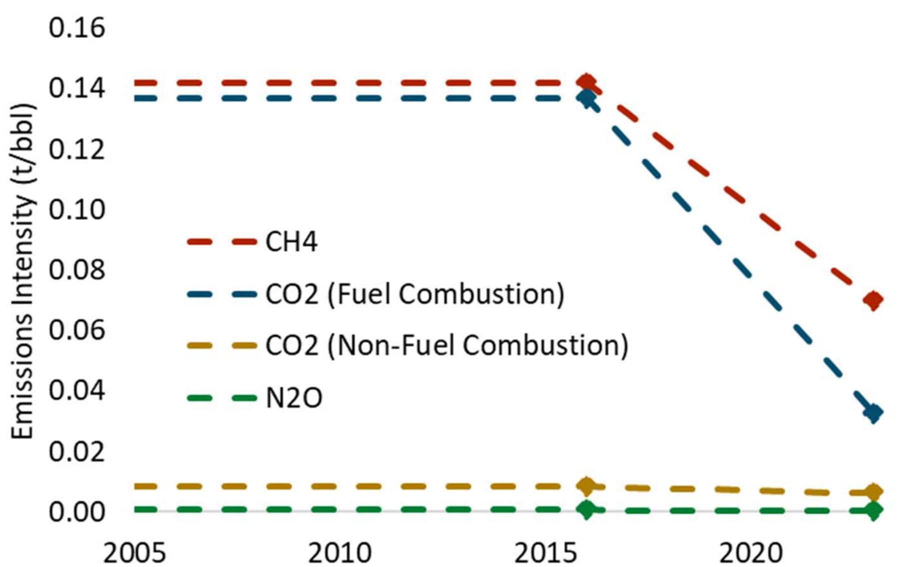
Basin	CO_2 (t/yr)	CH_4 (t/yr)	N_2O (t/yr)
San Juan	10,697,190	408,462	154
Permian	8,638,737	294,141	154
Pedregosa Basin	291,546	21	8
Basin-And-Range Province	289,521	30	8
Orogrande Basin	265,543	41	7
Raton	7,976	2,318	0
Estancia Basin	7,592	1	0
Sierra Grande Uplift	5,830	49	0
Grand Total	**20,203,936**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

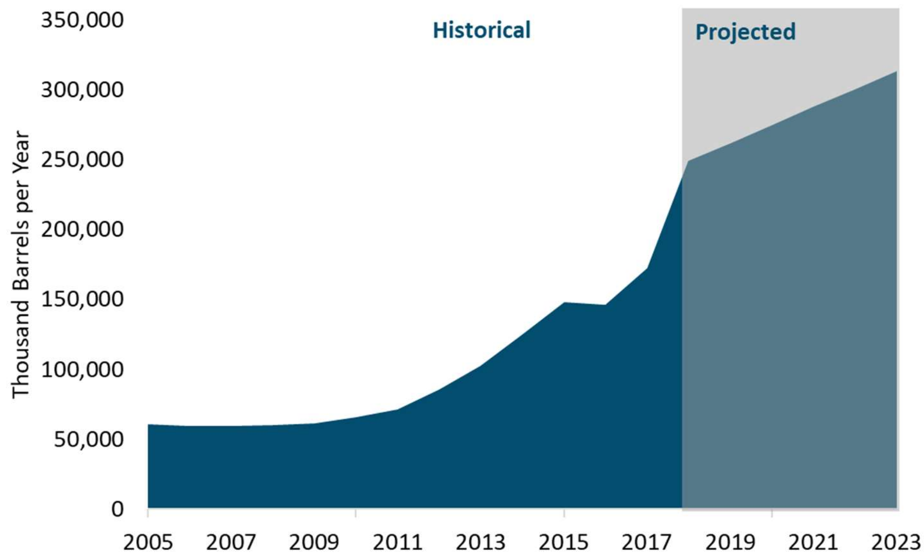
intensity with historical crude production (as displayed in Figure 3). When scaling emissions to 2018, E3 assumed a declining emissions intensity of production between the 2014-2016 starting point from WRAP inventory and the 2023 estimate from the WRAP baseline forecast. This emissions intensity was 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



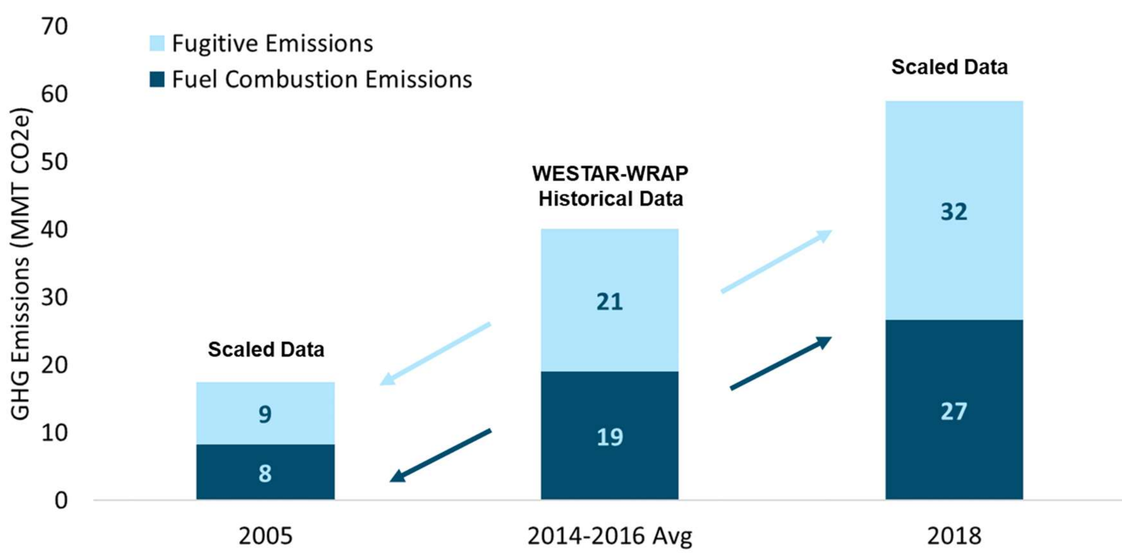
Source: 2014-2016 from WRAP inventory. The 2014-2016 values are assumed constant when back-casting to 2005. 2023 emissions intensities values sourced from WRAP baseline forecast, and 2016-2023 is a linear trendline

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

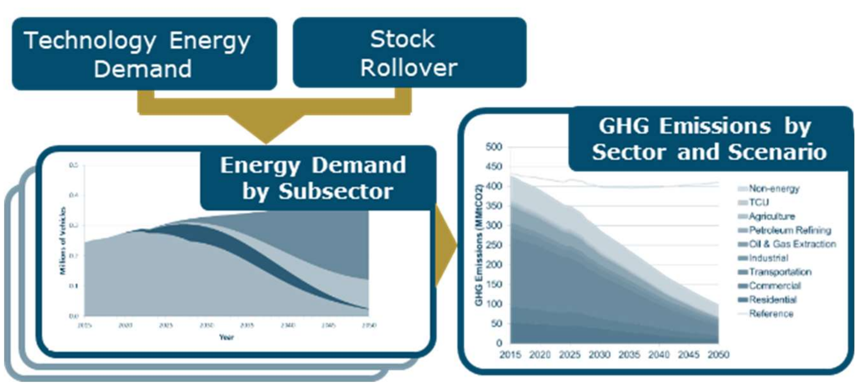
Model framework

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.

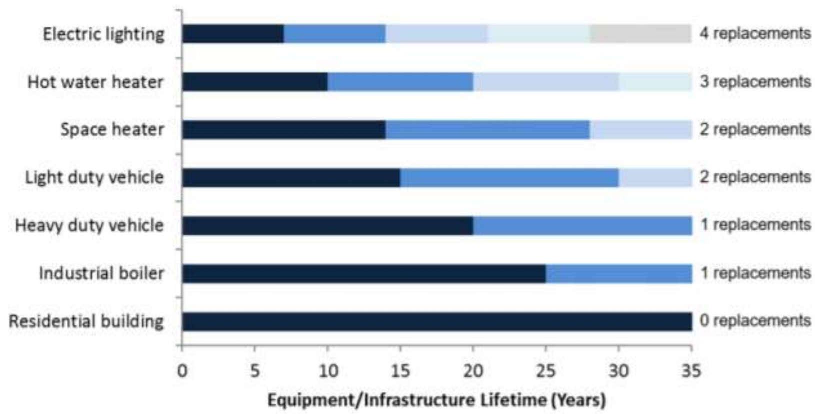
E3 developed a NM PATHWAYS model of bottom-up energy and emissions within all sectors of the economy, benchmarked to the 2018 inventory described in the previous section, and developed economy-wide emissions scenarios through 2050. The PATHWAYS model characterizes bottom-up and user-defined emissions 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.

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[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

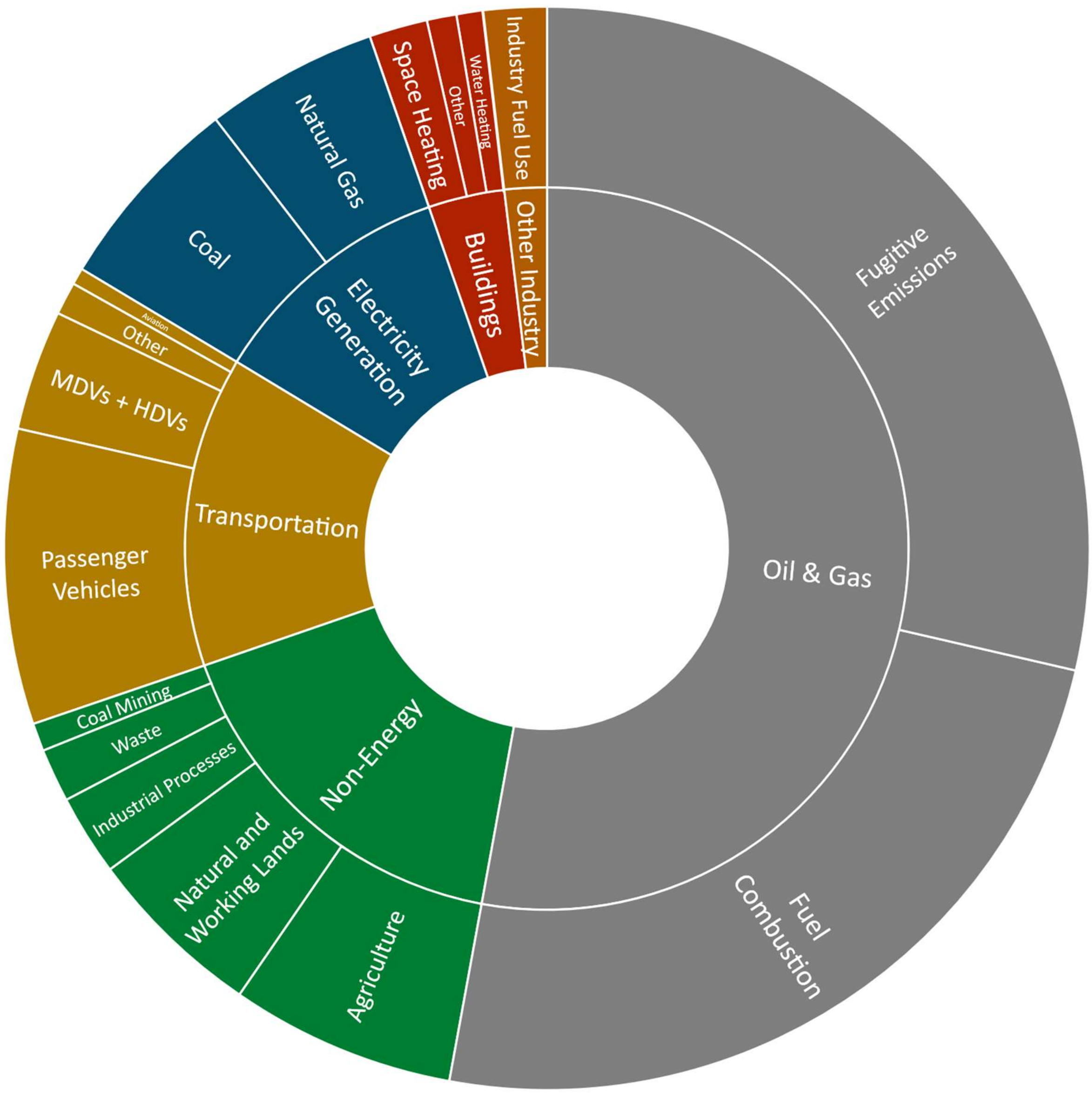


Figure 8. New Mexico GHG emissions in 2018: without oil and gas, by sector and subsector

Results through 2030

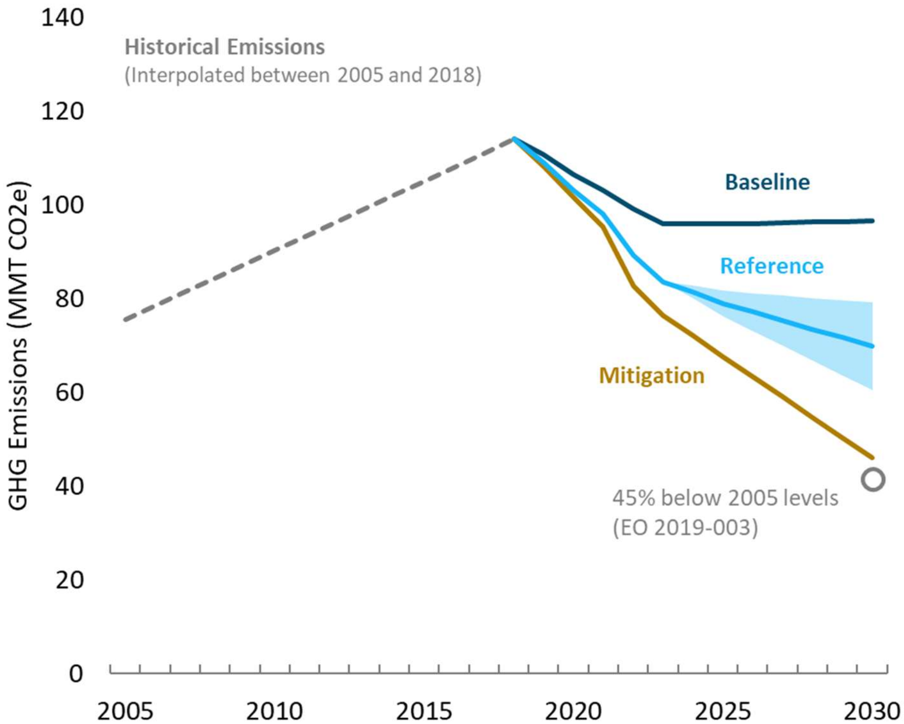
This section includes the results of the economy-wide emissions forecasting analysis through 2030: it includes emissions by scenario; the effect of key policies on emissions reductions in the Reference scenario; emissions by sector in the Reference and Mitigation scenarios.

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



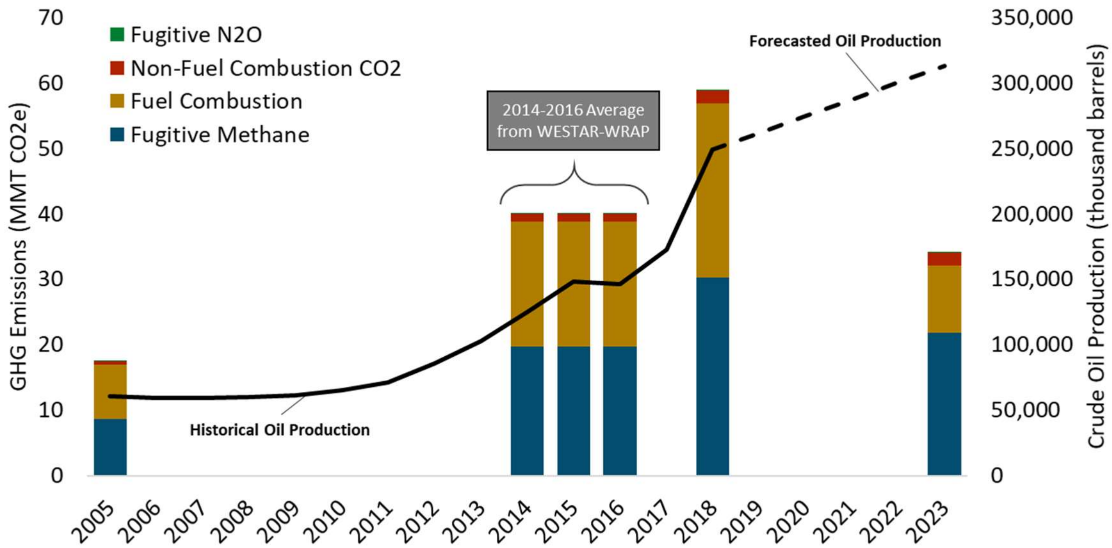
Note the uncertainty band around the Reference scenario, which includes a range of emissions reductions achievable in the oil and gas sector depending on the effects of state policies. The central estimate includes a 60% reduction in fugitive CH_4 emissions intensity from oil and gas sector by 2030,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

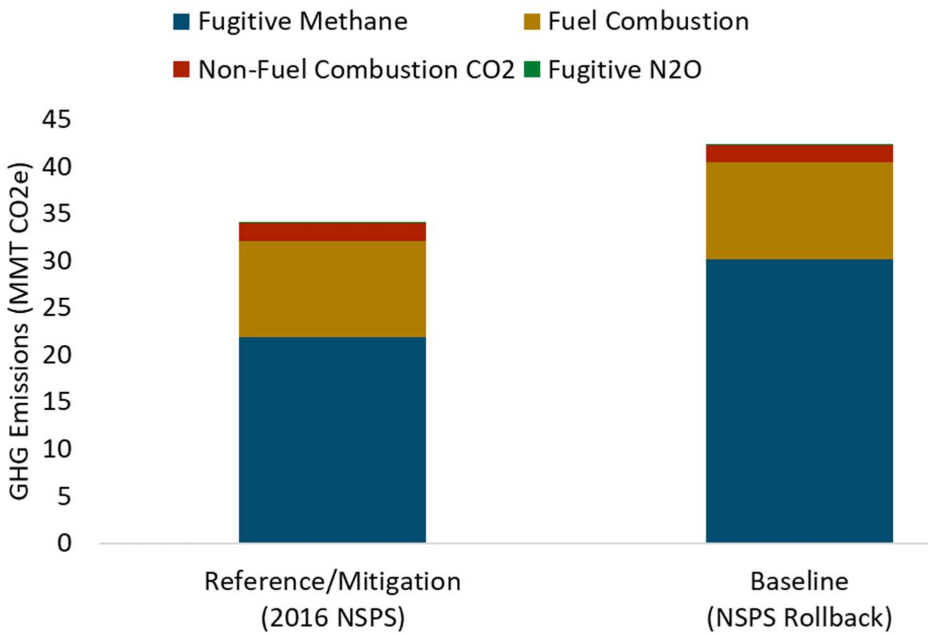
Figure 10. Oil & gas sector emissions reductions through 2023



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

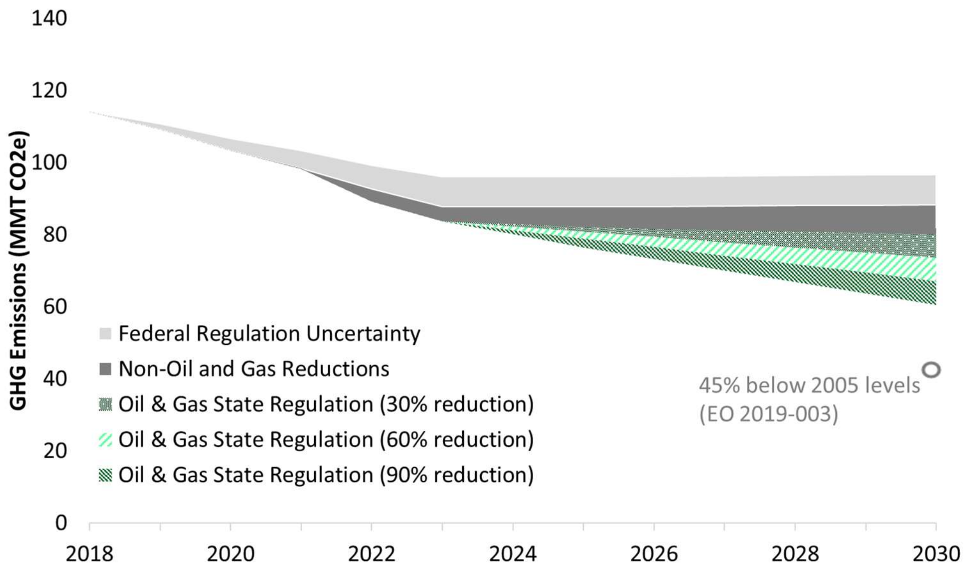


Table 20. Reference Scenario emissions reductions by measure: 2030 reduction snapshot (MMT CO2e)

