COUNTY OF SANTA CLARA

2017 COMMUNITY WIDE GREENHOUSE GAS INVENTORY and FORECAST

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1 Introduction

This document presents the data, methods, and results for the 2017 greenhouse gas (GHG) emissions inventory and forecast for the County of Santa Clara (the County), including all city jurisdictions in the county, with a breakout analysis of the GHG emissions for the unincorporated area of the County. Included is an analysis of findings and trends in the County's GHG emissions in order to support the County's GHG emissions reduction targets and ultimately the County's Climate Roadmap. The document also includes results for the 2017 agricultural GHG inventory which was developed to understand the contribution of GHG emissions from the Agricultural sector and areas for potential sequestration.

The State of California has set state-wide GHG emissions reduction goals to mitigate negative climate change impacts and transition the State to a low-carbon economy. In particular, the State has set goals to reduce state-wide GHG emissions to 1990 levels by 2020, as established by Assembly Bill (AB) 32, and 40 percent below 1990 levels by 2030, as established by Senate Bill (SB) 32. The 2020 goal set by AB 32 was achieved by the State in 2016 (CARB 2018).

In addition, Executive Order (EO) B-55-18 established a state goal of carbon neutrality by 2045. The California Air Resources Board (CARB) is the agency responsible for addressing these goals. Many local jurisdictions are completing their own GHG inventories, forecasts, and climate action plans to align with SB 32 and EO B-55-18.

Local governments play a fundamental role in reducing local GHG emissions and preparing for a more resilient future. Local government policies can influence high-emissions behaviors and mitigate climate change effects (CARB 2017). County governments are also uniquely situated to lead or coordinate regional-level climate action efforts, which may not be available at the city, town, or individual level. To this end, the County has already developed a Sustainability Master Plan, with goals to achieve carbon neutrality county-wide, increase resilience and climate change preparedness, maintain healthy air and water resources, enhance and protect natural and working lands, and improve community health and the local economy. Other important sustainability efforts have included Silicon Valley 2.0, a climate risk assessment and adaptation planning tool, a Green Building Policy and ordinance for County Government buildings, and other plans to maintain the health of the local environment. However, the forthcoming Climate Roadmap will be the County's first climate action plan, and the County has never developed a quantitative community GHG emissions inventory, forecast, or reduction targets. Estimating GHG emissions in an inventory enables the County to quantify the major sources of GHG emissions produced by the community and establish an emissions baseline for developing a forecast of anticipated future emissions. The forecast allows the

County to track emissions trends and facilitates target setting for future progress tracking. The inventory conducted for the County includes GHG emissions from activities within the County's jurisdictional boundaries during 2017. Based on the inventory, Rincon developed a back-cast of the County's GHG emissions to 1990 as well as a forecast to 2025, 2030, 2035, and 2045. The forecast provides an up-to-date projection of how GHG emissions are expected to change for the County in the future based on changes in population and employment, as well as existing State and federal legislation aimed at reducing GHG emissions through 2045. This document also presents a gap analysis, developed to identify GHG emissions reduction activities that will be needed to achieve the County's GHG emissions reduction targets. Like all GHG inventories and forecasts, the analysis in this document relies on the best available data and calculation methodologies currently available.

2 Legislative Context

The State of California has developed state-wide legislative targets and programs to reduce GHG emissions in California. The State, via CARB, has issued several guidance documents concerning the establishment of GHG emissions reduction targets for local climate action plans to comply with legislated GHG emissions reductions goals. In the first *Climate Change Scoping Plan* (hereafter referred to as the 2008 Scoping Plan), CARB encouraged local governments to adopt a reduction target for community emissions paralleling the State commitment to reduce GHG emissions (CARB 2008). In 2017, CARB published *California's 2017 Climate Change Scoping Plan* (hereafter referred to as the 2017 Scoping Plan Update) outlining the strategies the State will employ to reach the additional State targets set by Senate Bill 32 (CARB 2017).

Publication of the next Climate Change Scoping Plan is expected to include recommendations for complying with the carbon neutrality goal established by EO B-55-18. While currently no State plan exists to achieve the goal established by EO B-55-18, the executive order directs CARB to ensure future Scoping Plan updates identify and recommend measures to achieve the carbon neutrality goal. Executive Orders are binding only unto State agencies and are not binding on local governments or the private sector, however, it is expected that this goal will be codified as a target in the coming years. Showing progress toward this goal is considered best practice when developing a climate action plan to maintain alignment with the State should the goal be codified, and avoid developing a climate action plan that could later become inconsistent with State requirements.