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

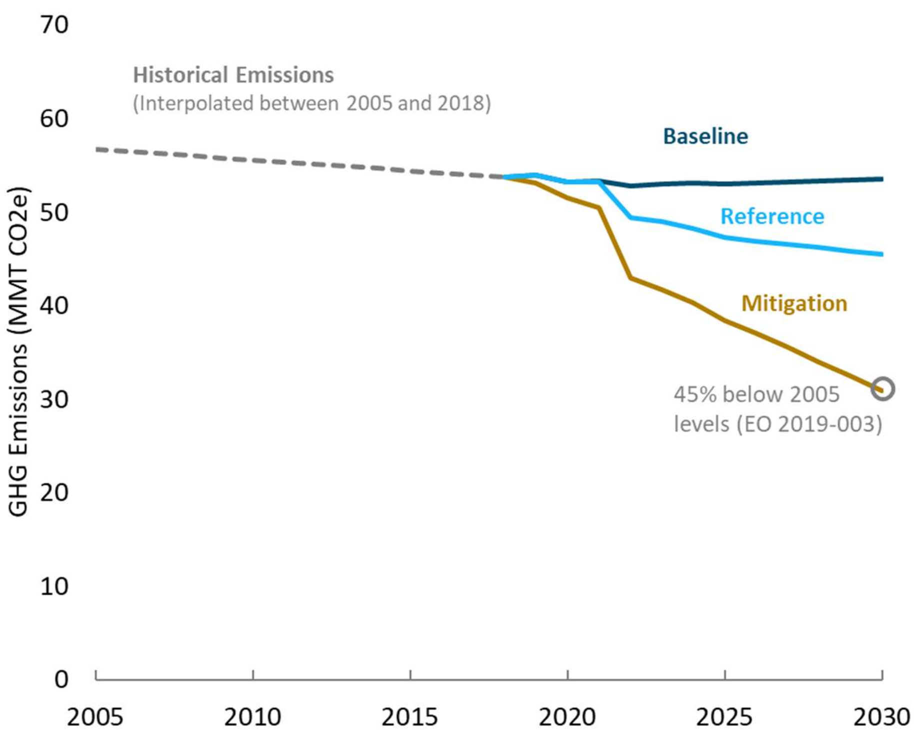


Figure 14 shows in more detail the level of emissions reductions achieved by Reference scenario policies. The Energy Transition Act (ETA) is the source of the majority of emissions reductions from non-oil-and-gas sectors. The significant drop in emissions in the 2022 time frame is associated with retirement 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

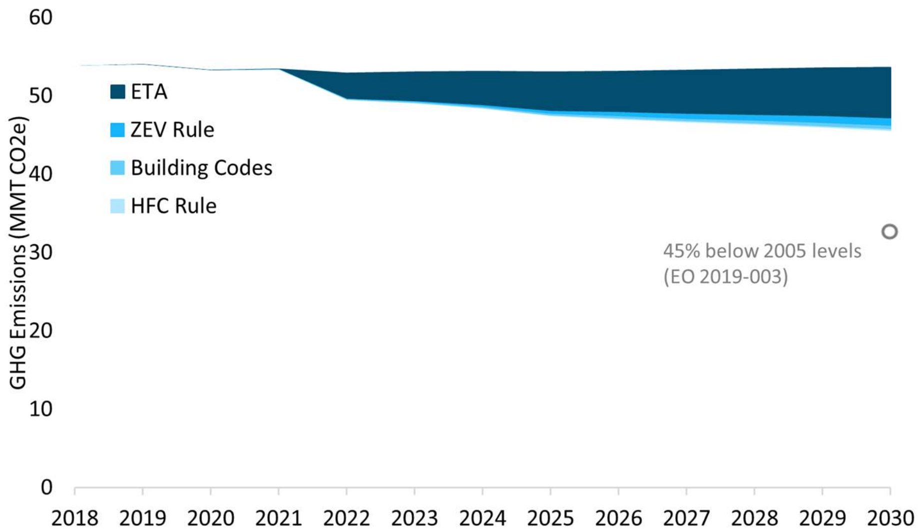


Table 21. Reference Scenario emissions reductions by measure relative to the Baseline Scenario, excluding oil and gas: 2030 reduction

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

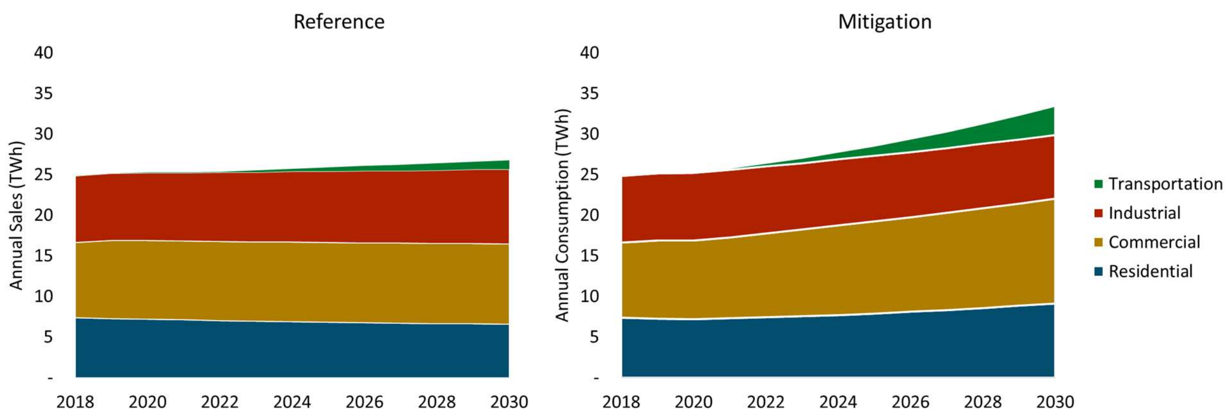


Figure 16. Electricity generation by source, Reference and Mitigation scenarios (2020,2030)

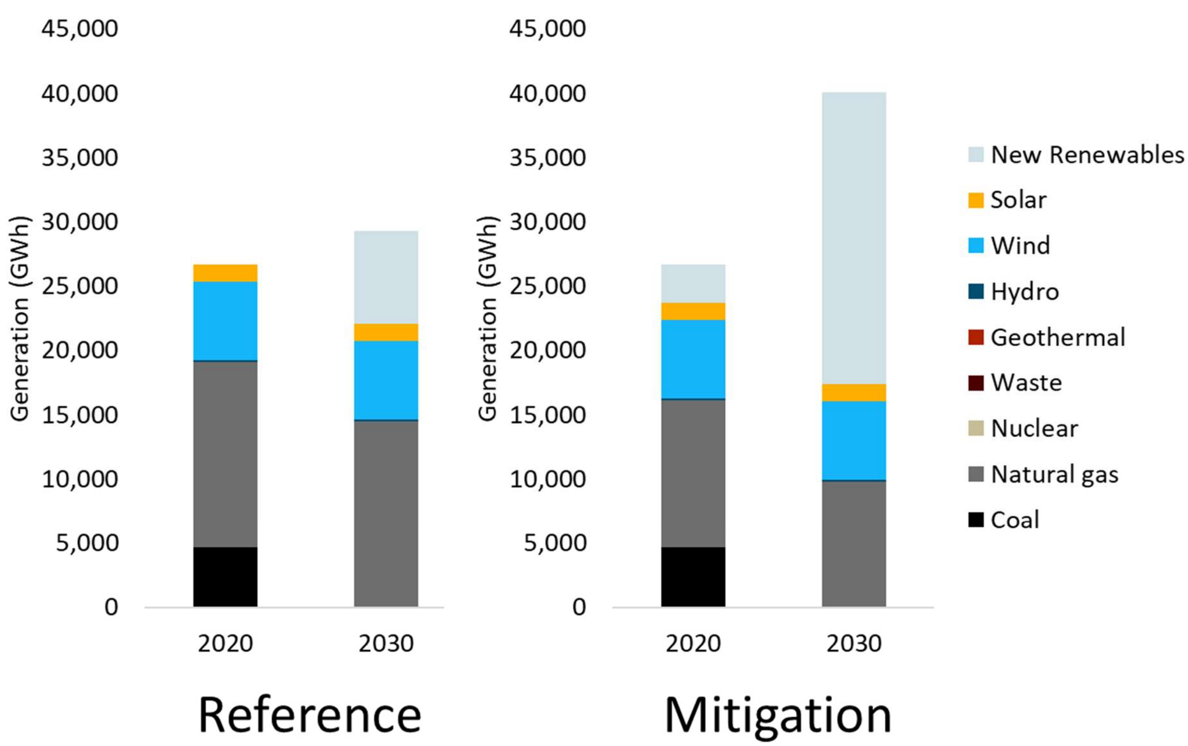
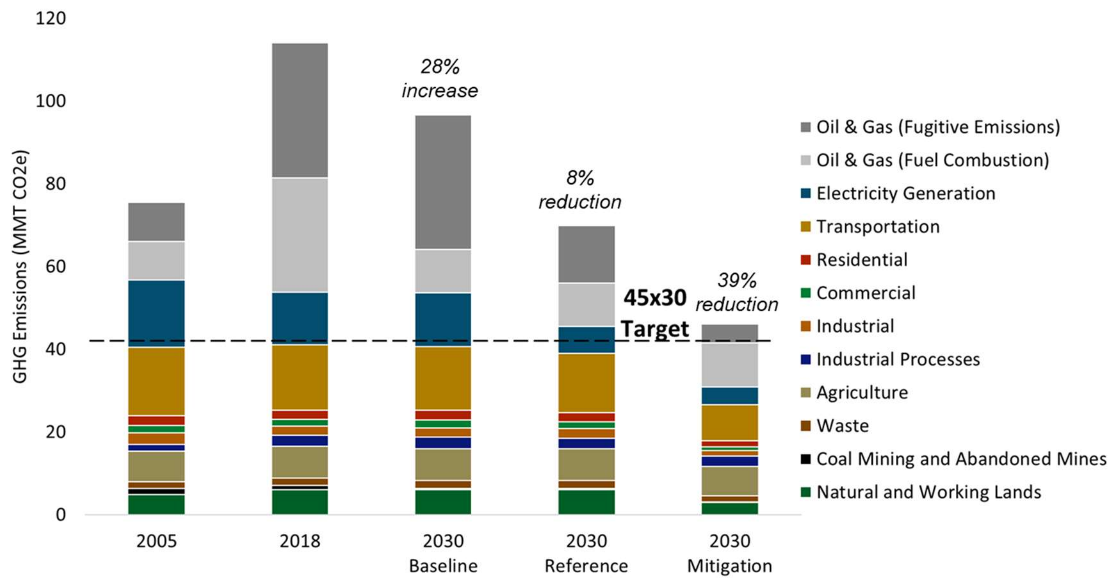


Figure 17 and Table 22 provide a comparison of emissions by sector in 2030 compared to 2005 and 2018, while Figure 18 shows a comparison of emissions by sector through 2030 for the Reference and Mitigation scenarios.

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

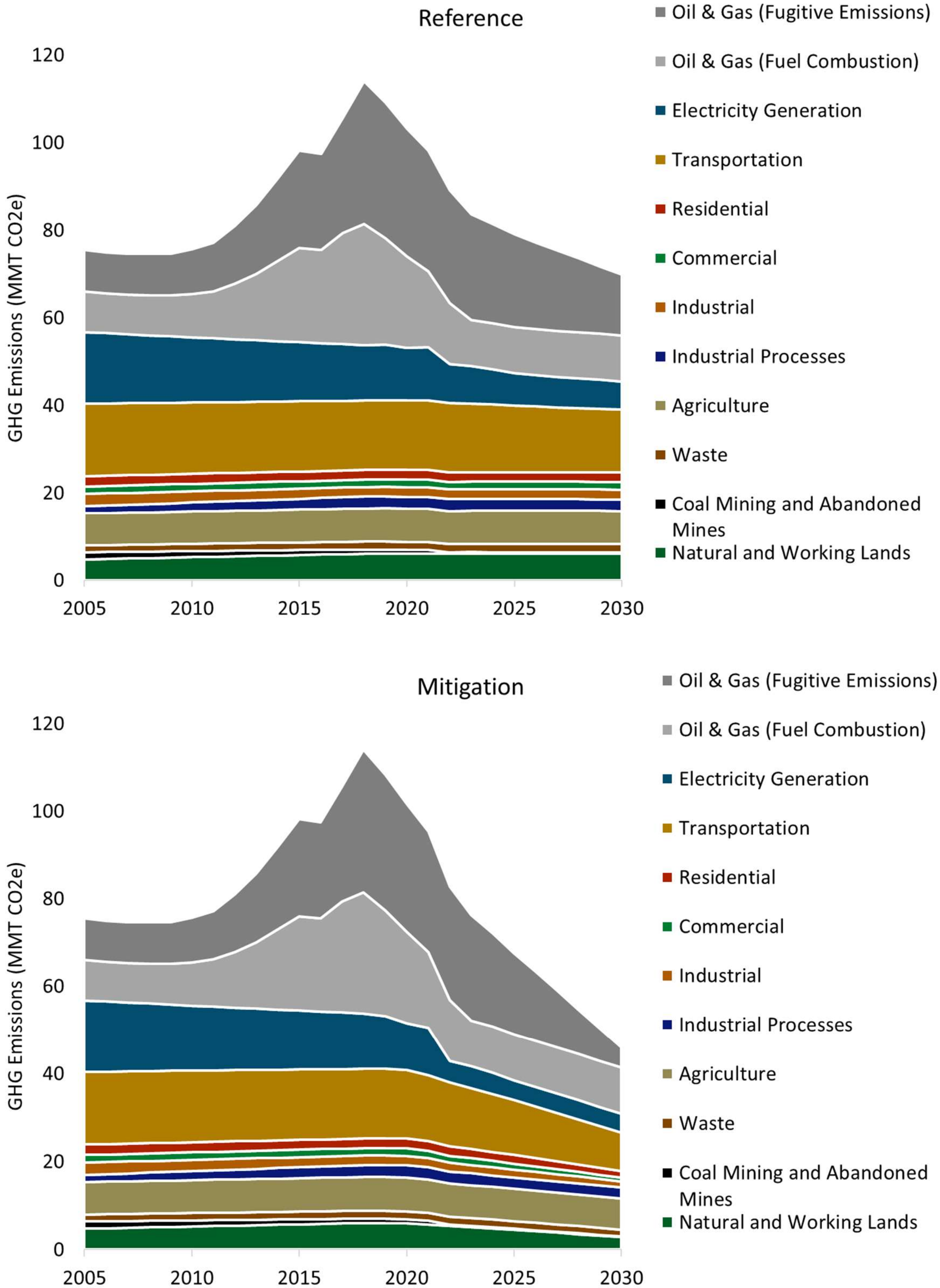
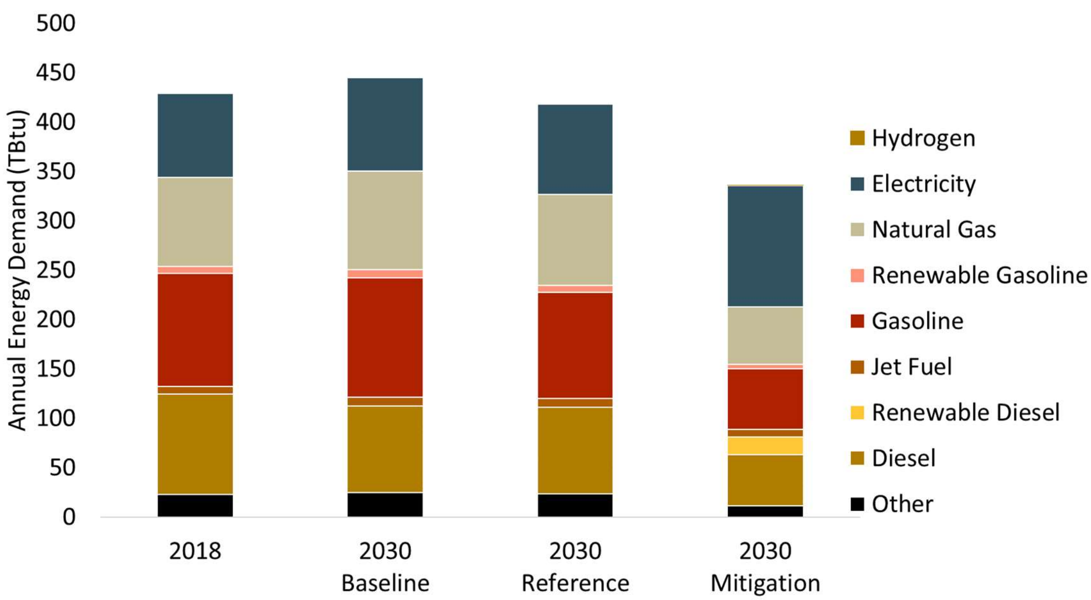


Figure 19 also highlights the impact of energy efficiency and electrification technologies on energy demand. The Baseline scenario shows an increase in energy demand in 2030 relative to 2018, driven by population and economic growth. The Reference scenario includes energy efficiency measures and shows 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

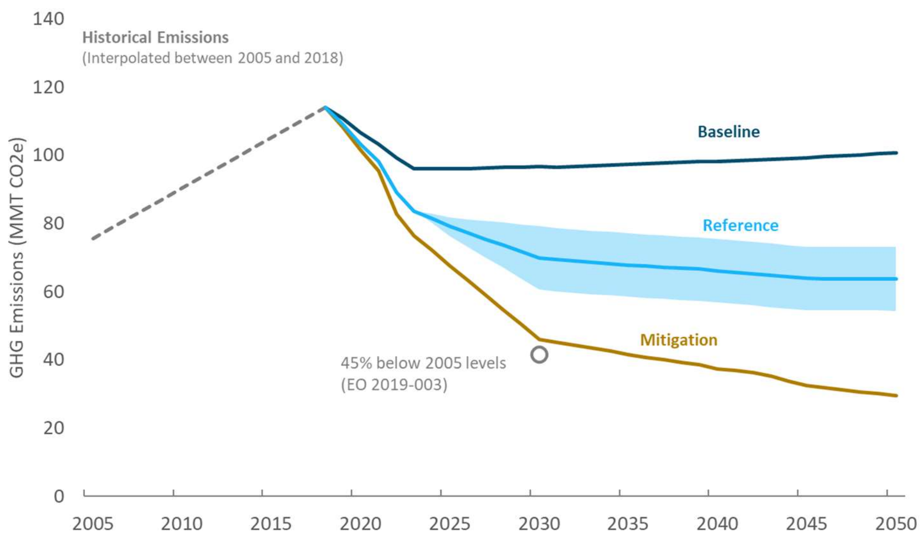


Results through 2050

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

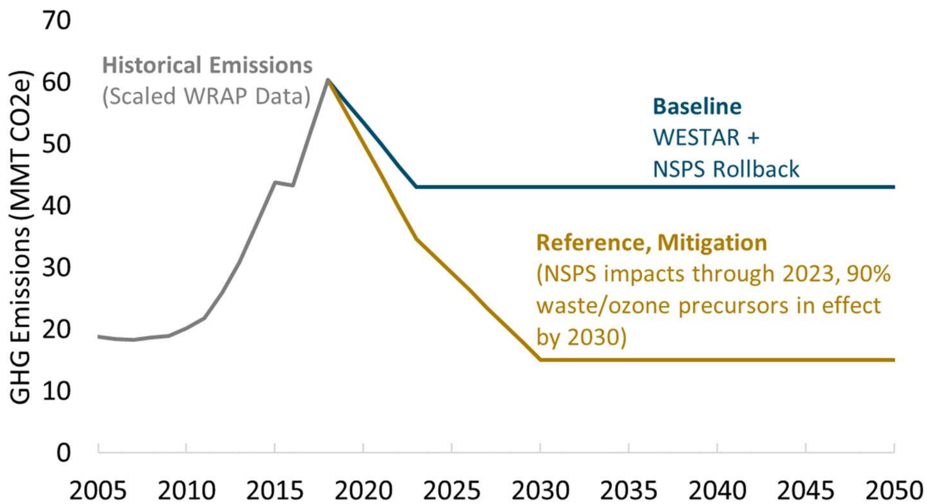


Figure 22 shows the emissions reductions achieved by the various policies modeled within the Reference scenario. The next section disaggregates emissions reductions from policies outside of the oil and gas sector, but this figure focuses on emissions reductions achievable through federal and state policies 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

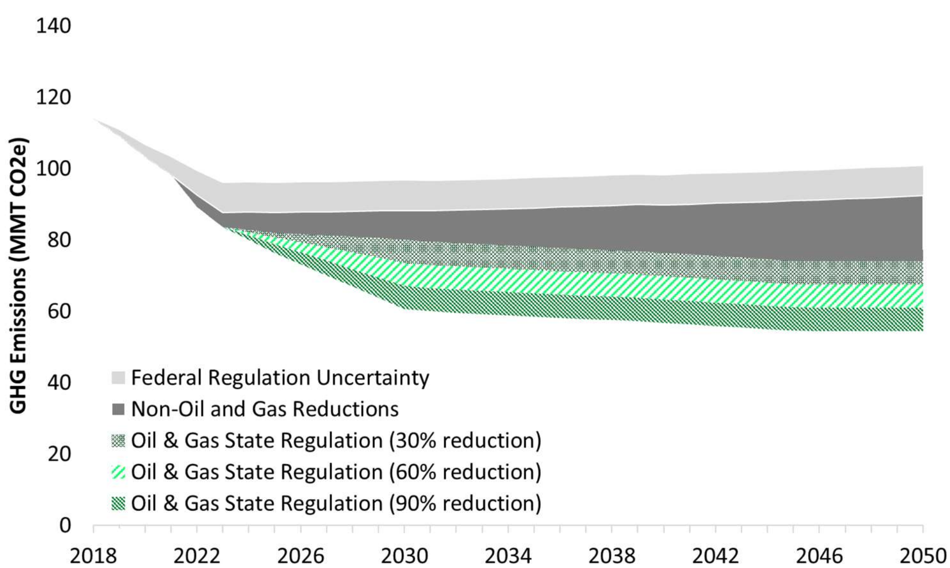


Table 23. Reference Scenario emissions reductions by measure: 2050 reduction

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

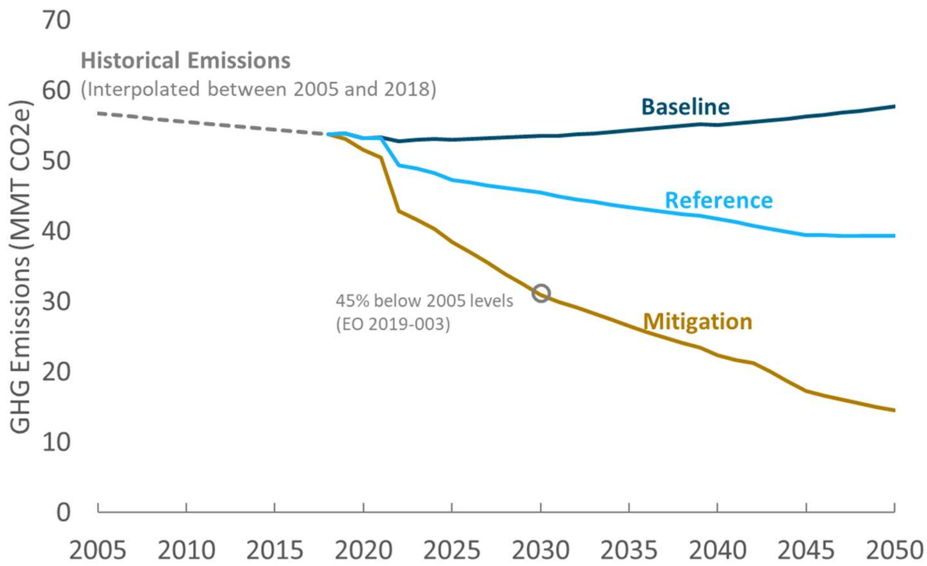


Figure 24 shows in more detail the level of emissions reductions achieved by Reference scenario policies. As can be seen in this figure, the Energy Transition Act (ETA) is source of the majority of emissions reductions from non-oil-and-gas sectors.

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

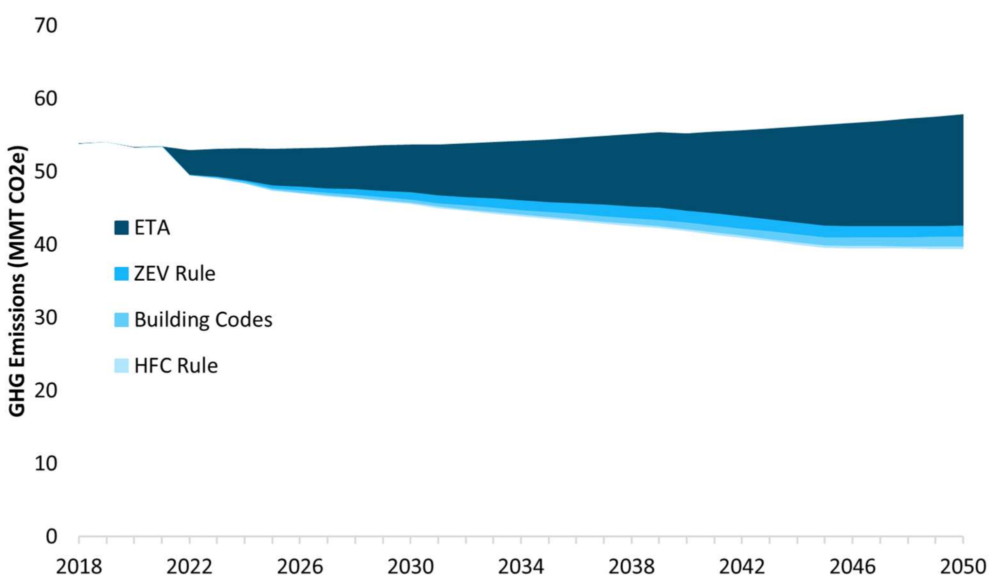


Table 24. Reference Scenario Emissions reductions by measure, no oil and gas: 2050 reduction

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

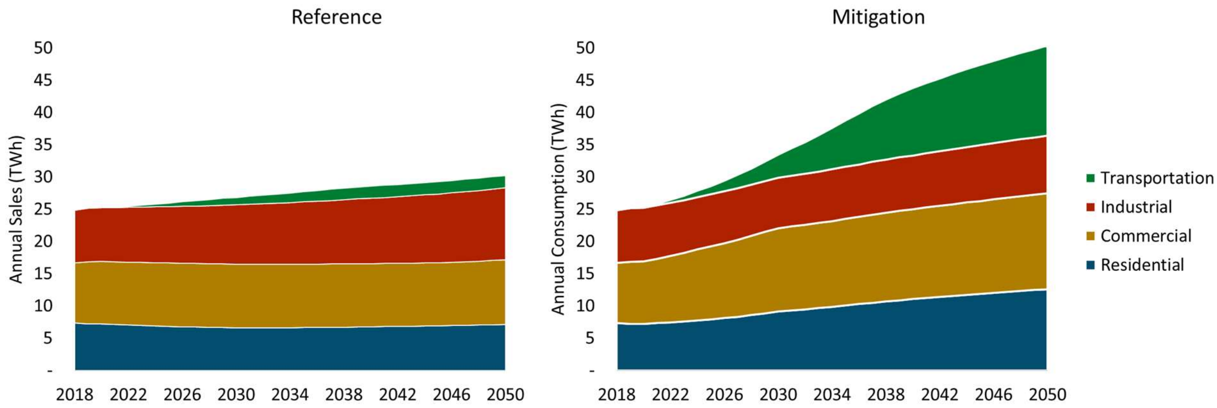


Figure 26. Electricity generation by source, Reference and Mitigation scenarios (2020,2030,2040,2050)

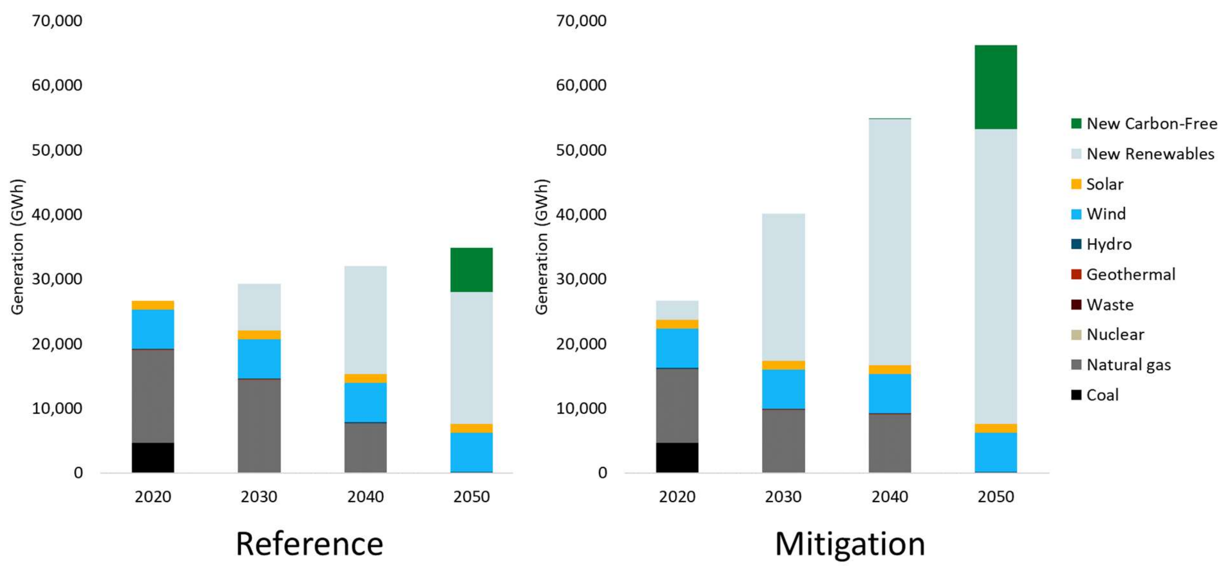
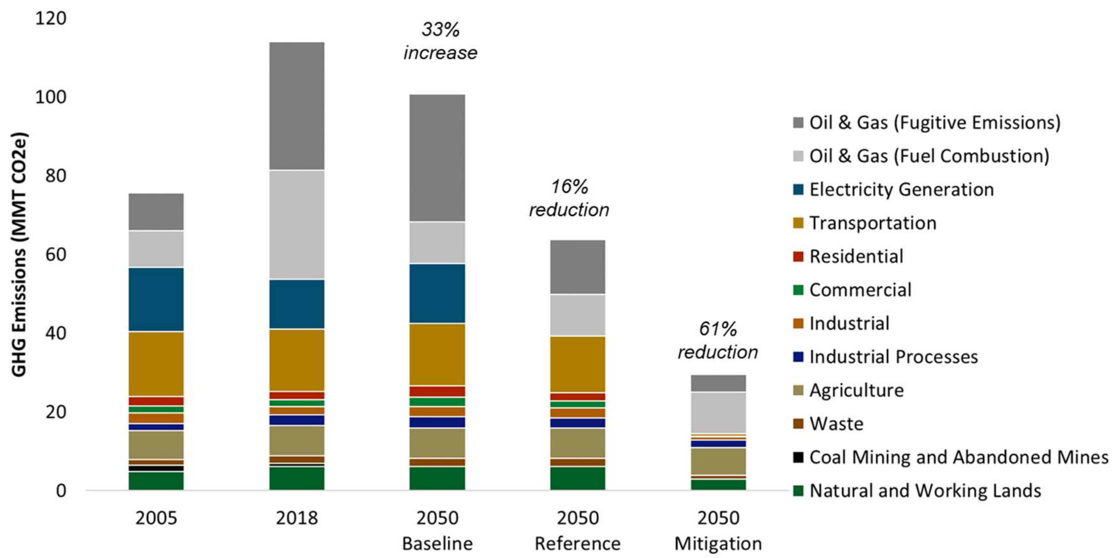


Figure 27 and

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

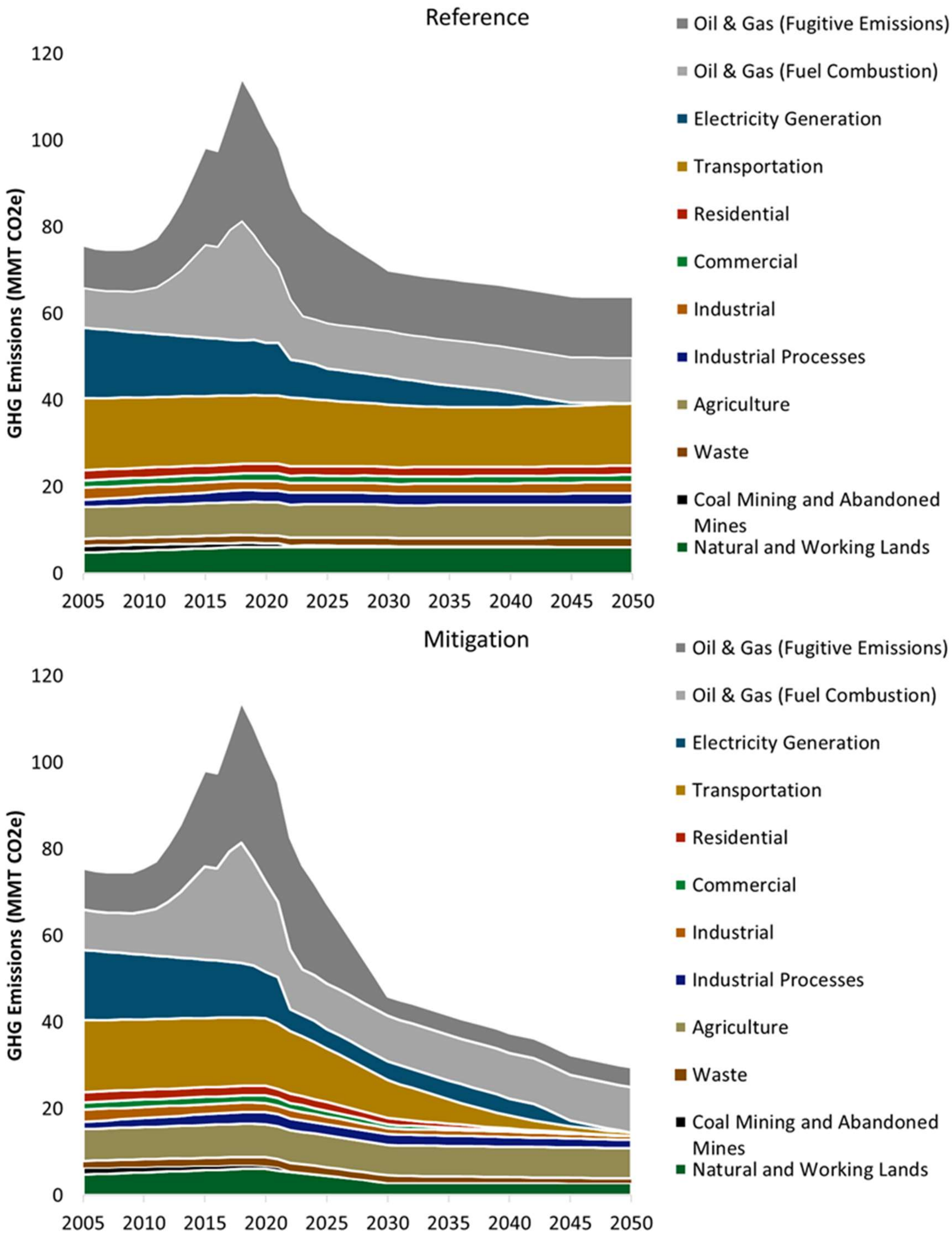
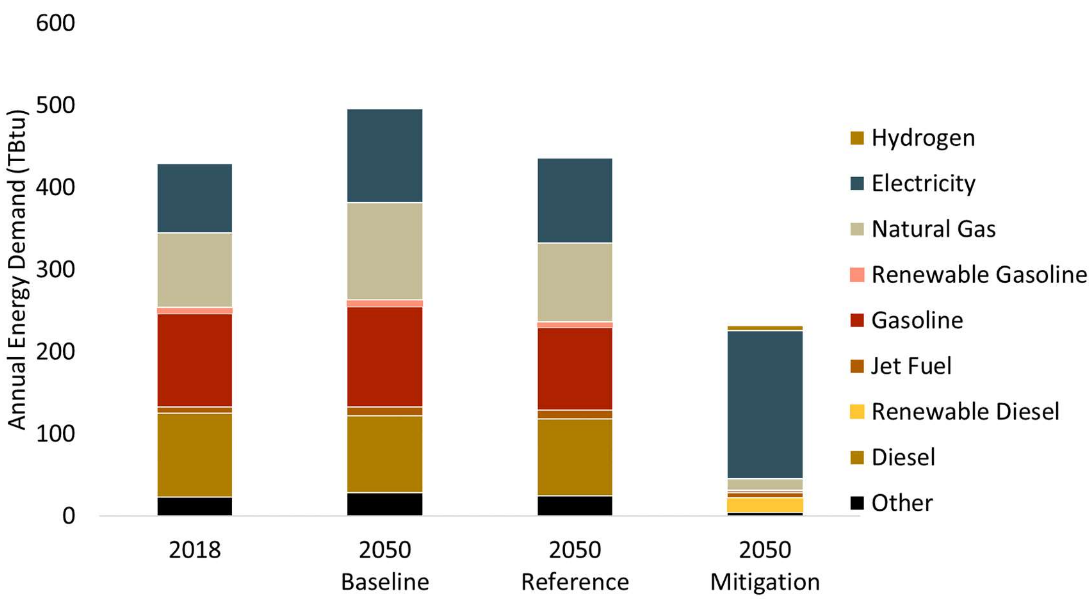


Figure 29 shows the impact of energy efficiency measures in the Reference scenario, as the gap between the Baseline and the Reference scenario continues to grow from 2030 through 2050. However, the Mitigation scenario shows a dramatic reduction in energy demand relative to the Reference scenario. This 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

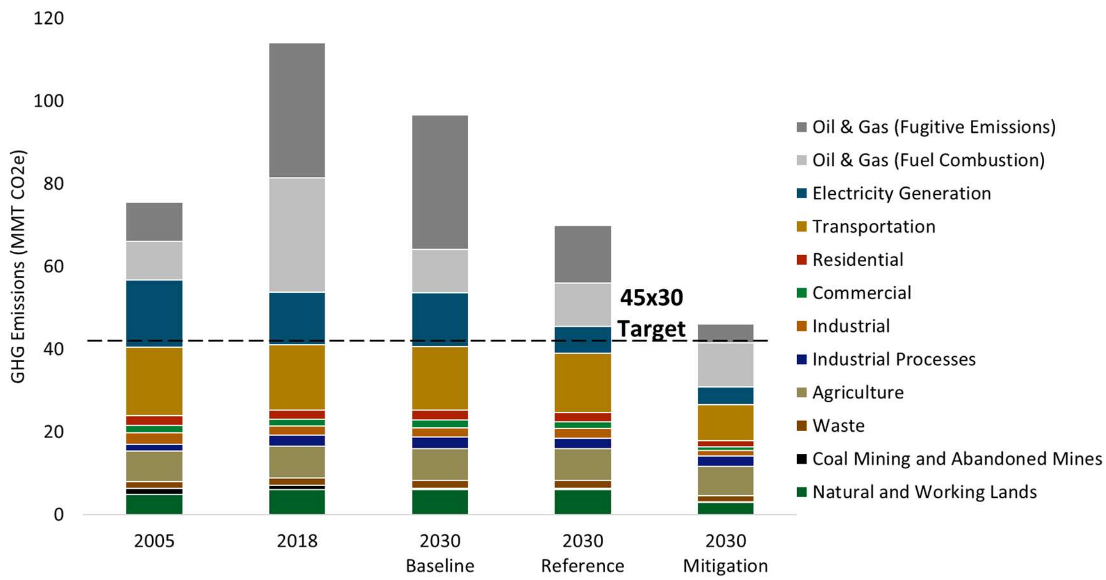
This report has estimated greenhouse gas emissions in New Mexico for 2005 and 2018, and has produced an analysis of emissions in the state for 2030 and 2050 under three scenarios: one business as usual scenario representing federal but no state energy and climate policies (Baseline), one scenario represent 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.