2.1 Legislative Targets

The State of California has adopted legislation and policies to address climate change, the most relevant of which are summarized below.

- **Executive Order S-3-05,** signed by former Governor Schwarzenegger in 2005, establishes statewide GHG emissions reduction goals to achieve long-term climate stabilization as follows: by 2020, reduce GHG emissions to 1990 levels and by 2050, reduce GHG emissions to 80 percent below 1990 levels. The 2050 goal was accelerated by the 2045 carbon neutral goal established by EO B-55-18, as discussed below.
- **Assembly Bill 32,** known as the Global Warming Solutions Act of 2006, requires California's GHG emissions be reduced to 1990 levels by the year 2020 (approximately a 15 percent reduction from 2005 to 2008 levels). The 2008 Scoping Plan identifies mandatory and voluntary measures to achieve the statewide 2020 GHG emissions limit.

- **Senate Bill 32,** signed by former Governor Brown in 2016, establishes a statewide mid-term GHG emissions reduction goal of 40 percent below 1990 levels by 2030. CARB formally adopted the 2017 Scoping Plan Update in December 2017, laying the roadmap to achieve 2030 goals and giving guidance to achieve substantial progress toward 2050 State goals.
- **Executive Order B-55-18,** signed by former Governor Brown in 2018, expanded upon EO S-3-05 by creating a statewide GHG emissions goal of carbon neutrality by 2045. EO S-55-18 identifies CARB as the lead agency to develop a framework for implementation and progress tracking toward this goal in the next Climate Change Scoping Plan Update.

2.2 Legislative Reduction Programs

Additional legislative programs are expected to reduce emissions in specific GHG emissions sectors throughout California, as identified in the 2017 Scoping Plan Update. Many of these programs were incorporated into the forecast analysis and are summarized in the subsections below.

Transportation Legislation

Prior to 2012, mobile emissions regulations were implemented on a case-by-case basis for GHG and criteria pollutant emissions separately. In January 2012, CARB approved a new emissions-control program (the Advanced Clean Cars program) combining the control of smog, soot causing pollutants, and GHG emissions into a single coordinated package of requirements for passenger cars and light trucks model years 2017 through 2025. The Advanced Clean Cars program coordinates the goals of the Low Emissions Vehicles, Zero Emissions Vehicles, and Clean Fuels Outlet programs, and is more stringent than the federal CAFE standards. The new standards will reduce Californian GHG emissions by 34 percent in 2025 (CARB 2012).[1] Reductions from the Advanced Clean Cars program were incorporated into the forecast using updated transportation emission factors from CARB's EMFAC2017 model, as discussed in Section 6.4.

Governor Newsom recently passed EO-N-79-20, which requires that all new cars and passenger trucks sold in California by 2035 be zero-emission vehicles (ZEV). While this will likely lead to an expedited timeline for adoption of ZEVs in California, EO N-79-20 as an executive order is binding only unto state agencies and would require state-wide infrastructure changes (i.e., additional ZEV

[1] On September 27, 2019, the U.S. Environmental Protection Agency and National Highway Traffic Safety Administrator published the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule Part One: One National Program that revokes state-level authority to set emission standards for vehicles. It is expected that the new rule will affect underlying assumptions of CARB's EMFAC2017 model, used to quantify forecasted emissions for VMT for the County in this document. Currently, little guidance exists regarding the magnitude of this impact, and the results from the model have been preserved in this document. However, if more information becomes available or the model is updated prior to the release of this document, the forecast will be updated accordingly.

chargers) that are not established in a concrete implementation plan at this time. This program was therefore conservatively excluded from the forecast.

Title 24

Although it was not originally intended to reduce GHG emissions, California Code of Regulations Title 24, Part 6: California's Energy Efficiency Standards for Residential and Nonresidential Buildings, was adopted in 1978 in response to a legislative mandate to reduce California's energy consumption, which in turn reduces fossil fuel consumption and associated GHG emissions. The standards are updated triennially to allow consideration and possible incorporation of new energy-efficient technologies and methods. Starting in 2020, new residential developments had to include on-site solar generation and near-zero net energy use. For projects implemented after January 1, 2020, the California Energy Commission estimates the 2019 standards will reduce consumption by 34 percent for residential buildings and 30 percent for commercial buildings, relative to the 2016 standards. These percentage savings relate to heating, cooling, lighting, and water heating only and do not include other appliances, outdoor lighting not attached to buildings, plug loads, or other energy uses. These reductions were incorporated into the forecast, as discussed in Section 6.4.

The 2017 Scoping Plan Update calls for the continuation of ongoing triennial updates to Title 24 which will yield regular increases in the mandatory energy and water savings for new construction. Current Title 24 standards are incorporated into the forecast through 2045, however, future updates to Title 24 standards that may require energy efficiencies beyond current standards for residential and non-residential alterations are not taken into consideration in the forecast analysis due to lack of data and certainty about the magnitude of energy savings realized with future updates.

Renewables Portfolio Standard (RPS) & Senate Bill 100

Established in 2002 under SB 1078, enhanced in 2015 by SB 350, and accelerated in 2018 under SB 100, California's RPS is one of the most ambitious renewable energy standards in the country. The RPS program requires investor-owned utilities, publicly owned utilities, electric service providers, and community choice aggregators to increase procurement from eligible renewable energy resources to 50 percent of total procurement by 2026 and 60 percent of total procurement by 2030. The RPS program further requires these entities to increase procurement from GHG-free sources to 100 percent of total procurement by 2045. This program was incorporated into the forecast by adjusting the electricity emissions factors for future years, as discussed in Section 6.4.

Assembly Bill 939 & Assembly Bill 341

In 2011, AB 341 set the target of 75 percent recycling, composting, or source reduction of solid waste by 2020 calling for the California Department of Resources Recycling and Recovery (also known as CalRecycle) to take a statewide approach to decreasing California's reliance on landfills. This target was an update to the former target of 50 percent waste diversion set by AB 939.

As actions under AB 341 are not assigned to specific local jurisdictions, potential future reductions from the bill were not included in the forecast analysis. Instead, actions beyond the projected waste diversion target set under AB 341 will be quantified and credited to the County during the Climate Roadmap measure development process.

Senate Bill 1383

SB 1383 established a methane emission reduction target for short-lived climate pollutants in various sectors of the economy, including waste. Specifically, SB 1383 establishes targets to achieve a 50 percent reduction in the level of the statewide disposal of organic waste from the 2014 level by 2020 and a 75 percent reduction by 2025 (CalRecycle 2019). Additionally, SB 1383 requires a 20 percent reduction in "current" edible food disposal by 2025. Although SB 1383 has been signed into law, compliance with this senate bill must occur at the jurisdiction-level rather than the state-level. As such, SB 1383 is not included as part of the forecast analysis. Instead, measures addressing compliance with SB 1383 will be addressed through newly identified GHG reduction measures included in the Climate Roadmap, to ensure the County receives due credit for its implementation.

3 GHG Emissions Inventory

This inventory serves to provide a comprehensive understanding of the County's GHG emissions, for county-wide and for the unincorporated County specifically, and was developed to serve the following purposes:

- Provide an understanding of where the highest sources of GHG emissions in the County originate and where the greatest opportunities for emissions reduction exist
- Enable the County to understand the scale of GHG emissions from various sources and develop improved GHG emissions accounting and reporting principles
- Create a GHG emissions baseline from which the County can establish a forecast, reduction targets, and evaluate future progress
- Aid in the development of the County's Climate Roadmap

This inventory was completed using the International Council for Local Government Initiatives (ICLEI) protocols. Specifically, the *U.S. Community Protocol for Accounting and Reporting Greenhouse Gas Emissions Version 1.2* (ICLEI CP) was used for calculating both county-wide emissions and unincorporated County's emissions (ICLEI 2019). The ICLEI CP serves to guide the measurement and reporting of emissions in a standardized way. They also include steps to evaluate the relevance, completeness, consistency, transparency, and accuracy of data used in the inventory and forecast. The following sections contain further information on the inventory approach, methods and data used, and results.

The County's 2017 agricultural GHG inventory was developed in alignment with the State using approved methods used by the California Air Resources Board (CARB) in the state-wide GHG emissions inventory.[2] The agriculture inventory includes emissions resulting from activities related to agriculture in the unincorporated County such as agriculture fuel use, soil management, enteric fermentation, range management, manure management, soil management, and biomass burning of crop residues. Once completed, the inventory provides the basis for policy development, the quantification of GHG emissions reductions associated with proposed agriculture measures, and the establishment of an informed emissions reduction target.