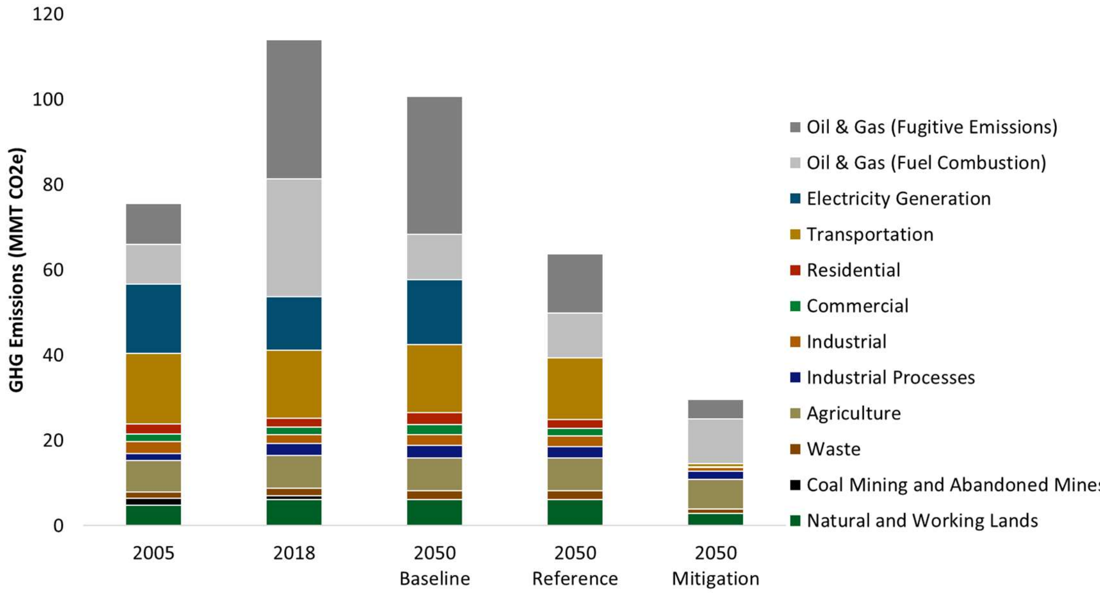
Figure 30. Economywide emissions by sector: 2005, 2018, 2030



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

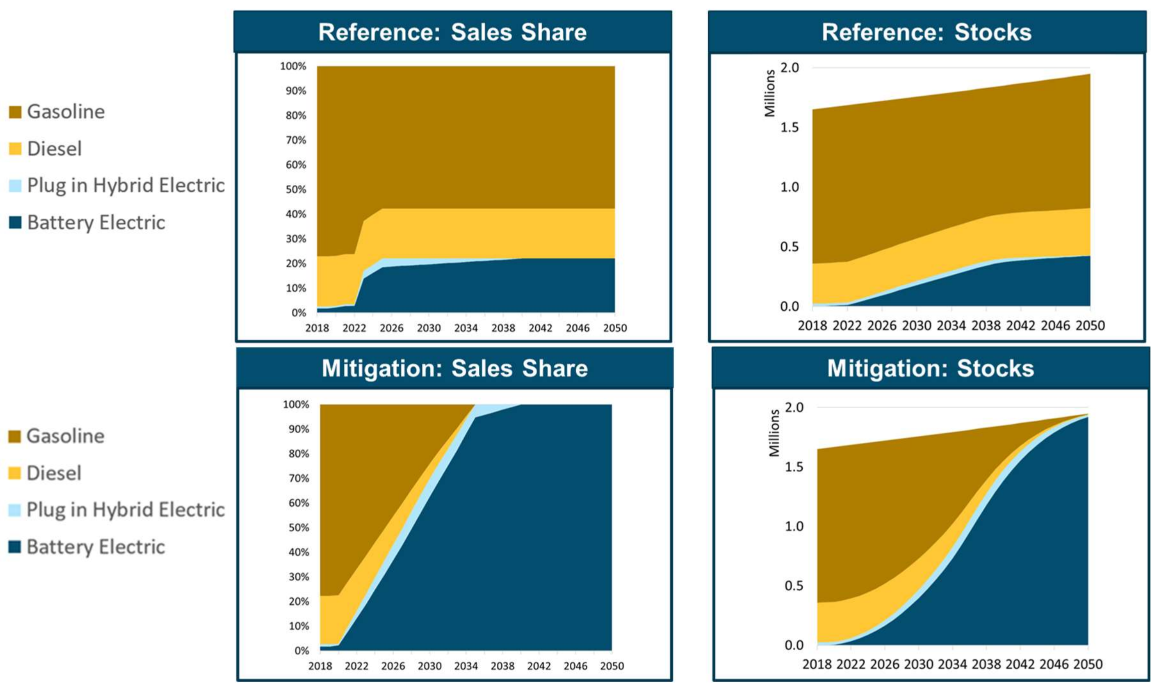
WRAP Source Description	E3 Category
Oil Tank	Non-Fuel Combustion
Oil Tank Flaring	Non-Fuel Combustion
Oil Tanks	Non-Fuel Combustion
Oil Well Completion: All Processes	Non-Fuel Combustion
Oil Well Heaters	Fuel Combustion
Oil Well Pneumatic Devices	Fuel Combustion
Oil Well Pneumatic Pumps	Fuel Combustion
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



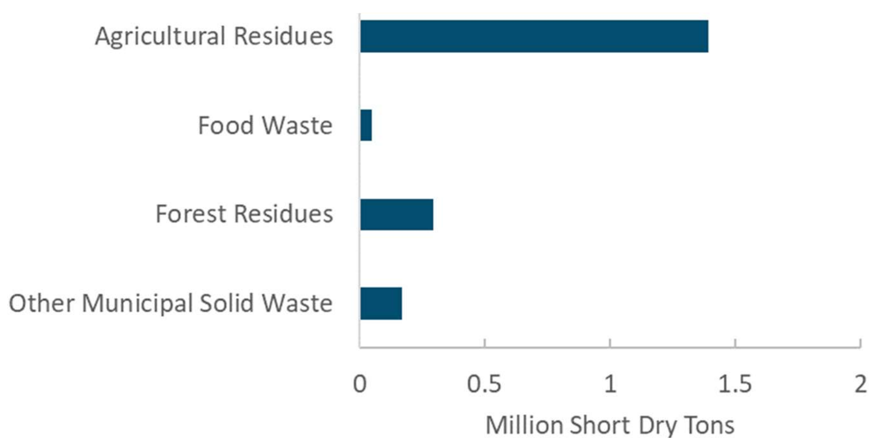
Advanced renewable biofuels

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.

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

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RMI

1 in 5 Cars Need to Be Electric by 2030: What Will it Take?

December 18, 2019
By Britta Gross

Last month, GM President Mark Reuss wrote an op-ed titled, "Electric cars won't go mainstream until we fix these problems." Mark's article summarizes the top reasons why EVs haven't yet achieved widespread adoption: EVs struggle to compete with gasoline vehicles on cost and range, and there is not enough public EV charging infrastructure. Mark predicts that EVs with more efficient batteries will achieve cost parity with the internal combustion engine (ICE) vehicle within a decade, "maybe sooner," and that widespread EV adoption will then be possible.

A decade ago, this would have been an exciting pronouncement. And the business-as-usual timeline of patiently waiting for consumer demand to grow, while battery efficiency and cost reductions are made, and more abundant EV charging infrastructure is put in place, would have been viewed by many as a pragmatic investment approach. But popular support is growing around the overwhelming scientific consensus that **we're in a climate scenario now that won't wait for business as usual.** And as this consensus gains more and more traction, all eyes will be on the light-duty vehicle sector.

Transportation is the single largest carbon-emitting sector in the United States, responsible for 29 percent of all emissions. And as electricity generation continues to rapidly transition to cleaner, renewable energy sources, transportation's share of emissions is only growing. Within the transportation sector, light-duty vehicles in the United States account for 59 percent of emissions, 23 percent come from medium and heavy-duty trucks, and the majority of the remaining transportation emissions come from planes, ships, rail, buses, and motorcycles. **Bottom line, there's virtually no way to meet carbon reduction goals without a significant contribution from the light-duty vehicle sector.**

An RMI review of key modeling results in literature reveals that even if the electric grid were on a path to achieve 75–85 percent of clean energy production by 2040, **15–20 percent of global light-duty vehicles would need to be electrified by 2030** in order to limit global temperature rise to less than 2°C and avoid the most catastrophic effects of climate change (and ensure that our cities are cleaner and more livable for billions of people around the world).

In the United States, this represents a staggering 40-50 million vehicles—and means that a seismic shift in how we power our vehicles and provide mobility services is necessary within the next ten years. According to evidence cited in RMI's recent *Seven Challenges for Energy Transformation* report, "the difference between 1.5°C and 2.0°C of warming, although seemingly small, would be tremendously consequential." To

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provide some temperature context, according to NASA's Earth Observatory program, a 5°C drop in the global temperature was enough to "bury a large part of North America under a towering mass of ice 20,000 years ago." That's all it took.

A seismic shift in how we power our vehicles and provide mobility services is necessary within the next ten years.

Unfortunately, we are currently tracking toward a world with 3°–5°C of warming. Thus, our actions over the next 10 years, starting today, are more critical now than most of us thought. And today we are nowhere near the pace of EV adoption required to achieve this goal, raising the question, "What would it take for EVs to reach 20 percent of the vehicles on the road by 2030?" What Herculean efforts, policies, and incentives would be required? Can it even be done?

Shifting Demand

It's clear that we must redouble all efforts to stimulate EV adoption across all car, bus, and truck segments. It's also clear that policymakers and regulators are increasingly committed to achieving the carbon reduction goals. What automakers, bus-makers, truck-makers, electric utilities, and other key stakeholders need now more than ever is certainty in what lies ahead and what it will take to get there.

Of particular interest in Mark Reuss' article was the mention of expected regulatory action against gasoline and diesel vehicles. If EVs on their own merits haven't yet convinced consumers to make the switch, it is logical that if it were less convenient or more costly to own and operate an ICE vehicle, then consumers would be motivated to take a serious look at EVs.

All automakers have no doubt noticed the growing chorus of cities and countries around the world that have announced targets and timelines for the phaseout of diesel and then gasoline engines between 2025 and 2050. A ban of ICE vehicles would have been unthinkable just a few years ago—today, not so much. And there are other actions that could be taken—from feebates to gas-guzzler taxes and green zones in cities. Any of these policies would make it less appealing to own an ICE vehicle and very likely cause a shift in consumer buying behaviors. Automakers say they will build what consumers demand, so a demand shift is at the heart of a transition.

The question vehicle manufacturers need to answer is: What would you need from policymakers and regulators in order to deliver 40–50 million electric vehicles by 2030? What investments, incentives, or assurances do you need to withstand the "valley of death" that accompanies the introduction of EVs in the market until cost parity with a mainstream ICE vehicle can be reached? And what would it take to scale up the production of so many EVs? If policymakers and regulators are committed to the carbon reduction goals—what do you need them to do?

A Role for Everyone

Similarly, utilities (and their regulators) need to seriously engage beyond demonstration and pilot projects. Since 80 percent of all charging takes place at the home, the magnitude of the 2030 challenge would require that every utility offer well-promoted home charging programs that reach consumers living in homes as well as in townhomes, condominiums, and apartments.

And since 15 percent of charging takes place at work, utilities would also need to offer programs that reach every employer, both public and private. Workplace charging also provides an important alternative for consumers who don't have a garage, driveway, or other convenient location to charge each evening. Once home and workplace charging programs are priorities, EV charging will feel much more ubiquitous to consumers. As for public charging, there is a need for more visible public charging—particularly fast-charging that will take us from city to city and fast-charging hubs in urban environments that can be shared by consumers, taxis, ride-sharing services, and even buses and delivery trucks. Again, if policymakers and regulators are committed to the carbon reduction goals—what do you need them to do?

And what do consumers need to do? One of the most important steps a consumer can take to reduce his or her carbon footprint is to replace an ICE vehicle with an EV. So with every vehicle purchase, consumers need to be asking: Is there an EV out there (new or used) that meets my daily driving needs and my pocket book? Or if not, am I prepared to cut back on a significant portion of the miles I drive each day? Because to meet the carbon reductions needed by 2030 will require both the electrification of the vehicles we drive and a reduction in the miles we travel.

So what's it going to take? Support for aggressive investment in battery and vehicle plants, more incentives to lower the upfront price of EVs, regulations that bite into ICE vehicles, infrastructure that's visible to all consumers? The window of opportunity to avoid the most severe consequences of climate change is closing quickly, and the challenge becomes more pressing with every year that passes. The business-as-usual approach to EV adoption won't get us there.

REV UP

ELECTRIC VEHICLES

A NATIONWIDE STUDY

OF THE ELECTRIC VEHICLE SHOPPING EXPERIENCE

November 2019

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SIERRA CLUB

ACKNOWLEDGMENTS

This report was written by the Sierra Club's **Hieu Le** and **Andrew Linhardt**. Hieu served as the overall project manager for the campaign and report.

Thank you to the Sierra Club's **Mary Lunetta** and **Gina Coplon-Newfield**, who wrote and published the original "Rev Up Electric Vehicles" report[1], which examined how dealerships were selling EVs in 2016 in the 10 states that had adopted the Zero Emission Vehicle (ZEV) program at the time.

Many people contributed to the overall success of the campaign and the writing of this report. Special thanks to **Steph Larsen**, **Bhavi Moolya**, **Grace McRae**, **Julia Clemons**, **Larisa Manescu**, **Gina Coplon-Newfield**, **Jim Bradbury**, **Alejandra Núñez**, **Orly Strobel**, **Hillary Davis**, and **Rosie Walter** for all their work.

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Chris Wickham, a graduate of Georgetown's Mathematics & Statistics master's program, conducted data collection and analysis, as well as provided guidance on data presentation.

Lastly, thank you to the 579 volunteers who took the time to call and/or visit more than 909 car dealerships and stores and share their feedback through surveys. Some of you even bought an EV during this process!

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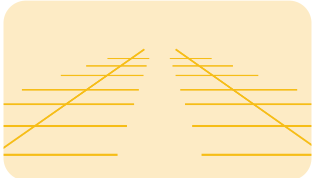
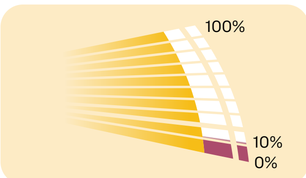


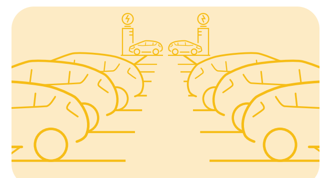
74% of auto dealerships nationwide aren't selling electric vehicles.

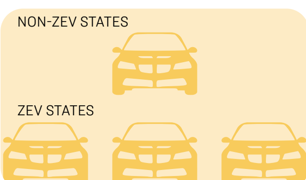
Salespeople often failed to provide information on federal or state consumer incentives or were poorly informed or uninformative about EV technology.



10% of the time when volunteers asked to test drive an EV, the vehicle was insufficiently charged and unable to be driven.

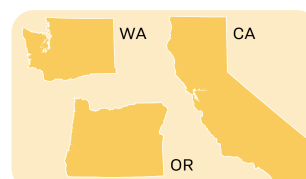
44% of the dealerships that did sell electric vehicles had no more than two EVs available on the lot. Of the dealerships that sold EVs, more than 66% did not display EVs prominently, with vehicles sometimes buried far in the back.





Non-ZEV states had much more limited EV inventory compared with ZEV states which had more EVs offered.

The Western region of the US had more inventory, greater EV availability, and the highest consumer satisfaction.



Respondents reported that 25% of dealerships contacted that had at least one EV on their lots offered both new and used EVs — a sign of the growing market for used EVs.

Among automakers, **Tesla** was reported as providing the best consumer shopping experience, with an average satisfaction score of **4.5** out of **5**.

Chrysler was reported as providing the worst consumer shopping experience, with an average satisfaction score of **2.9** out of **5**.

INTRODUCTION

The 2018 IPCC report "Global Warming of 1.5°C"[2] details the critical challenge the world and our country face in attempting to prevent the worst impacts of the global climate crisis. The United States accounts for approximately 15% of global emissions, with the leading source being our transportation sector[3]. Together with the 2012 federal clean car standards, which is the most significant US climate policy ever enacted, accelerating the adoption and sales of electric vehicles (EVs) is crucial to tackling the climate crisis.

EV technology has advanced significantly in the US since 2016. Automakers now offer more than 40 models (with many more to come), and EVs produce significantly lower emissions than cars with internal combustion engines. This is true even after accounting for any emissions associated with the electricity that is used to charge electric vehicles. EVs will become even cleaner as electricity generation increasingly shifts to renewable sources. This isn't the case for internal combustion engine vehicles, as their reliance on fuel contributes to increasing emissions from the oil and gas sector, which emitted 315 million metric tons of CO2 in 2018, according to the EPA. However, comprehensive research suggests that actual emissions from the oil and gas sector are likely to be at least 60–100% higher than EPA's estimates suggest.[4] Fuel from light and heavy duty internal combustion vehicles account for 70% of petroleum consumption in the nation.

EVs currently are projected to account for more than 57% of global car sales by 2040. To meet our climate goals, though, we must accelerate that timeline dramatically.

In 2018, EV sales had a historic year; combined with widespread consumer interests, like the fact that two-thirds of American consumers have expressed interest in purchasing an EV, the U.S. EV market could be even bigger as technology is ready to meet the driving needs of millions of Americans.

As of the date of publication of this report, the Trump administration has taken the unprecedented step of revoking the Clean Air Act authority that allows for California and the other "clean car states" to enact strong clean car standards, including the ZEV program — which requires automakers to sell increasing numbers of EVs. California, other states, and a number of environmental and consumer organizations, including the Sierra Club, are challenging the administration's unlawful action in the courts.

Three years ago, the Sierra Club released "Rev Up Electric Vehicles: Multi-State Study of the Electric Vehicle Shopping Experience,"[5] a report based on a grassroots initiative that sent volunteers to car dealerships and stores to evaluate how the auto industry was selling EVs and what the consumer shopping experience was like in the 10 states that had adopted the ZEV standards. The resulting report highlighted that EVs were not being displayed prominently and were hard to locate on the lots; many salespeople did not have a basic knowledge of EVs, such as charging times and the availability of rebates and incentives; and some EVs were not charged properly for a test drive.

Our volunteer observations and experiences shopping for an EV, combined with auto industry advertising data from 2017 and 2018, which shows that the industry is spending 28 times more on national advertising for internal combustion engine vehicles than on advertising EVs, indicated very clearly that the auto industry was failing to meet the EV demands expressed by consumers and is providing them with a bad shopping experience.

In May 2019, we launched a new initiative to update our original report, with the goal of showing how well or poorly the auto industry is doing now in providing people with a strong EV shopping experience — this time covering the entire country. This is the first-ever nationwide investigation into the shopping experience for consumer EVs. Based on survey responses and testimonials from volunteers who called or visited 909 auto dealerships and stores across all 50 states, we found that the auto industry is failing to meet market demands. **Shockingly, we found that 74% of auto dealerships nationwide do not have a single EV on their lot for sale and that consumers were still not being given important information about charging, battery range, and financial incentives.** In some instances, volunteers indicated that they could not go for a test drive because the vehicle was insufficiently charged or that they were encouraged to purchase a non-electric vehicle instead.

Automakers talk a good game about their desire to accelerate the EV market. They claim they are doing their best but consumers just aren't interested. Our survey results show very clearly that this is not the case in the US.

DETROIT NEWS[6]

"We're working very hard to be — not part of the problem — but to be part of the solution"

— HONDA MOTOR CO.'S VICE PRESIDENT OF ENVIRONMENTAL VEHICLES, **STEVE CENTER**

REUTERS[7]

"We're all in on this and we're taking our mainstream vehicles, our most iconic vehicles, and we're electrifying them"

FORD MOTOR COMPANY TO REPORTERS

GENERAL MOTORS

"We're committed to an all-electric future...It's a simple equation: More electric vehicles on the road means fewer emissions and cleaner air for all."

COMPANY WEBSITE

CNN[8]

Volkswagen, which has paid more than $30 billion in penalties since being caught in 2015 rigging the emissions of millions of diesel cars, has embraced electrics...*"Volkswagen will change radically,"* CEO Herbert Diess told shareholders in March. *"Some of you may still be rubbing your eyes in amazement..."*

CNN BUSINESS REPORT

People are eager for EVs, but the auto industry makes it difficult for them to shop for EVs. Instead of investing in an electric future that will meet our climate goals, the auto industry is doubling down on selling internal combustion engine vehicles and failing to train dealerships properly on how to sell EVs. Our study collected data from all 50 states and offers a snapshot of how EVs are being sold in different regions and of how states that follow California's ZEV standards compare with states that do not.

Some of our volunteers did indicate that they had a tremendous EV shopping experience and were impressed with both the salespeople and the level of information provided. Some of them even ended up purchasing a new EV! We've made sure to highlight the auto dealerships and automakers that are doing a good job.

PHOTO CREDIT: PLUG IN AMERICA // BEE TWO SWEET

AVAILABILITY & INVENTORY

If we are to achieve widespread EV adoption, a majority of auto dealerships still need to take the first step and offer EVs for sale. Automakers also need to provide dealerships with sufficient inventory and offer deals on EVs, just as they do for internal combustion engine vehicles. As it stands, consumers who wish to buy an EV must usually call or visit several auto dealerships before finding one that offers EVs.

To get a clearer picture of what EV availability looks across the US, we analyzed data for auto dealerships nationwide:

- Nationwide, **74%** of auto dealerships had no EVs for sale on their lots.
- In non-ZEV states, EV availability was even lower: More than **78%** of auto dealerships in those states had no EVs on their lots.
- In the 10 ZEV states, our volunteers found that **59%** of auto dealerships had no EVs on their lots.

We gave our volunteers the option of asking auto dealership personnel why they did not offer EVs. The answers and reasons varied:

"I asked if they had any Chevy Bolts (the BEV). They said that they did not. 'We don't have any. They only sell them out in Oregon and California. It's a West Coast thing.' They did have one used 2017 Chevy Volt (the PHEV)."

LESTER L. (CHEVROLET DEALERSHIP IN KANSAS)

"[They said] 'We are going to let the other car companies figure EVs out. Lexus is going to be late to the game.'"

CHLOE S. (LEXUS DEALERSHIP IN TEXAS)

"Oddly, the salesperson told me he loves gas cars, 'the more gas the better, you will NEVER see EVs used for racing.'"

HOLLY L. (CHEVROLET DEALERSHIP IN FLORIDA)

Auto Dealerships That Do Sell EVs

When shopping for internal combustion engine vehicles, consumers expect a wide selection and often get their choice of color, trim, and other packages. EV consumers deserve the same standards for inventory and selection.

Although the percentage of auto dealerships that don't offer EVs is significantly higher, we wanted to examine what inventory looked like for the minority of dealerships that do sell EVs.

For the dealerships that did have EVs on their lots, we asked our volunteers to observe (in a range approximation) how many EV models were on their lots:

- Of the dealerships contacted that had at least one EV on their lot, **43%** had no more than two vehicles.
- **19%** of the dealerships that sold EVs had 3 to 5 vehicles, while **11%** had 6 to 10.
- Only **9%** of dealerships that sold EVs followed the recommendation of industry experts to offer more than 10 vehicles.

"Only one Leaf in stock due to 'low demand and scarcity'"

RUSS G. (NISSAN DEALERSHIP IN TEXAS)

"This was the only dealership in the area with an EV to test drive. They did not have the Leaf Plus, which would've had a 200-mile range."

JUDY H. (NISSAN DEALERSHIP IN VIRGINIA)

"Although inventory may have sold out by now, Century Chevrolet in Broomfield, Colorado, had an extensive selection of Chevy Bolts when I was there. They were pleasant to work with. The car is awesome. It's like a quiet jet when accelerating."

GREG J. (CHEVROLET DEALERSHIP IN COLORADO)

Visibility

Our volunteers reported that finding EVs on the lot was often difficult. Of the dealerships that sold EVs, more than 66% did not display EVs prominently, with vehicles sometimes buried far in the back and hard to spot. Instead, EVs and charging stations should be featured prominently, as that would increase consumer interest.

> *"Vehicle was buried in the lot in the far back. It was completely dead. Had to jump-start the vehicle because it sat so long."*
>
> **CJ M. (CHRYSLER DEALERSHIP IN DELAWARE)**

> *"No EV info was displayed prominently on the website. No 2020 Leafs w/bigger battery packs/extended range and performance were available."*
>
> **JERRELL L. (NISSAN DEALERSHIP IN TEXAS)**

> *"I asked for a test drive and that took another 15 minutes to arrange, because as he said, 'Whoa, the Leaf is really buried back there. I'm talking deep deep! We'll need to move a bunch of cars to get it out.'"*
>
> **DAWN H. (NISSAN DEALERSHIP IN CONNECTICUT)**

> *"The EV models were parked right out front. The test drive was great and solidified my commitment to buying an Ioniq EV, although I bought from another dealership that offered a lower price and the color I wanted."*
>
> **ALYSON B. (HYUNDAI DEALERSHIP IN MARYLAND)**

EV Knowledge and Consumer Incentives

Consumers often have many questions related to EV technology, such as charging and battery range. They also want to know the specifics of federal and state incentives that reduce the upfront costs of purchasing or leasing an EV. Having well-trained staff who can answer such questions will both sell more EVs and provide a better shopping experience, especially since EVs are still relatively new to the majority of consumers.

We asked our volunteers to observe the expertise of the salespeople and/or dealership staff and to note whether information about EV charging and financial incentives was provided up front or not at all.

EXPERTISE ON CHARGING AND BATTERY RANGE

- In **29%** of the dealerships visited, salespeople provided information up front without being asked on information relating to charging and battery range.
- In **28%** of the dealerships visited, salespeople provided no information at all about how to charge an electric vehicle.
- In **20%** of the dealerships visited, salespeople did offer information about charging, but only after our volunteers requested it.

> *"The salesperson didn't really understand PHEVs. He thought if we drove it a few miles it would charge up the battery so I could drive it in electric mode."*
>
> **ROY I. (KIA DEALERSHIP IN ARIZONA)**

EXPERTISE ON CONSUMER INCENTIVES

- In **31%** of the dealerships visited, salespeople did not provide any information on state and federal incentives.
- In **27%** of the dealerships visited, salespeople provided information up front without being asked.
- In **20%** of the dealerships visited, salespeople did offer information about incentives, but only after our volunteers requested it.

> *"The worst! He provided incorrect information and delivered it with confidence. He said you could only claim the federal credit once (he said since I already own a Tesla, I couldn't get a tax credit on a Leaf — wrong!). When I said, "What about the CT tax credit?" He answered, "Don't you mean the federal? I'm not aware of anything for Connecticut." This is also wrong. In CT, there's a credit for vehicles under $50K under a program called CHEAPR. I informed him of both. He then responded that this was indeed a very good deal."*
>
> **DAWN H. (NISSAN DEALERSHIP IN CONNECTICUT)**

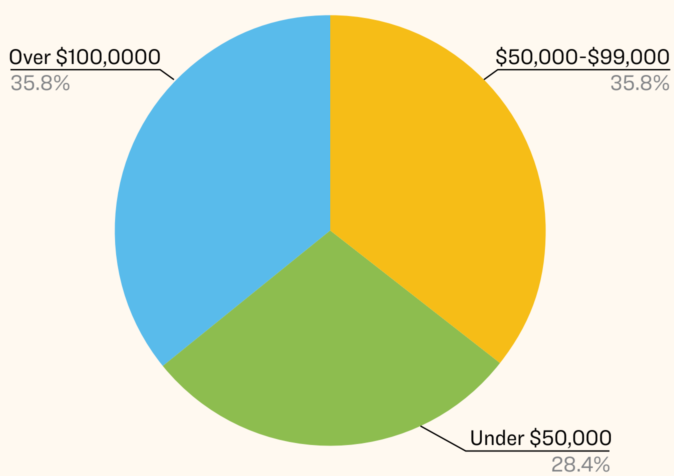
CONSUMER INTEREST & AUTOMAKER EV ADVERTISING

In 2018, electric vehicle sales rose by more than 81%[9] over the previous year. A 2019 study[10] by Consumer Reports and the Union of Concerned Scientists found that nearly two-thirds of prospective US buyers are considering purchasing an electric vehicle in the future:

- **31%** would consider an electric vehicle for their next purchase.
- **27%** would consider an electric vehicle at some point down the road.
- **5%** say they are definitely getting an electric vehicle the next time they purchase a vehicle.

The study also found that people across all income levels are interested in EVs as they become more affordable and popular across all demographics, with people of color more likely to consider going electric than all buyers combined (42% vs. 36%).

Figure 1: Incomes of Prospective EV Buyers



The study also found that a majority of Americans support making more electric vehicle models available and that more than three-quarters of prospective car buyers are unaware whether their state currently offers any discounts, rebates, or credits for purchasing or leasing EVs[11]. This is something that can be resolved.

Automaker EV Advertising Data

In the time since our original 2016 Rev Up EVs report was published, the US auto industry has made no serious effort to boost electric vehicle sales or provide people interested in EVs with an excellent shopping experience. Northeast States for Coordinated Air Use Management (NESCAUM), a nonprofit association of air-quality agencies, analyzed advertising expenditures for the top six EV manufacturers (other than Tesla): General Motors, Toyota, Nissan, Ford, Fiat-Chrysler, and Volkswagen. Their analysis compared the 2017[12] and 2018[13] advertising expenditures for manufacturers' EV models versus their best-selling internal combustion engine vehicles.

- The auto industry, in general, spends very little (and in some cases, nothing) on advertising electric vehicles, especially in comparison to what they spend on advertising their best-selling internal combustion engine vehicles.
- In 2017, total spending on national advertising for the best-selling internal combustion engine model of each manufacturer was $540 million across six models, an average of $90 million per model. The total spending on national advertising by the same manufacturers for electric vehicles was $29 million across nine models, or an average of $3.2 million per model. **That means the auto industry is spending 28 times more on national advertising for internal combustion engine vehicles than on advertising EVs.**
- In 2018, total spending on advertising for the best-selling internal combustion engine model of each manufacturer in the California and Northeast markets was $230 million, an average of $38 million per model. The total spending on advertising in the California and Northeast markets was $22 million across six models, an average of $3.7 million per model. **That means the auto industry is spending 10 times more on advertising in the California and Northeast markets for internal combustion engine vehicles than on advertising EVs.**[14]

This information helps explain why the feedback from our volunteers was not as positive as it should have been. The lack of EV advertising is one more clear example that the auto industry and car dealerships continue to focus on selling as many gas-guzzlers as possible, while only paying lip service to EVs.

> *"Sales person told me that VW corporate didn't want them selling any electric cars at their dealership because there was such a poor charging infrastructure in place in the community."*
>
> **MATTHEW A. (VOLKSWAGEN DEALERSHIP IN IOWA)**

> *"Nobody knew. Negative false remarks about electric vehicles. Example prices all wrong. Salesperson said best range is 35 miles and car is super expensive."*
>
> **TOM C. (FORD DEALERSHIP IN FLORIDA)**

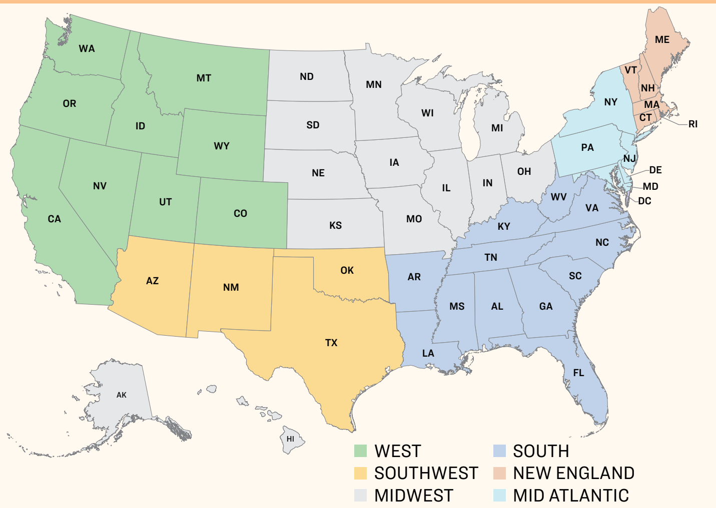
> *"They claimed that there's no demand on one hand, but the salesman also said that he had received several internet leads expressing interest in the Kona EV."*
>
> **SUSAN K. (HYUNDAI DEALERSHIP IN GEORGIA)**

REGIONAL VARIATIONS

The experiences of our volunteers differed depending on where in the country they were. Unsurprisingly, dealerships in some regions provided a better EV consumer shopping experience than others did.

For purposes of this report, we compared results from six different regions: New England, the Mid-Atlantic, the South, the West, the Southwest, and the Midwest.

Figure 2: Regions Reported On



Our volunteers found that dealerships and automakers in the West did a far better job of selling EVs, while consumers in other areas of the country faced higher barriers to EV access and information.

Figure 3: Customer-Satisfaction Ratings

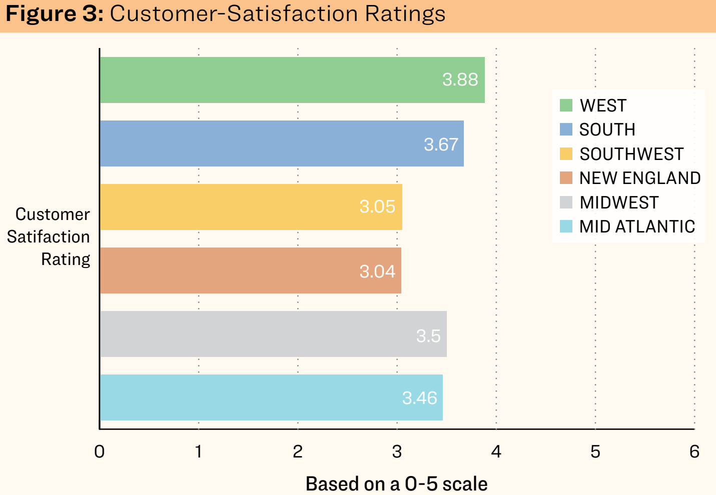


Figure 4: EV Inventories by Region

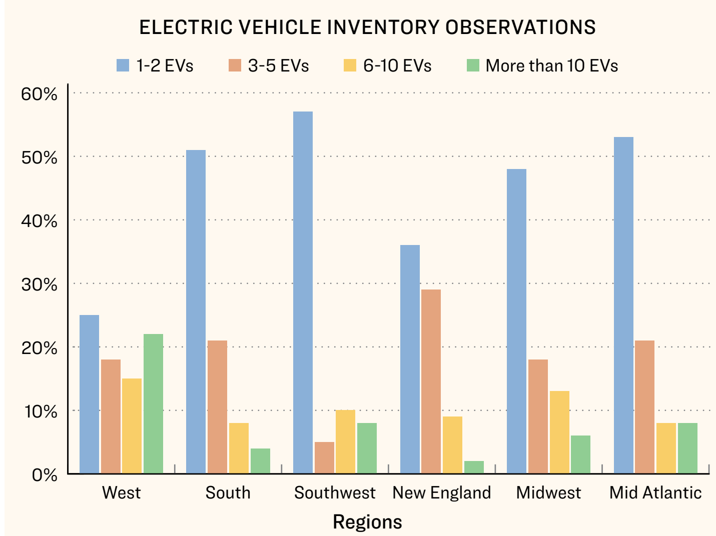


Figure 5: Charging Information by Region

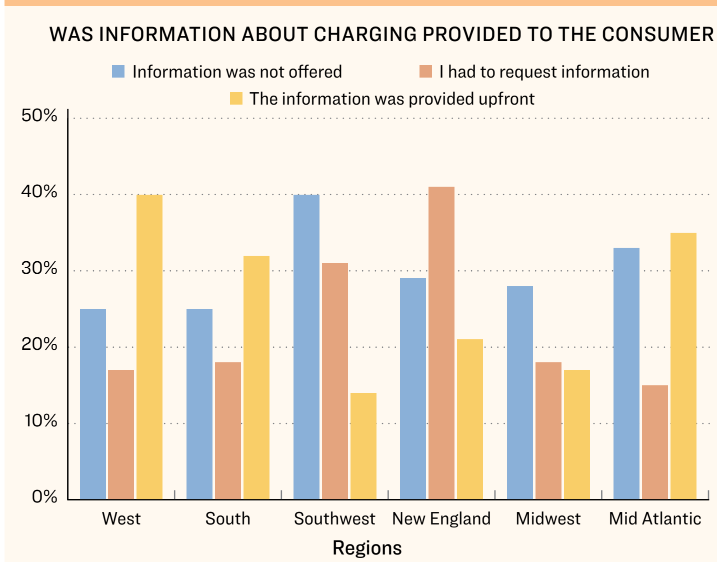
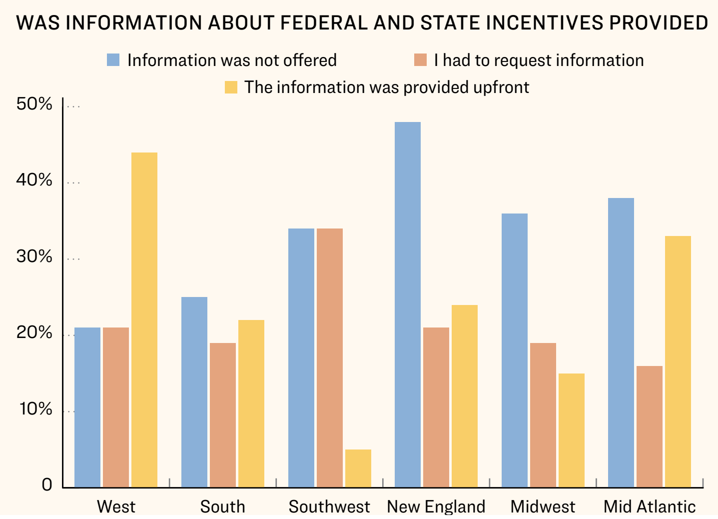


Figure 6: Incentives Information by Region



> *"I test drove a car [a plug-in hybrid] but could not utilize the electric mode because it wasn't charged."*
>
> **JOHN W. (CHEVROLET DEALERSHIP IN MINNESOTA)**

> *"We ended up buying our Volt at Modern Chevrolet because of the price. I knew more about the car and the tax credit than they did. They had a charge station, but it was out of order, of course."*
>
> **JEFF G. (CHEVROLET DEALERSHIP IN NORTH CAROLINA)**

> *"I bought the car. They had limited expertise. Referred me to the website. When I picked up the car it was not fully charged. I have the impression that they haven't given any consideration to the needs of the electric car buyer. However, the salesman was enthusiastic about the car itself. Within a week they called me to schedule my first maintenance 6 months out. When I asked what maintenance my car would need they didn't know."*
>
> **LUCY B. (CHEVROLET DEALERSHIP IN CALIFORNIA)**

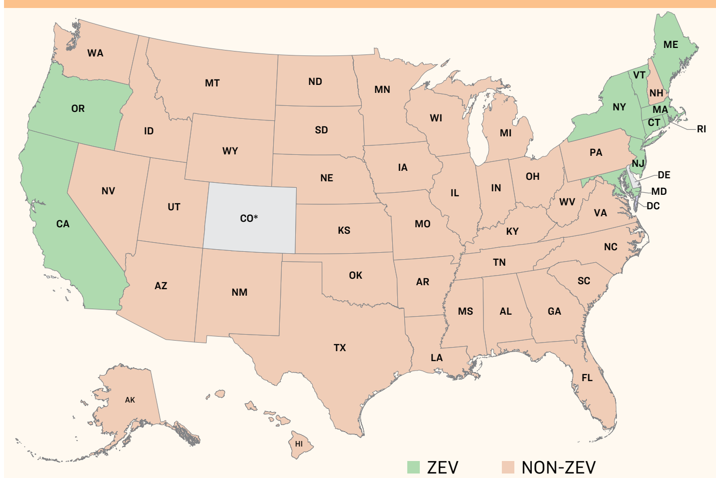
ZERO EMISSION VEHICLE MANDATE

California's Zero Emission Vehicle (ZEV) program requires automakers in the state to sell increasing numbers of electric vehicles (full-battery electric and plug-in hybrid).