[2] California Air Resources Board (CARB). Documentation of California's 2000-2020 GHG Inventory. Available at: https://ww2.arb.ca.gov/applications/california-ghg-inventory-documentation http://www.arb.ca.gov/cc/inventory/data/data.htm

3.1 GHG Emissions Boundary

The inventory was conducted to cover the relevant emissions sources within the boundary of the County, including the 15 cities and unincorporated area within the County. This county-wide inventory provides a high-level understanding of emissions, however, the majority of emissions sources covered by the county-wide inventory are outside of the operational control of the County. In light of this, the inventory also includes a breakout of emissions for the unincorporated County only, in order to provide GHG emissions information for the area where the County does have jurisdictional control. Both GHG emissions boundaries – the county-wide boundary and unincorporated area boundary – are used for the inventory analysis and GHG emissions analysis results for both are included in the sections below.

The unincorporated County boundary includes urban service areas (USAs) that will likely be annexed by various cities within the County in the future. The County estimates that all USAs in the County account for approximately 10,000 single family homes, 200 multi-family homes, and 300 "other" unit types, including multi-unit buildings, condominiums, and other living spaces. While emissions associated with USAs are currently attributable to the unincorporated County, they will be attributable to the various cities they are annexed to once annexation occurs. It should also be noted that the County currently does not plan for, or provide services in these areas, as they are being overseen by the respective cities.

The County notes that the unincorporated County emissions are partially attributable to operations at Stanford, which operates partially outside of the County's control.

3.2 Greenhouse Gases

The ICLEI CP suggests that inventories assess GHG emissions associated with the six internationally-recognized GHGs, as outlined in Table 1 (ICLEI 2019). This inventory focuses on the three GHGs most relevant to the County's operations: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The other gases (hydrofluorocarbons, perfluorocarbons, and sulfur hexafluorides) are emitted primarily in private sector manufacturing and electricity transmission and are therefore omitted from this inventory. This approach is consistent with typical community inventory approaches, as these industrial emissions are outside of the County's jurisdictional control (see further discussion of this in Section 3.3) Table 1 also includes the global warming potentials (GWP) for each gas. This inventory was prepared in conformance with ISO 14064-1 and therefore, uses the latest 100-year GWP values published in the IPCC Fifth Assessment Report

(IPCC 2014).[3] The GWP refers to the ability of each gas to trap heat in the atmosphere.[4] For example, one pound of methane gas has 28 times more heat capturing potential than one pound of carbon dioxide gas. GHG emissions are reported in metric tons of CO_2 equivalent (MT CO_2e), per standard practice.

Table 1 Greenhouse Gases

Greenhouse Gas	Source	GWP
Carbon Dioxide (CO_2)	Combustion	1
Methane (CH_4)	Combustion, anaerobic decomposition of organic waste (landfills, wastewater treatment plants), fuel handling	28
Nitrous Oxide (N_2O)	Combustion and wastewater treatment	265
Hydrofluorocarbons	Leaking refrigerants and fire suppressants	4 - 12,400
Perfluorocarbons	Aluminum production, semiconductor manufacturing, HVAC equipment manufacturing	6,630 - 11,100
Sulfur Hexafluoride (SH_6)	Transmission and distribution of power	23,500

Source: IPCC Fifth Assessment Report (IPCC 2014)

3.3 GHG Emissions by Scope and Sector

GHG emissions within a community (i.e., within the County or within the unincorporated area of the County) can be categorized by "scope" or by "sector." Scope refers to jurisdictional degree-of-control over the emissions source and the location of the source. GHG Emissions sources are categorized as direct (scope 1) or indirect (scope 2 or scope 3).

ICLEI recommends that local governments examine their GHG emissions by sector, in addition to scope. Sector refers to the high-level activity that generates the emissions. GHG emissions inventories can consider many different sectors; the most common examples are energy (i.e., electricity and natural gas), transportation (i.e., vehicle miles travelled), water, and waste. Many local governments will find a sector-based analysis more directly relevant to policy-making and project management, as it assists in formulating sector-specific reduction measures typical in climate action planning. The scopes and sectors considered in community inventories generally, and also in this inventory, are detailed in Table 2.

[3] International Organization for Standardization (ISO) published ISO 14064-1 in 2006 (revised 2018) to provide an international standard for the quantification and reporting of GHG emissions.
[4] According to the United States Environmental Protection Agency (EPA), the GWP was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of one ton of a gas will absorb over a given period of time, relative to the emissions of one ton of carbon dioxide (EPA 2020).