The Clean Air Act authorizes other states to adopt California's more stringent standards. Currently, 14 states, plus the District of Columbia, have adopted the Low Emission Vehicle standards. Eleven of those have taken the additional step of adopting the ZEV program: California, Colorado, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont. In September 2019, the Trump administration took two actions that threaten California's authority to regulate emissions from new motor vehicles. First, the National Highway Traffic Safety Administration (NHTSA) invalidated the California greenhouse gas standards and the ZEV program under the federal fuel economy law. Second, the EPA withdrew the waiver it had granted in 2013 that authorized California to implement its own greenhouse gas standards and the ZEV program for model years 2021 through 2025. This clean cars rollback impacts all of the "clean car states."

It is worth noting that in October 2019, General Motors (owner of Chevrolet brand), Fiat-Chrysler, Toyota, and several other automakers announced their intervention in support of the Trump administration in the legal battle over California's long-standing authority to set more stringent emission standards for new motor vehicles, as well as to require automakers to manufacture increasing numbers of electric vehicles. By siding with the Trump administration on preemption, automakers are attempting to weaken the clean car standards and the industry standards that are accelerating electric vehicle adoption.

Figure 7: ZEV and non-ZEV States



*Colorado adopted the ZEV standards in the summer of 2019. Because this had not yet taken effect at the time of our surveys, we considered Colorado as a non-ZEV state for the purposes of our evaluation.

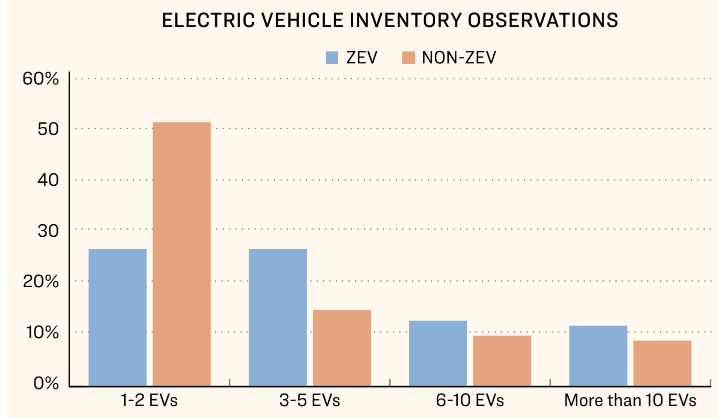
In analyzing how dealerships were selling EVs in ZEV states compared with non-ZEV states, we found that the

> ***"Salesman told me without hesitation that he doesn't like hybrids or electric cars because he doesn't want to deal with the cost of replacing the battery. He, like everyone else, didn't factor in the savings."***
>
> **CHRISTOPHER H. (HYUNDAI DEALERSHIP IN OREGON)**

dealerships in the states that had enacted the ZEV program were doing a much better job overall, resulting in a larger share of EVs being sold. To be clear, this is as a result of effort by both the dealerships and the automakers to provide inventory and increased salesperson training. In 2018, the US saw 328,118 EV sales — an increase of 81% from the previous year. The 10 ZEV states accounted for 63% of total EV sales (205,346), while non-ZEV states accounted for only 37% of total sales (122,772).

> ***"Salesman criticized the state's Democratic governor for signing into law a requirement that 10% of all cars sold in next 10 years had to be electric. They had zero electric vehicles on the lot, all the vehicles were standard gas vehicles. I'll never go back there but will get an auto broker."***
>
> **BETTY H. (TOYOTA DEALERSHIP IN COLORADO)**

Figure 8: EV Inventories, ZEV and Non-ZEV States



When volunteers visited dealerships, they found significant differences in inventory and number of EVs available between ZEV and non-ZEV states. Non-ZEV states had much more limited EV inventory; among those that offered EVs, a majority (52%) offered only from 1–2 EVs. In ZEV states, a majority (53%) offered more than two EVs, 27% offered from 3 to 5, 13% offered from 6 to 10, and 12% offered more than 10.

Differences in customer satisfaction between ZEV and non-ZEV states were statistically insignificant, except in California, where satisfaction was notably higher. However, salespeople at auto dealerships in ZEV states were more likely to provide information on charging, battery range, and federal and state rebates and incentives for consumers.

AUTOMAKER BRAND VARIATIONS

Our volunteers contacted dealerships representing 19 different automobile brands:

Audi, BMW, Chevrolet, Chrysler, Fiat, Ford, Honda, Hyundai, Jaguar, Kia, Lexus, Mercedes, Mini, Mitsubishi, Nissan, Subaru, Tesla, Volkswagen, and Volvo.[15]

We asked volunteers to rate their overall shopping experience at each dealership on a five-point scale. A score of 1 was considered "very negative" and a score of 5 was considered "very positive." Figure 9 shows the average score for each automaker brand.

Our volunteers reported that Tesla provided the best overall EV shopping experience, while Chrysler provided the worst overall EV shopping experience.

We also examined the inventory of available EV models that were being sold on the lots, and whether or not our volunteers were being provided with information from salespeople relating to charging, battery range, and federal and state incentives for those particular models and automotive brand.[16]

Figure 9: Consumer Satisfaction by Automaker

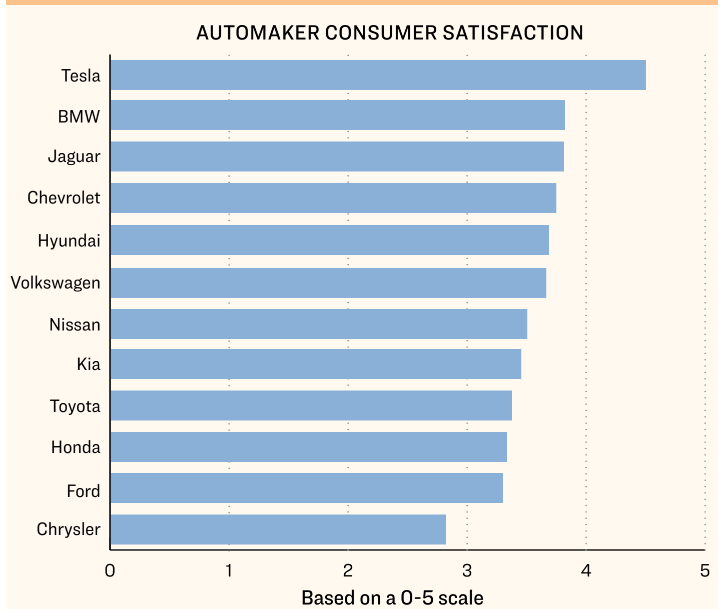


Figure 10: EV Inventories by Automaker

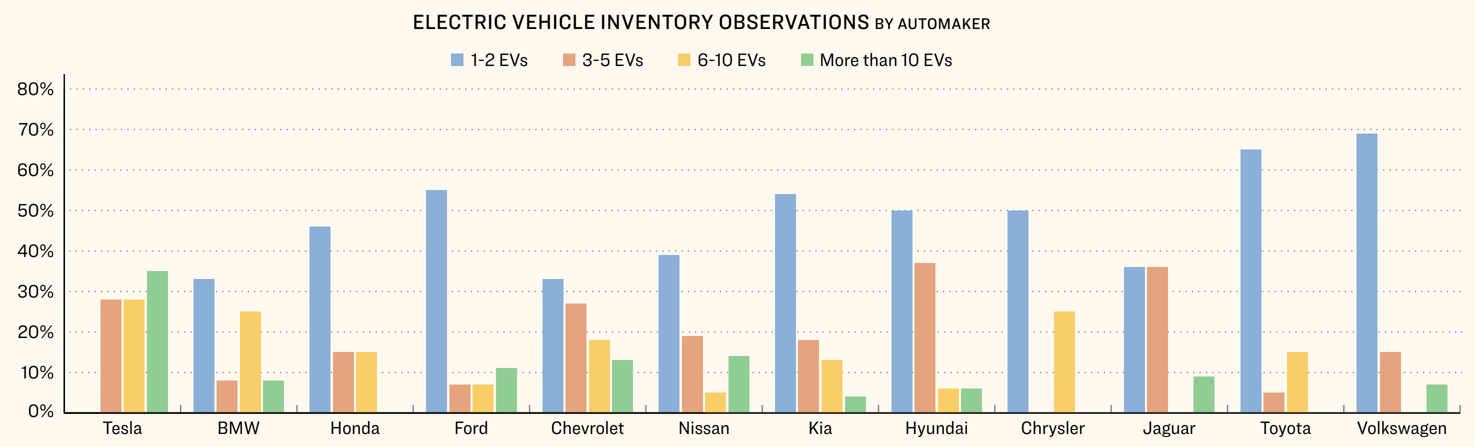


Figure 11: Charging Information by Automaker

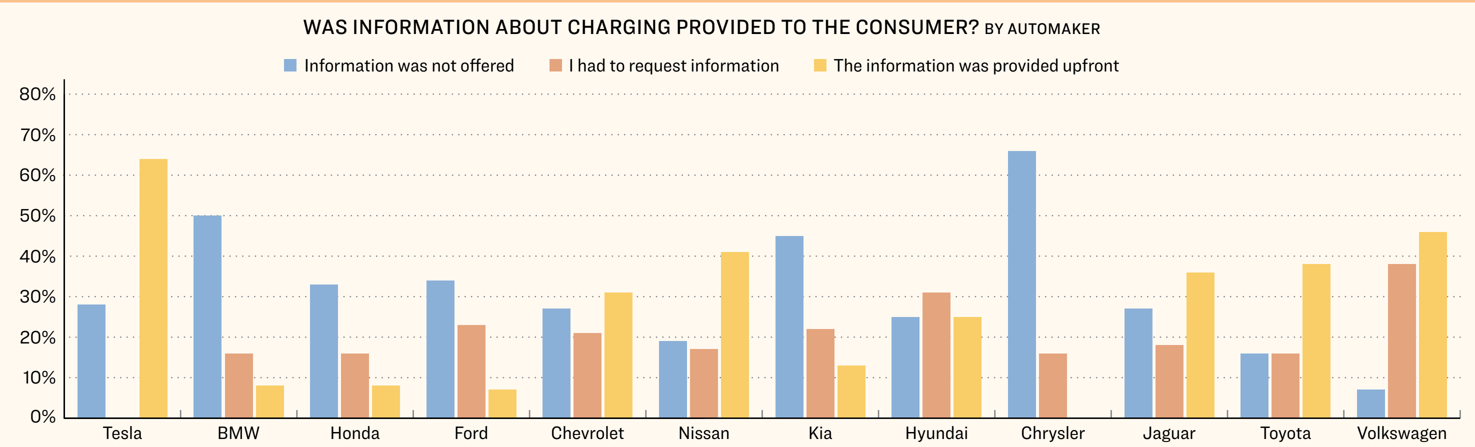
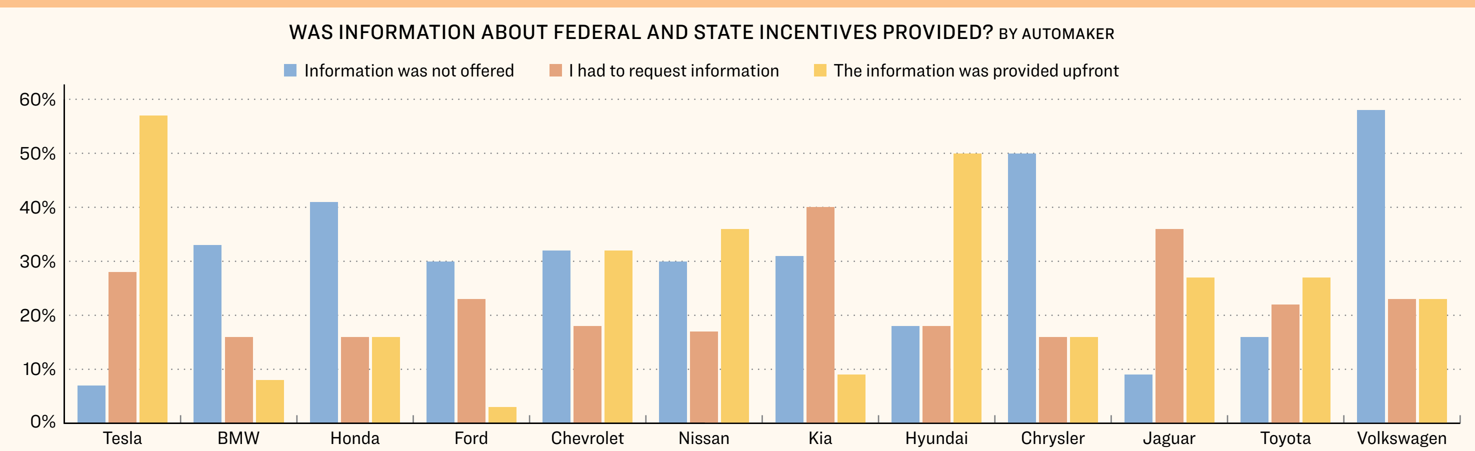


Figure 12: Incentives Information by Automaker



"I asked if Subaru might offer EVs in the future and the answer was no, that customers like their gas-saving cars as is. When I suggested EVs use no gas, the representative said EVs aren't that great because they use lithium for batteries, a nonrenewable resource. He then said public transportation is the ultimate answer to our auto emissions challenges. He did add that VW will be offering an electric bus in the near future."

KAREN S. (SUBARU–VOLKSWAGEN DEALERSHIP IN COLORADO)

HOW CALIFORNIA COMPARES

California is the fifth-largest economy in the world. With a population of more than 40 million people, the state represents critical market share that could help spur EV adoption in the rest of the country. In 2018, California accounted for almost half[17] of all EV sales in the nation, and the percentage of EVs in the state will only continue to grow.

We had the most volunteers and auto dealership surveys from California and, given the state's importance in shaping and advancing the EV market, we were interested in looking at how it compares with the rest of the country. Overall, our volunteers had much more positive shopping experiences in California than in all other states.

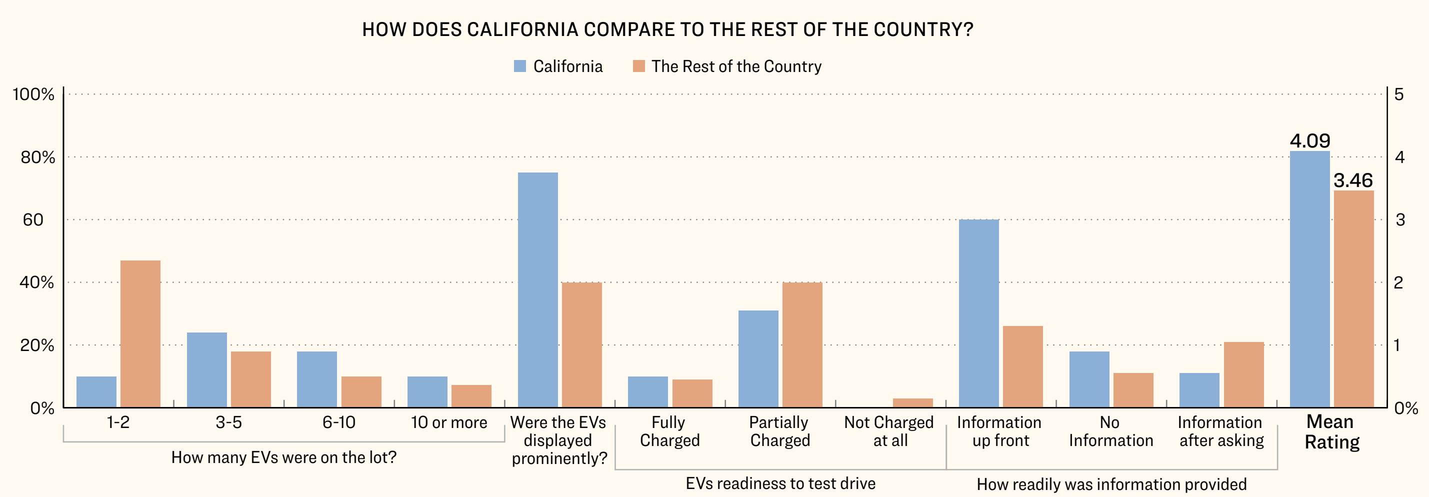
California

- For dealerships with EVs on their lots, we found that **24%** offered from 3 to 5 models, **18%** offered from 6 to 10 models, **10%** offered more than 10 models, and **10%** offered only 1 or 2 models.
- **75%** of dealerships with EVs displayed them prominently on the lot.
- **73%** of the dealers with EVs had vehicles that were fully charged for a test drive, and **10%** had vehicles that were partially charged.
- **60%** of our volunteers received information up front on state/federal rebates and tax incentives that would save them money, **18%** received no information, and **11%** received information only after requesting it.
- The mean rating for EV shopping in California was **4.09** out of **5**.

The Rest of the Country

- For dealerships with EVs on their lots, we found that **47%** offered only 1 or 2 models, **18%** offered from 3 to 5 models, **10%** offered from 6 to 10 models, and **9%** offered more than 10 models.
- Only **40%** of dealerships with EVs displayed them prominently on the lot.
- **34%** of the dealers with EVs had vehicles that were fully charged for a test drive, **9%** had vehicles that were partially charged, and **3%** had vehicles that were not charged at all.
- **26%** of our volunteers received information up front on state/federal rebates and tax incentives that would save them money, **33%** received no information, and **21%** received information only after requesting it.
- The mean rating for EV shopping in all other states was **3.46** out of **5**.

Figure 13: How Does California Compare to the Rest of the Country?



BEST PRACTICES & POLICY RECOMMENDATIONS

Based on all of the feedback we received from our volunteers, along with guidance from industry experts, what follows is a summary of best practices and recommendations for both automakers and dealerships to successfully sell their EVs, as well as for policy makers to provide regulatory incentives for EV expansion.

Availability and Inventory

As indicated from our independent sampling, we found that 74% of the auto dealerships that our volunteers visited nationwide did not have any EVs on their lots. The failure of dealerships to offer EVs creates a huge barrier to access for consumers. For those that do offer EVs, 44% of those dealerships visited only had one or two cars available, which limits choice in regard to vehicle features such as color and trim. Depending on their region and state, many consumers may be left out of the EV market altogether simply through lack of availability.

To improve this situation, automakers should manufacture and advertise higher volumes of EVs. They must also provide more incentives and discounts for dealerships to sell EVs, as they do for various internal combustion engine vehicles. Dealerships on the other hand, must secure a larger number of EVs from automakers.

Another barrier to address is the costly dealership certification fee that many automakers impose on dealerships just so they can sell EVs. This is something that should be offered at a free or affordable rate in order to expand accessibility and inventory of EVs across the country.

Visibility

Prominently displaying EVs and charging stations will generate consumer interest and increase sales. Our volunteers often had difficulty locating EVs because they were buried far back on the lots.

It is important that EVs be displayed prominently, whether inside the showroom or at the front of the lot. This both makes it easier for consumers to find vehicles and reassures them that EVs are products that the automakers and dealers are excited to promote and sell.

Expertise

Many widespread myths persist about electric vehicles, which makes it especially important for dealerships to have well-trained staff and salespeople who are knowledgeable about them. Many customers will have questions about charging and range, as well as about federal and state incentives.

Explaining the advantages of EV technology and alerting customers to available incentives are two of the most effective tools for increasing widespread EV adoption. However, as our volunteers found, salespeople often provide consumers with insufficient or incorrect information about EVs regarding charging, battery range, and federal and state incentives. Automakers and auto dealers should utilize certification and training programs to ensure that salespeople have the proper knowledge about EVs.

Recommendations

Automakers should:

- Manufacture more EVs for sale across a wider share of states and regions, and increase inventory volume.
- Manufacture additional EV models with different features such as battery range and performance.
- Provide better incentives to dealerships for selling EVs.
- Provide free or affordable certification for dealerships to sell EVs.
- Increase marketing and advertising for EVs.
- Provide information to dealerships on EV technology and federal/state incentives.[18]
- **Auto dealers should:**
- Proactively secure more EVs from automakers.
- Provide sales staff access to periodic EV training and certification opportunities on charging technology, consumer incentives (state and federal rebates, tax credits), and effective sales strategies.
- Have one or more salespersons designated as EV experts.
- Encourage potential EV customers to schedule their visit when a staff EV expert is available.
- Display EVs prominently.
- Work with local pro-EV groups to participate in test ride events.

- Help prepare incentive paperwork for customers at the point-of-sale, where feasible.
- Ensure that EVs are consistently charged and ready to be test driven.

State regulators and policymakers should:

- Maintain or increase existing consumer rebate and incentive programs for the purchase and lease of new and used EVs, and provide additional incentives for low-income and disadvantaged communities, including provisions that protect people against dubious auto financing scams.
- Create EV consumer-rebate programs in states that do not have them—ideally to be administered at the point-of-sale and for the salesperson and/or dealership to receive a small cut of the rebate.
- Announce target EV consumer adoption and infrastructure goals for 2025, 2030, and 2050.
- Provide grants and incentives for businesses, municipalities, and government agencies to invest in EV fleets and EV charging infrastructure.
- Create consumer EV-education programs.
- Require utilities to install charging infrastructure, including at workplaces, at apartment complexes, and in low- and moderate-income neighborhoods.
- Grant utilities the freedom and flexibility to invest in consumer and dealer education and incentive programs, just as they'd previously been granted such flexibility for promoting energy efficient appliances.

METHODOLOGY

This study was conducted by the Sierra Club from May through July 2019. Our research and polling team provided us with individual target numbers of auto dealerships in each state to survey—based on figures from the National Automobile Dealers Association[19] — in order to obtain a representative sample for a nationwide report. We reached our survey goals in all 50 states.

We recruited 579 volunteers via email, phone, and media outreach. Collectively, they surveyed more than 909 auto dealerships and stores across all 50 states.

We asked volunteers to indicate the date that they expected to call or visit a dealership so we could schedule follow-up emails and calls until their completion.

To avoid potential bias or skewing of results, volunteers were directed to choose auto dealerships in their area and then visit or make a phone call as part of the campaign.

Volunteers were given a fact sheet[20] that explained the campaign, supplied background information on electric vehicles, and provided general instructions. Rev Up EVs is not a "secret shopper" initiative. Volunteers were welcome to mention to salespeople that they were participating in a survey on behalf of the Sierra Club — or not — depending on their preference.

Participants were not given a script and were asked to have their interactions be as organic as possible.

After their visit or phone call, each volunteer completed an online survey to report the findings. In consultation with our polling and research department and our data consultant, we analyzed the results from 685 surveys.

We also used a proportion-estimation procedure to estimate the percentage of dealerships that offer any electric vehicles. We did this separately from the volunteer visits; 224 phone calls were made to randomly selected dealerships evenly distributed throughout the country. We did this because of the possibility that volunteers might make an effort to find dealerships with EVs available and thus under-report on dealerships that did not have EVs. Since we conducted a large number of calls (N>200), our procedure met the requirements for proportion estimation with a normal distribution. We estimate that 74% of auto dealerships do not offer any EVs, and are 95% confident that the true proportion lies between 68% and 80%.

APPENDIX: TOP-RATED DEALERSHIPS

The following dealerships received the highest rating (five stars) from our volunteers after their EV shopping experience.

ARKANSAS
Parker Audi, **Little Rock**

CALIFORNIA
Selman Chevrolet, **Orange**
Novato Chevrolet, **Novato**
North Bay Nissan, Petaluma
Tesla, **San Diego**
Stevens Creek Kia, **San Jose**
Nissan Fremont and Nissan Dublin, **Fremont**
Toyota of Carlsbad, **Carlsbad**
Fiat, **Orange**
Putnam Nissan, **Burlingame**
Tesla, **Los Angeles**
John L Sullivan Chevrolet, **Roseville**
Tesla, **Santa Monica**
Oakland Kia, **Oakland**
Sunnyvale Volkswagen, **Sunnyvale**
Central Valley Hyundai, **Modesto**
KIA, **Victorville**
Manly Honda, **Santa Rosa**
Platinum Chevrolet, **Santa Rosa**
Jim Bone Nissan of Santa Rosa, **Santa Rosa**
Victory Chevrolet, **Petaluma**
San Leandro Hyundai-Kia, **San Leandro**
Future Nissan of Folsom, **Folsom**

FLORIDA
Pompano Ford & Lincoln, **Pompano Beach**
Sarasota Mitsubishi Suzuki , **Sarasota**
Honda of Fort Myers, **Fort Myers**
Audi of Sarasota, **Sarasota**
Kraft Nissan, **Tallahassee**
Tesla, **Boca Raton**
Grieco Chevrolet, **Fort Lauderdale**
Mercedes-Benz of Naples, **Naples**

GEORGIA
Rick Hendrick Chevrolet, **Duluth**
Atlanta Classic Cars Mercedes-Benz, **Duluth**
Dyer & Dyer Volvo, **Atlanta**

HAWAII
New City Nissan, **Honolulu**

IDAHO
Dennis Dillon Nissan, **Boise**

ILLINOIS
Illini Nissan, **Champaign**
Bob Jass Chevrolet, **Elburn**
Fletcher Jones, **Chicago**

INDIANA
D-Patrick Nissan, **Evansville**
Tesla of Indianapolis, **Indianapolis**

KENTUCKY
Jaguar Louisville, **Louisville**

MARYLAND
Ourisman Chevrolet of Baltimore, **Baltimore**
Ideal Hyundai, **Frederick**
Tesla, **Bethesda**
Antwerpen Hyundai, **Catonsville**
Ourisman Hyundai, **Bowie**

MICHIGAN
Atchinson Ford, **Van Buren Twp**
Feldman Chevrolet of Highland, **Highland**
Kia of Canton Michigan, **Canton**
Robert DeNooyer Chevrolet, **Holland**

MINNESOTA
Jeff Belzer's Chevrolet, **Lakeville**
Rosedale Chevrolet, **Roseville**

NORTH CAROLINA
Carvana, **Boone**
Michael Jordan Nissan, **Durham**
Chevrolet of New Bern, **New Bern**

NEW JERSEY
Ciocca Chevrolet, **Lawrenceville**
Tesla of Cherry Hill, **Cherry Hill**
Ramsey Nissan, **Ramsey**

OHIO
Porsche Beachwood, **Beachwood**

OREGON
Wilsonville Chevrolet, **Portland**
Gladstone Mitsubishi, **Milwaukie**
Subaru of Portland, **Portland**
Kendall, **Eugene**
Rustom Nissan, **Portland**
Platt Auto, **Milwaukie**

PENNSYLVANIA
Sloane Toyota of Glenside, **Glenside**
Fred Beans Ford, **Doylestown**
#1 Cochran Nissan, **Monroeville**

RHODE ISLAND
Balise Toyota of Warwick, **West Warwick**

TENNESSEE
Mtn View Nissan, **Chattanooga**
Oak Ridge Nissan, **Oak Ridge**
West Chevrolet, **Alcoa**

TEXAS
Alfa Romeo of Fort Worth, **Fort Worth**
Auto Nation Chevrolet, **Austin**
Audi North Austin, **Austin**

UTAH
Stephen Wade Chevrolet, **St. George**
Tesla Salt Lake City, **Salt Lake City**

VIRGINIA
Tesla, **Richmond**
Koons Falls Church Ford, **Falls Church**
Pohanka Chevrolet, **Chantilly**

VERMONT
Burlington Hyundai-Subaru, **Burlington**
Lamoille Valley Chevrolet, **Hyde Park**

WASHINGTON
Bill Pierre Chevrolet, **Seattle**
Kia of Puyallup, **Puyallup**

WISCONSIN
International Autos, **Milwaukee**
Heiser Chevrolet, **West Allis**

WEST VIRGINIA
Germain Nissan, **Columbus**
Wilson Ford Lincoln, **White Hall**

ENDNOTES

1 https://content.sierraclub.org/creative-archive/sites/content.sierraclub.org.creative-archive/files/pdfs/1371%20Rev%20Up%20EVs%20Report_09_web.pdf

2 https://www.ipcc.ch/sr15/

3 https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

4 Recent research suggests that oil and gas industrial facilities release at least 13 million metric tons of methane pollution a year – the same climate impact as operating nearly 300 coal-burning power plants for a year or driving more than 200 million motor vehicles for a year. Methane, the primary component of fracked gas, and one of the top emissions from the onshore oil and gas production and supply chain, has 87 times the warming power as CO2 during the time in remains in the atmosphere.

5 https://content.sierraclub.org/creative-archive/sites/content.sierraclub.org.creative-archive/files/pdfs/1371%20Rev%20Up%20EVs%20Report_09_web.pdf

6 https://www.detroitnews.com/story/business/autos/mobility/2019/05/03/why-automakers-betting-so-big-electric-vehicles/3615444002

7 https://www.reuters.com/article/us-autoshow-detroit-ford-motor/ford-plans-11-billion-investment-40-electrified-vehicles-by-2022-idUSKBN1F30YZ

8 https://www.cnn.com/interactive/2019/08/business/electric-cars-audi-volkswagen-tesla

9 https://www.greentechmedia.com/articles/read/us-electric-vehicle-sales-increase-by-81-in-2018

10 https://www.ucsusa.org/clean-vehicles/electric-vehicles/ev-survey-2019

11 https://advocacy.consumerreports.org/wp-content/uploads/2019/07/ConsumerReports-UnionofConcernedScientists-2019-EV_Survey-7.17.19.pdf

12 https://mailtrack.io/trace/link/7a0072b7c0d45fe829a16908d575b6889defc6d9?url=http%3A%2F%2Fwww.nescaum.org%2Fdocuments%2F2017-ev-marketing.pdf&userId=1678180&signature=1820c7027d9c1e96

13 https://www.nescaum.org/documents/2018-ev-marketing.pdf/

14 National advertising data for 2018 has not yet been analyzed by NESCAUM. Current analysis only includes advertising expenditures in the California and Northeast markets.

15 The following auto brands were surveyed but did not meet our quantity threshold to be included in this analysis: Audi, Fiat, Mercedes, Subaru, Volvo, Mini

16 The following auto brands were surveyed but did not meet our quantity threshold to be included in this analysis: Audi, Fiat, Mercedes, Subaru, Volvo, Mini

17 https://www.latimes.com/business/story/2019-09-10/ev-electric-car-sales-california-tesla

18 Third party certification program exists (Plug Star and Smart Columbus) which provide trainings to auto dealerships on how to effectively sell EVs to interested consumers:

19 https://www.nada.org/

20 https://content.sierraclub.org/evguide/sites/content.sierraclub.org.evguide/files/rev-up-2.0-faq.pdf

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Electric Vehicles Are Driving Electric Rates Down

June 2020 Update

Jason Frost, Melissa Whited, and Avi Allison

Plug-in electric vehicles (EVs) offer a key opportunity to reduce harmful emissions and save customers money at the same time. EVs are responsible for far fewer greenhouse gases and local air pollutants than conventional vehicles and become cleaner as more renewable electricity is added to the grid. In addition, EVs are generally much less expensive to operate than conventional vehicles.

EVs are growing as a share of the light duty vehicle market. At the end of 2019, more than 1.4 million EVs had been sold in the US alone.[1] Another sign of the accelerating transition to cleaner electric transportation is the number of electric models that auto manufacturers are planning to introduce in the next few years. For example, GM announced in March 2020 that the company will launch 20 EV models globally by 2023 and aim to sell 1 million EVs per year by 2025.[2] With more available options that suit a wider range of customer needs, sales of EVs are likely to continue increasing in the coming years. With large quantities of cars plugging into the grid, there is a potential for significant electric utility system impacts. EVs hold significant potential to reduce electric rates for all customers because they can bring in more revenue than associated costs, largely due to the fact that EVs can be charged during hours of the day when the electric grid is underutilized.

This analysis examines costs and revenues associated with EVs between 2012 and 2019 in the two utility service territories in the US with the most EVs of any---Pacific Gas & Electric (PG&E) and Southern California Edison (SCE). **We observe that over those eight years, EV drivers in PG&E's and SCE's service territories have contributed $806 million more in revenues than associated costs, driving rates down for all customers.**

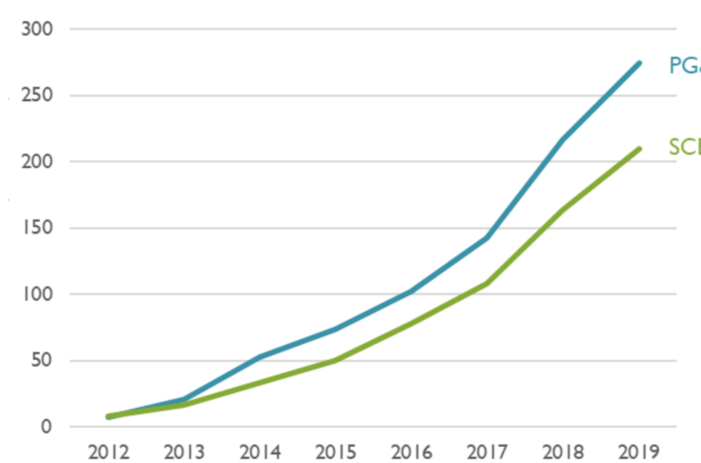
How Are EVs Affecting Electricity Rates?

Recent growth in EV adoption has raised the question of how EVs affect the electricity rates paid by all households, including those that do not own EVs. This is an important equity question that should be analyzed when determining the role that electric utilities should play in supporting the transition to EVs. Answering this question requires comparing electric utility revenues from EV charging with utility costs associated with serving EV load. If the utility revenues from EVs exceed the utility system costs, then EV adoption can reduce electricity rates for all customers. Conversely, if the costs are greater than the revenues, non-EV owners could end up paying more for their electricity.

To address this question using real-world data, Synapse evaluated the utility system revenues and costs associated with EVs in the service territories of Pacific Gas & Electric (PG&E) and Southern California Edison (SCE), the two utilities that have the most EVs of any utility in the US, with more than 484,000 EVs in their territories as of the end of 2019.[3]

Specifically, we analyzed the electricity rates that EV owners pay compared to the marginal cost of electricity plus the expenditures associated with utility EV infrastructure programs.

Figure 1. Cumulative EV Adoption in California Utility Service Territories



Our analysis relied on EV load profiles from the California Joint IOU Load Research Reports, as well as marginal costs from the CPUC's Avoided Cost Calculator.[4] We also used the load profiles for residential customers that are available on PG&E's and SCE's websites as an estimation of residential load profiles without EVs.

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Revenues from EVs

Charging an EV can substantially increase household electricity consumption. On average, we estimate that EVs in California increase consumption by approximately 250 kilowatt hours (kWh) per month.

California is currently transitioning to default time-of-use (TOU) rates and away from the existing default tiered electric rates. Under the old tiered rate structure, the price of electricity increases as customers move into higher-usage tiers. The extra electricity required to charge EVs is likely to push people into higher tiers. As a result, EV drivers paying these rates tend to pay high rates for charging their electric vehicles.

Unlike tiered rates, TOU rates have different prices during on-peak hours and off-peak hours and are meant to align prices more closely with the actual cost to provide electricity during those hours. By charging EVs primarily during off-peak hours, customers can simultaneously lower their electric bill and reduce costs on the grid. However, the TOU rates onto which most customers will be defaulted in California are not designed for more flexible loads, such as EVs. Optional TOU rates designed for EVs with higher on-peak to off-peak price ratios generally offer EV drivers greater savings while providing a greater incentive to charge during off-peak hours.

Accounting for the Costs Imposed by EVs

The costs imposed by EVs are the most important factor in determining the impact of EVs on electric rates. Fortunately, the Load Research Reports show that EVs are requiring few distribution system upgrades and, when on TOU rates, are charging at low-cost times for the grid.

Substantial EV Charging Can Be Integrated Without Substantial Cost

The 2019 Load Research Report shows that the integration of EVs in California has required very few utility system upgrades. Between 2012 and 2018, just one out of every 670 EVs resulted in a distribution system or service line upgrade (this data was not reported in 2019).[5] Between 2012 and 2019, PG&E's and SCE's EV-related utility system upgrade costs averaged $16 per vehicle in 2019 dollars. This suggests that California has yet to hit a point where distribution system EV integration costs become meaningful.

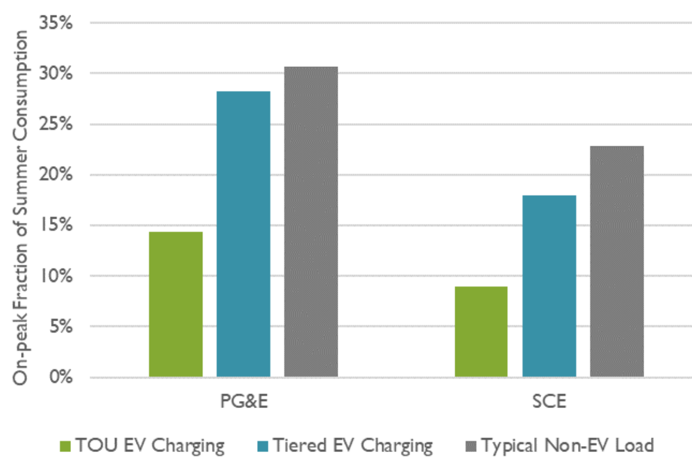
EV Customers on TOU Rates Charge in Low-Cost Ways

TOU rate structures generally include a high-priced "on-peak" period centered around weekday afternoons, a low-priced off-peak period that mainly covers night and early-morning hours, and an in-between "mid-peak" period. It turns out that these rates are effective at encouraging customers to shift their electricity usage to lower-cost hours. EV charging load profiles were calculated based on 2018 data from the 7th Load Research Report, as the April 2020 Charging Infrastructure Cost Report does not include updated load profile data for 2019.

EV Customers on TOU Rates Charge Off Peak

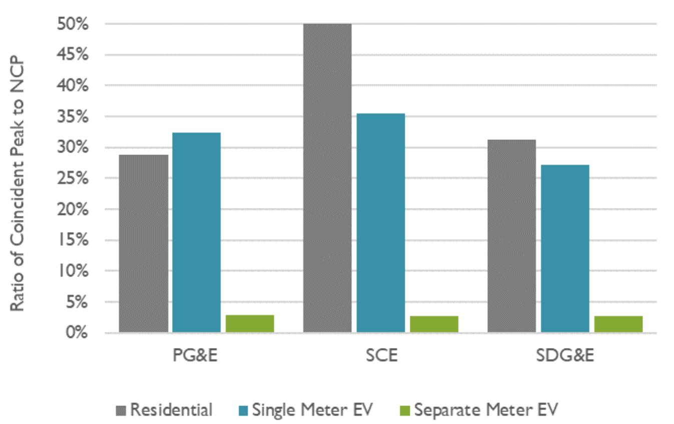
In California, EV customers on TOU rates consistently consume a far lower percentage of their electricity during on-peak hours compared to standard residential customers, in response to price signals that encourage use of the grid at lower cost times. Figure 2 shows how EV drivers on TOU rates tend to reduce their charging at peak hours relative to those on standard tiered rates. On average, EV customers on PG&E's TOU rates charged only 14 percent during on-peak hours in the summer months. Only 9 percent of EV charging occurred during on-peak hours for customer on SCE's TOU rate.