Table 2 GHG Emissions Scopes and Sectors for Community Inventories

Emissions Category	Definition[1]
Scope	
Scope 1	Direct GHG emissions from sources located within the jurisdictional boundaries of the community, including emissions from fuel combustion vehicles in the community and direct emissions from natural gas combustion in homes and businesses within the community.
Scope 2	Indirect GHG emissions associated with the consumption of electricity within the community.
Scope 3	All other indirect or embodied GHG emissions not covered in scope 2, which occur because of activity within the jurisdictional boundaries (e.g., methane emitted at landfills outside the community resulting from solid waste generated within the community).
Sector	
Energy	GHG emissions associated with the consumption of energy for residential and commercial buildings in the jurisdiction. Types of energy considered are natural gas (scope 1) and electricity (scope 2).
Transportation	GHG emissions associated with the operation of passenger, commercial, and off-road vehicles within the jurisdiction (scope 1). Transportation data is typically modeled and characterized by vehicle-miles-travelled for different types of vehicles.
Waste	GHG emissions associated with decomposition of solid waste in a landfill generated by the jurisdiction (scope 3).
Water	GHG emissions associated with the electricity used for acquisition, distribution, and treatment of water (scope 3).
Wastewater	GHG emissions associated with wastewater treatment processes, as well as the acquisition, distribution, and treatment of water (scope 3).
Agriculture	GHG emissions associated with commercial agriculture production such as fuel use, biomass burning (scope 1), enteric fermentation, manure management, and soil management (scope 3).

[1] Scope and sector definitions in this table are from the ICLEI CP

Excluded GHG Emissions Sources

The inventory excludes some community sectors from consideration, as they were either not under the jurisdictional control of the County or were not considered relevant emissions sources for the inventory. Community sectors considered outside of the County's jurisdictional control included consumption-based emissions, which are not included in the State's GHG inventory, and industrial process emissions, which are managed by the Cap-and-Trade Program.[5, 6] For reference, industrial GHG emissions reported within the boundaries of Santa Clara County by zip code in 2017 totaled 3,045,255 MT CO_2e.[7]

Natural and working lands and agricultural emissions were additionally excluded due to the scale of effort required to quantify GHG emissions sources and sinks associated with this sector. However, upon development of the Climate Roadmap, the County may consider quantifying carbon sequestration activities within the natural and working lands sector that exceed the County's current carbon sequestration efforts.

3.4 Inventory Year

The State of California uses 1990 as a reference year to remain consistent with AB 32, which codified the State's 2020 GHG emissions reduction goal to reduce statewide emissions to 1990 levels by 2020. However, cities and counties throughout California typically elect to use years later than 1990 to conduct an inventory because of the increased reliability of recordkeeping and data from later years and the large amount of growth that has occurred since 1990. Typically, local jurisdictions elect to develop and inventory for the most recent year possible, as a best practice to ensure the forecast, developed directly from inventory results, is as accurate as possible. The year 2017 was selected as the inventory year for the County's inventory as it was the most recent year with reliable and consisted data were available. The 2017 inventory was then used to forecast emissions for 2025, 2030, 2035, and 2045, and create a back-cast of 1990 emissions for the County. Forecasting methods are described in Section 0, while methods used to back-cast to 1990 emissions levels are described in Section 5.1.

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[5] Consumption based emissions are GHG emissions from the production and import of goods to the community.

[6] While industrial process emissions are excluded from this GHG inventory, industrial emissions from electricity and natural gas are included due to data availability issues preventing the disaggregation of industrial data from nonresidential data. The Cap and Trade program is a State-wide program administered by CARB which caps industrial GHG emissions for the State each year and requires industrial entities to report and reduce their emissions on an annual basis. Industrial entities that do not reduce their emissions can purchase emissions credits from other entities that have exceeded their emissions reduction threshold.

[7] Per the CARB's Mandatory GHG Reporting Emissions Data webpage, accessed at: https://ww2.arb.ca.gov/mrr-data. This GHG emissions total includes industrial process emissions as well as industrial combustion emissions (e.g., natural gas combustion).

3.5 Activity Data and Emissions Factors

In general, GHG emissions are calculated using activity data and emissions factors according to the following equation:

$$Activity\ Data\ \times Emissions\ Factor = GHG\ Emissions$$

Activity data refer to the relevant measured or estimated energy use or other GHG emissions-generating process such as fuel consumption by fuel type or metered annual electricity consumption. Activity data for each year of the inventory are geographically and temporally bounded by the location (County boundary and unincorporated County boundary) and year (2017). Emissions factors are observation-based conversion factors used to equate activity data to generated GHG emissions. Emissions factors are activity data-specific, and are usually expressed in terms of emissions per unit of activity data (e.g., pounds of CO_2e per megawatt-hour). The data sources used to complete this inventory are summarized, by sector, in Table 3. Unless otherwise specified, data was collected for 2017, within the geographical boundary of both the County and unincorporated County. Emissions factors used and their sources are detailed under the following sections.

Silicon Valley Clean Energy (SVCE) provided residential electricity and natural gas usage data and on-road transportation data for both the unincorporated County and the incorporated area of SVCE's service territory, including the Cities of Campbell, Cupertino, Gilroy, Los Altos, Los Altos Hills, Los Gatos, Milpitas, Monte Sereno, Morgan Hill, Mountain View, Saratoga, and Sunnyvale. These data were compiled by SVCE as part of their 2017 service area GHG emissions inventory (SVCE, 2020). Commercial electricity and natural gas data from SVCE were provided for the County as a whole.[8] SVCE sourced electricity data from its own records. SVCE requested and compiled the natural gas data from PG&E. Transportation data (in units of vehicle miles travelled, or VMT) was queried from Metropolitan Transportation Commission's (MTC) data library on a city-by-city basis and aggregated for the unincorporated County and cities within SVCE's service territory.[9]

SVCE's territory does not cover the Cities of Palo Alto, San Jose, or Santa Clara, and data for these cities were omitted from SVCE's inventory. Electricity, natural gas, and transportation data for these cities, were sourced from each city's most recent GHG emissions inventory (City of Santa Clara 2018, City of Palo Alto 2018, City of Palo Alto 2017, and City of San Jose 2019). Electricity data from the inventories came from City of Palo Alto Utilities (CPAU), PG&E, and Silicon Valley Power (SVP) for the Cities of Palo Alto, San Jose, and Santa Clara, respectively.

[8] Due to data availability issues, commercial electricity and commercial natural gas include electricity and natural gas usage from industrial sources. Data availability issues prevented the disaggregation of industrial data from nonresidential data.

[9] MTC data were used instead of data from Santa Clara Valley Transportation Authority (VTA) for consistency with other inventory methods in the region.

Natural gas data came from PG&E and CPAU. The inventories for Palo Alto and San Jose were dated 2017, while Santa Clara's was dated 2016. The 2016 data from Santa Clara's inventory was therefore used as a proxy for 2017 data.

Table 3 Activity Data and Sources

Sector	Activity Data	Unit	Data Source
Energy	Electricity usage (commercial, residential, direct access)	MWh	SVCE, CPAU via City of Palo Alto,[1] PG&E via City of San Jose, and SVP via City of Santa Clara[2]
	Natural gas usage (commercial, residential)	therms	CPAU via City of Palo Alto,[1] PG&E via SVCE, City of San Jose, and City of Santa Clara[2]
Transportation	On-road transportation - vehicle miles traveled[9]	miles	SVCE[1], City of Palo Alto travel demand model (2016)[3], City of San Jose travel demand model, and City of Santa Clara travel demand model (2016)[4,5]
	Off-road transportation – fuel consumed	gallons	CARB OFFROAD2021[6]
Waste	Solid waste landfilled	tons	Calrecycle Multiyear Countywide Origin Summary Report[7]
Water	Water distributed by supply type	Acre-feet	SCVWD[8]
Wastewater	Wastewater process data	various	SJSC RWF via City of San Jose, Palo Alto RWQCP via City of Palo Alto, SCRWA, DMS WPCP[9]
Agriculture	Livestock population, fertilizer application, and crop data	various	CARB 2000-2020 GHG Inventory,[10] CDFA,[11,12] Santa Clara Crop Report,[13] BAAQMD

SVCE = Silicon Valley Clean Energy; CPAU = City of Palo Alto Utilities; PG&E = Pacific Gas & Electric; SVP = Silicon Valley Power; SCVWD = Santa Clara Valley Water District; SJSC RWF = San Jose Santa Clara Regional Wastewater Facility; RWQCP = Regional Water Quality Control Plant; SCRWA = South County Regional Wastewater Facility; DMS WPCP = Donald M Somers Water Pollution Control Plant; CDFA = California Food and Drug Administration; BAAQMD = Bay Area Air Quality Management District