Figure 2. EV Customers on TOU Rates Consume Little During System Peak Hours



TOU on-peak and off-peak periods are a rough approximation of when the electric system is stressed. But system costs are disproportionately driven by only a few highest-peak hours of the year. What happens during those few hours when the electric system hits its peak demand? It turns out that customers on EV rates avoid charging their vehicles during those hours, too. By comparing the annual average peak demand of EV customers (also known as a non-coincident peak, or NCP) to that group's average demand during the system peak (also known as coincident peak demand), we can estimate how much EV customers contribute to system coincident peak demand. On average, separately metered EVs consume less than 5 percent of their peak levels during system peaks, which is much lower than standard residential customers (see Figure 3).

Figure 3. EV Customers on TOU Rates Consume Little During System Peak Hours



Rather than increasing demand on the system, EV customers on TOU rates often hit their monthly maximum demand when the system is least taxed – typically between 11 p.m. and 2 a.m.

EV Customers on TOU Rates Peak in Beneficial Patterns

Although EV customers charge during off-peak hours, concerns have been raised that these customers will create new peaks on the distribution system by charging at the same time (when the off-peak period begins).

While there is substantial variability across the three utilities, EV customers tend to have diversified peaks, similar to the residential class as a whole. This is measured by comparing the class peak demand to the sum of the individual customers' peak demands. If all individual customers peaked at the same time, then the class peak demand would be the same as the sum of the individual customers' peak demands. If individual customers peak outside of the class peak hour, then the class peak demand will be lower than the sum of the individuals' peak demands.

However, the data indicate that the diversity of demand varies considerably by utility. This phenomenon is the result of how the TOU rates and off-peak periods are designed. Specifically, the number of hours in the off-peak period is likely the primary factor driving the difference in EV customer peak diversity across the California utilities. SCE's 10-hour off-peak period provides the greatest diversity of demand, while SDG&E's 6-hour off-peak period encourages customers to charge at more or less the same time. Thus, expanding the number of hours covered by an off-peak period would likely result in increased peak diversity among customers on TOU rates.

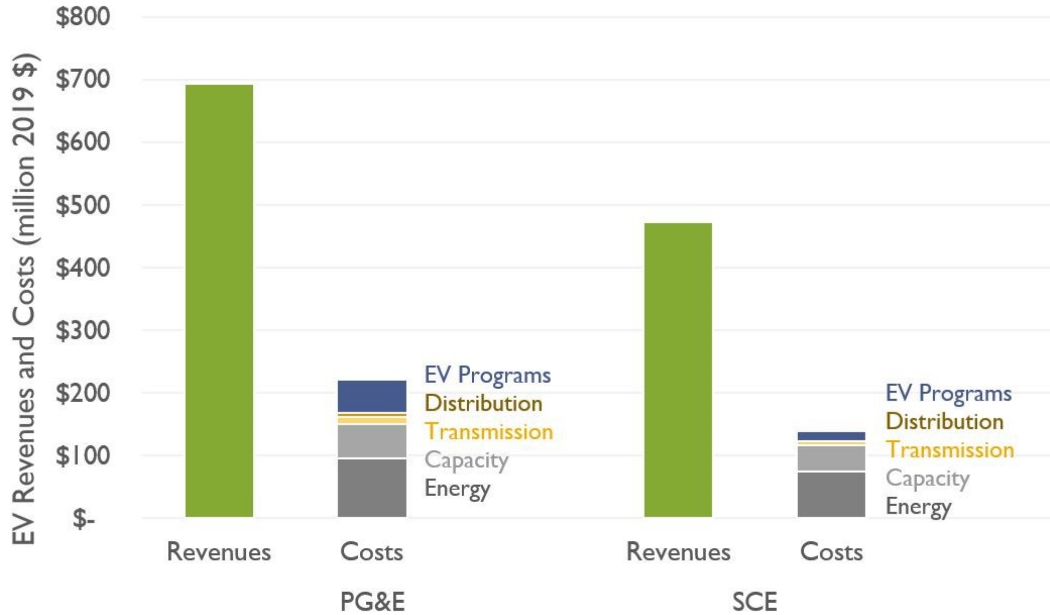
Impacts on Rates

By comparing the revenues from EVs to the costs imposed by EVs, we can determine the impacts that EVs are having on electricity rates. Since California is currently in the process of transitioning to default TOU rates, we conducted this analysis for one case in which most EV customers are assumed to be on traditional tiered rates (as has been the case in recent years) and one in which most customers are on TOU rates. The rate structure that a customer is on impacts both 1) the utility revenues associated with EVs and EV charging behavior and 2) the associated electric supply and distribution costs. Importantly, we find that EVs generate more utility revenue than costs and put downward pressure on rates when customers are on either type of rate.

In the first case, in which approximately 80 percent of customers remain on tiered rates, our analysis indicates that in the two utility service territories with the most EVs in the US, EVs have increased utility revenues more than they have increased utility costs — leading to downward pressure on electric rates for EV-owners and non-EV owners alike. Between 2012 and 2019, EV drivers in PG&E and SCE territory have contributed $806 million more than associated costs (in 2019 dollars.) Figure 4 shows the extent to which revenues from EVs outweigh the costs imposed for the period 2012-2019.[6]

This finding holds across both utilities and is not simply a result of the fact that the majority of EV drivers are paying higher tier prices on default tiered rates. To see how the fraction of EV drivers on TOU rates impacts the net benefits, we recalculated the costs and benefits under the assumption that 75 percent of EV drivers paid TOU rates throughout the study period. (In reality, closer to 20 percent of EV drivers have been on optional TOU rates designed for EVs, but that could change with the implementation of default TOU rates in California, which

Figure 4. PG&E and SCE Revenues and Costs of EV Charging, 2012-2019



will provide an opportunity to educate customers about the optional rates designed for EVs.) In the case with more EV customers on rates designed for EVs, revenues still exceeded costs between 2012 and 2019 by a total of $621 million.

A key reason why revenues from EVs outweigh the costs is that EV customers — particularly those on TOU rates — tend to charge during off-peak hours. By charging during off-peak hours, EVs impose minimal costs on the grid and help to utilize resources more efficiently. In fact, recent research conducted by Lawrence Berkeley National Laboratory, PG&E, and the Natural Resources Defense Council shows that shifting EV charging to off-peak times could allow the grid to accommodate all homes having EVs without upgrading most parts of the distribution system.[7]

Revenues from EVs Can Help Fund EV Charging Infrastructure

EVs can provide substantial emissions reductions while also helping to reduce electricity rates for all customers by using the system more efficiently. Utilities can play an important role in ensuring that EVs benefit both EV drivers and non-EV drivers alike by encouraging EV customers to enroll in TOU rates. In addition, utility investments that facilitate the deployment of charging infrastructure can accelerate the EV market, growing the potential benefits from widespread EV adoption.

If done carefully, utility-funded investments can deliver benefits to all ratepayers in excess of their costs. Our analysis indicates that increased EV adoption in the two utility service territories with the most EVs in the US has already resulted in more electricity revenues than costs, and future growth in the EV market will lead to further increases in utility revenues. With TOU rates and targeted investments in charging infrastructure, EV adoption can reduce costs for both EV-drivers and other electric customers while reducing harmful emissions.

Endnotes

[1]Transportation Research Center at Argonne National Laboratory. Available at: anl.gov/es/light-duty-electric-drive-vehicles-monthly-sales-updates.

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[3]8th Joint IOU Electric Vehicle Charging Infrastructure Cost Report. April 1, 2020.

[4] 2018 Avoided Cost Calculator. Available at https:// www.cpuc.ca.gov/general.aspx?id=5267.

[5] 7th Joint IOU Electric Vehicle Load Research Report. April 2, 2019. Available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=228787-14&DocumentContentId=60075.

[6] We have included the full costs of the EV programs and distribution upgrades incurred to date in this graph, rather than depreciating the costs over time. This is a conservative assumption, as most of these costs will likely be depreciated over the useful lives of the equipment. If we were to show the depreciated costs, the EV Program and Distribution costs incurred between 2012 and 2018 would be reduced by 84 percent for both utilities.

[7] Coignard et al., Will Electric Vehicles Drive Distribution Grid Upgrades?: The Case of California. June 5, 2019. Available at https://ieeexplore.ieee.org/document/8732007.

STATE OF NEW MEXICO
BEORE THE ENVIRONMENTAL IMPROVEMENT BOARD
AND THE
ALBUQUERQUE-BERNALILLO COUNTY AIR QUALITY CONTROL BOARD

IN THE MATTER OF: PROPOSED 20.2.91 NMAC –	)	
***NEW MOTOR VEHICLE EMISSION STANDARDS*,**	)	**EIB No. 21-66 (R)**
and	)	
THE PETITION TO REPEAL EXISTING RULE	)	
20.11.104 NMAC AND ADOPT PROPOSED	)	
REPLACEMENT 20.11.104 NMAC.	)	**AQCB No. 2022-01**
	)	

WRITTEN DIRECT TESTIMONY OF DR. MATTHEW CAMPEN

Q. Please state your name for the record.

A. Dr. Matthew Campen.

Q. And where do you work?

A. The University of New Mexico.

Q. What is your position?

A. I am Regents' Professor in the College of Pharmacy and Director of two National Institutes of Health-funded programs, the Mentored Research Career Development Program (KL2) and the Center for Metals in Biology and Medicine.

Q. For whom are you testifying?

A. I am testifying on behalf of NRDC, Conservation Voters New Mexico, Prosperity Works, the Sierra Club, Southwest Energy Efficiency Project, Western Resource Advocates, New Mexico Voices for Children, and New Mexico Environmental Public Health Network, and the Center for Civic Policy (collectively, "Clean Air Advocates").

Q. Could you describe your qualifications, including your education and relevant work experience?

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A. I hold a Bachelor of Science in Public Health from Virginia Polytechnic Institute; a Master of Science in Public Health, from the University of North Carolina, School of Public Health, in Chapel Hill; and a Doctor of Philosophy from the University of North Carolina, School of Public Health, Department of Environmental Science and Engineering, in Chapel Hill. I also completed a Postdoctoral Fellowship at Johns Hopkins University School of Medicine, Division of Pulmonary and Critical Care Medicine, in Baltimore, Maryland.

My current position is Regents' Professor at the University of New Mexico in Albuquerque. I have held that position since 2015. From 2009 to 2015 I was at the rank of Associate Professor in the Department of Pharmaceutical Sciences, College of Pharmacy, University of New Mexico in Albuquerque. Prior to that I worked for the Lovelace Respiratory research Institute (now the Lovelace Biomedical Research Institute), from 2007 through 2009 as Director of the Cardiovascular and Pulmonary Physiology Department; from 2004 to 2009 as Associate Scientist and Study Director, and from 2002 to 2004 as Associate Research Scientist in the Toxicology Division, National Environmental Respiratory Center, Lovelace Respiratory Research Institute, Albuquerque, New Mexico; from 2005 to 2008 as Adjunct Assistant Professor in the Department of Pathology, Center for Tropical Diseases, at the University of Texas, Medical Branch, Galveston, Texas; and from 2002 to 2009 as Adjunct Assistant Professor in the School of Medicine and School of Pharmacy, University of New Mexico, in Albuquerque.

I also previously served on the Albuquerque-Bernalillo County Air Quality Control Board. I have contributed chapters to the Environmental Protection Agency for their Integrated Science Assessments (for Carbon Monoxide and Particulate Matter), specifically related to cardiovascular toxicity, as an invited scientific expert. I was also an ad hoc member of the Clean

Air Scientific Advisory Committee for the EPA for their Clean Air Act-based review of Oxides of Nitrogen (2013-2016).

As a researcher, I have studied the toxicological impact of a wide variety of air pollutants and inhaled toxicants, including gasoline and diesel engine emissions, ozone, particulate matter of many sources (coal combustion, secondary organic aerosols, microplastics, uranium mine site-derived), sarin and VX gas, inhaled botulinum, hydrogen cyanide, nitrogen dioxide, and carbon monoxide. This research spans from basic work in cell culture and rodent models, to large animal (non-human primate) and human studies.

Q. What are your responsibilities as Regents Professor and Program Director?

A. My contributions to the University include teaching of toxicology, pharmacology and physiology in the Doctor of Pharmacy professional program and the Biomedical Sciences Graduate Program. I mostly teach graduate and professional students, but also deliver some undergraduate lectures. The bulk of my effort at UNM is on biomedical research. I am independently funded through the National Institutes of Health. As a researcher, I investigate the health impacts of many environmental air pollutants, currently with an emphasis on wildland fire smoke, ozone, microplastics, and mine site-derived particulate matter. I study neurological, cardiovascular, and gestational toxicity from these exposures. I also contribute to the administrative mission of the UNM Health Sciences Center, leading or otherwise participating in various committees essential to academic functions.

Q. Is your curriculum vitae Clean Air Advocates Exhibit 11?

A. Yes it is.

Q. Have you prepared testimony on the health effects of emissions from motor vehicles for this proceeding?

A. Yes I have.

Q. Please proceed with your presentation.

A. Emissions from vehicles have been shown to be among the most toxic components of the urban airshed. While much attention has been paid to diesel engine sources, gasoline engine exhaust has also been shown to contribute to adverse health outcomes. The major components of the emissions, particulate matter (PM), oxides of nitrogen (NOx), carbon monoxide (CO) and volatile organic compounds (VOCs) are all independently harmful to public health. Additionally, during summer months when sunlight is prevalent and direct, the ultraviolet rays of the sun catalyze reactions with the NOx and VOCs to form ozone (O_3), which is an additional driver of heart and lung disease.[1,2] Furthermore, interactions between these components enhance their toxicity.

Air pollutants arising from vehicle emissions have a wide array of health impacts, often determined by the health of an individual. As many pollutants can worsen heart and lung disease, those groups with preexisting cardiopulmonary conditions are often more sensitive to pollutant exposure. Other individuals may have a familial (or genetic) predisposition for neurological disorders, such as Alzheimer's disease, that can be accelerated by pollutants. Below, a brief summary of health outcomes for each major pollution component, as related to vehicle emissions, is provided, followed by a discussion of the scientific discoveries unique to gasoline emissions and overall traffic-related air pollution. The conclusion from most epidemiological studies is that current air quality standards are insufficient to fully protect the most vulnerable populations, thus continued efforts to reduce air pollution are highly justified.

Particulate Matter: We have understood the detrimental health effects of particulate matter for a century, with major smog disasters in London, Donora, Pennsylvania, and the Meuse Valley in Belgium highlighting the potential for acute mortality from both lung and heart disease.[3] As the Clean Air Act was implemented in the 1970's, much of the stationary-source pollution was reduced initially, allowing greater insight into the health contributions of PM air pollution from mobile sources.[4] PM arising from gasoline engines is very small, less than a micrometer in diameter, allowing it to be inhaled deeply into the lungs, where is exhibits a long residence time. Once deposited in the lung, numerous biological mechanisms are activated to clean those particulates, including an activation of immune cells known as macrophages. The macrophages, in turn, release biomolecules such as cytokines and proteases that can signal further inflammation and promote damage to the lungs and other organs in the body.

PM can cause a wide variety of health impacts, often dependent on preexisting conditions. Cardiovascular disease is the major health concern, as most people in the United States have risk factors such as high blood pressure, high cholesterol, obesity, and metabolic syndrome / type 2 Diabetes Mellitus.[3] Airborne PM has been shown to cause constriction of major blood vessels, which appears consistent with epidemiologically-observed elevated incidence of myocardial infarction and stroke. PM has been associated with electrocardiographic abnormalities and cardiac arrhythmia.[5] In other research ambient PM has been associated with neurological diseases and progression of Alzheimer's disease and related dementias.

Carbon Monoxide: CO is a colorless, odorless gas that has a high affinity for the hemoglobin in our blood that carries oxygen. CO has no direct impact on the lungs, but is a known neurotoxicant at high levels. At low levels of exposure, CO is associated with risk of coronary artery-related events, such as a heart attack, which has strong evidence from controlled exposure studies in humans[6,7] and rodents.[8]

Oxides of Nitrogen: NOx – especially nitrogen dioxide (NO_2) – can be irritating to the lungs and cause oxidative damage and inflammation. Asthma is the principal concern for NO_2, and the main driving issue for current National Ambient Air Quality Standards. NO_2 can also interact with sunlight and other gaseous components of air pollution to form O_3 and secondary organic particulates. In controlled human studies, we have shown that short-term exposure to NO_2 can recapitulate the acute vascular inflammatory impacts of vehicular exhaust.[9] Recent studies have shown associations between NO_2 levels and dementia in large population[10] and gestational exposure to NO_2 is associated with a higher incidence of autism spectrum disorder.[11]

Specific Research on Gasoline Engine Exhaust: While the lungs are the obvious target for PM toxicity many studies from our own laboratory have highlighted the potential for cardiovascular and neurological disease outcomes. Atherosclerosis, a disease of major blood vessels that can lead to myocardial infarction (heart attack) and stroke, can be worsened by exposure to gasoline emissions[12] as well as diesel engine emissions.[13] Gasoline engine emissions were also able to cause significant changes to the electrocardiogram consistent with cardiac stress.[14] Moreover, serum (from blood) obtained from rodents treated with gasoline emissions was able to caused vasoconstriction (narrowing of arteries) and increase the expression of inflammatory molecules in the endothelial cells that line all blood vessels.[15] Among the notable findings, when gasoline and diesel engine emissions were combined, as is unavoidable in urban regions, the cardiovascular toxicity was far greater.[16] The overall vascular inflammation, a precursor to ischemic heart disease, was far greater with vehicular emissions than other forms of PM.[17]

Neurological effects of traffic-related emissions have been identified in recent years, potentially contributing to developmental issues (e.g., autism) [11], anxiety/ depression/suicide rates,[18] and neurodegenerative diseases (e.g., dementia and Alzheimer's disease).[10,19,20] Toxicological studies have confirmed that vehicle emissions can indirectly impair the function of the blood brain barrier, which protects the brain from many toxic components of the blood, leading to neuroinflammation [21] [22]. O_3 inhalation has been shown to cause neuroinflammation and increase amyloid beta protein accumulation, both precursors of dementia, in rodent models.[23] Notably, whole vehicle emissions meaning the collective particulates and gases arising from engine exhaust, were far more potent at driving neuroinflammation than either the particle of gas fraction individually.[24]

Traffic-related air pollution has also recently been shown to promote hypertensive disorders of pregnancy, including preeclampsia [25]. Such effects are supported by direct exposure toxicological studies showing that pregnant rodents inhaling O_3 in early term pregnancy have cardiac deficits [26]. Gestational hypertension and preeclampsia can lead to acute and long-term cardiovascular consequences in mothers, as well as lead to premature delivery and low birth weight of newborns.

Summary

The scientific evidence for health impacts of vehicle-derived air contaminants is clear. The evidence includes epidemiological and toxicological research, highlighting both the magnitude of associations seen across large populations as well as the causal proof provided by controlled exposure studies. While the estimates for the influence of vehicle-derived air pollution indicate a low risk, the broad-based, population-level exposure means most people will experience that risk. The general finding from epidemiological studies is that there is no clear threshold for a "no effect level", meaning that even low levels of pollution can be detrimental to sensitive populations. Taking actions to reduce emissions – or reduce the numbers of emitting vehicles – is consistent with a reduction of risk especially in urban regions of New Mexico.

Q. Thank you, Dr. Campen, I have no further question.

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