[1] Palo Alto's inventory reported electricity and natural gas usage data for 2017 as a lump-sum, which was disaggregated into residential and commercial usage using Palo Alto's 2016 electricity and natural gas data ratios accessed at the City of Palo Alto's Sustainability Dashboard at https://data.cityofpaloalto.org/dashboards/8842/sustainability/

[2] Santa Clara did not have this data for 2017; therefore The 2016 data from Santa Clara's inventory was used as a proxy for 2017 data.

[3] On-road transportation data was not available from Palo Alto's 2017 inventory; 2016 data was used as a proxy for 2017 data.

[4] On-road transportation data for 2017 was not available for the City of Santa Clara; the 2016 data from Santa Clara's inventory was therefore used as a proxy for 2017 data.

[6] Accessed at: https://arb.ca.gov/emfac/emissions-inventory/5e0cb7d6006cc10661f4b3ffb9c120a486d46ea6

[7] Accessed at https://www2.calrecycle.ca.gov/LGCentral/DisposalReporting/Origin/CountywideSummary

[8] SCVWD provided data for the incorporated and unincorporated County separately

[9] Wastewater process emissions data for SJSC RWF were available from the San Jose 2017 inventory and for Palo Alto RWQCP from the Palo Alto 2017 inventory. The County as a whole is additionally served by SCRWA and DMS WPCP, from which wastewater process data was obtained directly.

[10] Accessed at: https://ww2.arb.ca.gov/applications/california-ghg-inventory-documentation

Sector	Activity Data	Unit	Data Source

[11] Livestock population data accessed at: https://www.cdfa.ca.gov/Statistics/

[12] Fertilizer tonnage data accessed at: https://www.cdfa.ca.gov/is/ffldrs/pdfs/2017_Tonnage.pdf

[13] Accessed at: https://ag.sccgov.org/sites/g/files/exjcpb456/files/2017%20Crop%20REport%202017%208%2029%2018%20final.pdf

3.6 Calculation Methods and Results

Energy

Electricity

Emissions from electricity were calculated by multiplying the activity data (electricity in MWh) from each electricity provider by the 2017 electricity emissions factor (lbs CO_2e/MWh) for each electricity source. Electricity providers within the County for 2017 included Silicon Valley Clean Energy (SVCE), which provided electricity to the unincorporated County and the cities of Campbell, Cupertino, Gilroy, Los Altos, Los Altos Hills, Los Gatos, Milpitas, Monte Sereno, Morgan Hill, Mountain View, Saratoga, and Sunnyvale; Pacific Gas & Electric (PG&E), which provided electricity to the City of San Jose; City of Palo Alto Utilities (CPAU), which provided electricity to the City of Palo Alto; and Silicon Valley Power (SVP), which provided electricity to the City of Santa Clara. The following emissions factors were used to calculate electricity emissions:

- SVCE: 2017 emissions factors for incorporated residential, unincorporated residential, and commercial electricity were provided by SVCE directly. While SVCE provides carbon-free and low-carbon electricity throughout much of the County and unincorporated County, some of SVCE's customers are opted out of SVCE's electricity portfolios and have elected to have electricity provided from PG&E or other sources (direct access) instead. The emissions factor provided by SVCE accounts for the carbon intensity of all electricity streams (including these opt-out accounts) within SVCE's jurisdiction.
- PG&E: 2017 emissions factor for residential and commercial electricity was calculated based on the CO_2 intensity factor from The Climate Registry's CRIS Public Reports[10] and the California-averaged CH_4 and N_2O intensity factors from the Environmental Protection Agency's Emissions & Generation Resource Integrated Database[11] for the CAMX region; emissions factor for direct access electricity was assumed to be equal to the eGRID 2016 emissions factor for the CAMX region

[10] Accessed at: https://www.theclimateregistry.org/our-members/cris-public-reports/

[11] Accessed at: https://www.epa.gov/egrid

- CPAU: 2017 emissions factor was assumed to be zero due to Palo Alto's procurement of 100 percent carbon neutral electricity
- SVP: 2017 emissions factor provided in the Santa Clara 2016 inventory (Santa Clara 2016)

Commercial electricity usage for the SVCE service territory was not available for the incorporated and unincorporated County separately due to the California Public Utilities Commission 15/15 Rule, which limits the sharing of aggregated energy usage data when that data includes usage for fewer than 15 customers with any one customer's load exceeding 15 percent of the group's energy consumption. Instead, the percentage breakdown of GHG emissions from commercial electricity for the incorporated and unincorporated County was provided by SVCE based on their replicated analysis and applied to the County-wide GHG emissions total. 80 percent of commercial electricity GHG emissions were attributed to the incorporated County, while 20 percent of commercial electricity GHG emissions were attributed to the unincorporated County.

Emissions from electricity transmission and distribution (T&D) losses were included in overall electricity emissions. T&D losses were assumed to be 4.23 percent of total electricity usage (eGRID 2016). Emissions from T&D losses were calculated separately for each electricity stream.

Table 4 GHG Emissions from Electricity

Territory	Provider	End-user	Activity Data (GWh)	T&D Loss Factor	Adjusted for T&D (GWh)	EF (lbs CO_2e/ MWh)	Emissions (MT CO_2e)
SVCE Service Territory – Incorporated County	SVCE	Residential	1,250	4.23%	1,303	170.27	100,637.00
Unincorporated County	SVCE	Residential	190	4.23%	198	159.08	14,276.00
SVCE Service Territory – Incorporated County	SVCE	Commercial	4,234	4.23%	4,413	233.94	373,969.00
Unincorporated County	SVCE	Commercial					94,308.00
Palo Alto	CPAU	Residential	152	4.23%	158	0.00	0.00
Palo Alto	CPAU	Commercial	795	4.23%	829	0.00	0.00
San Jose	PG&E	Residential	1,795	4.23%	1,871	212.45	180,260.60
San Jose	PG&E	Commercial	2,131	4.23%	2,221	212.45	214,031.53
San Jose	PG&E	DA	1,270	4.23%	1,324	529.90	318,287.21
Santa Clara	SVP	Residential	194	4.23%	202	681.37	62,576.87
Santa Clara	SVP	Commercial	3,167	4.23%	3,301	681.37	1,020,170.54
Results Summary							
County		Residential					357,750.48
County		Commercial					2,020,766.29
County Total							**2,378,516.77**
Unincorporated County		Residential					14,276.00
Unincorporated County		Commercial					94,308.00
Unincorporated County Total							**108,584.00**
Unincorporated County totals are included in the County totals							

Natural Gas

Emissions from natural gas were calculated by multiplying the activity data (natural gas usage in therms) by the emissions factor for natural gas (MT CO_2e/therm). The emissions factor for natural gas was determined based on the Environmental Protection Agency's *Emissions Factors for Greenhouse Gas Inventories* document, published March 9, 2018.[12] PG&E provides natural gas for all cities within the County and the unincorporated County, with the exception of Palo Alto, which receives natural gas from CPAU. Commercial natural gas and electricity use includes all non-residential end uses, including those from industrial facilities.

[12] Accessed at: https://www.epa.gov/sites/production/files/2018-03/documents/emission-factors_mar_2018_0.pdf

Table 5 GHG Emissions from Natural Gas

Territory	Provider	End-user	Activity Data (therms)	Emissions Factor (MT CO_2e/therm)	Emissions (MT CO_2e)
Incorporated County	PG&E/ CPAU	Residential	217,907,173	0.00531	1,157,403.05
Incorporated County	PG&E/ CPAU	Commercial	204,864,945	0.00531	1,088,129.91
Unincorporated County	PG&E	Residential	9,131,708	0.00531	48,502.61
Unincorporated County	PG&E	Commercial	23,811,512	0.00531	126,473.65
Results Summary					
County		Residential			1,205,905.66
County		Commercial			1,214,603.56
County Total					**2,420,509.23**
Unincorporated County		Residential			48,502.61
Unincorporated County		Commercial			126,473.65
Unincorporated County Total					**174,976.26**
Unincorporated County totals are included in the County totals					

Transportation

On-road Transportation

Emissions from on-road transportation were calculated by multiplying the activity data (vehicle miles travelled, VMT) by the emissions factor for mileage (g CO_2e/mile). VMT data was aggregated for the incorporated County as the sum total VMT from SVCE's incorporated area, Palo Alto, Santa Clara, and San Jose. VMT data for the unincorporated County was provided separately by SVCE. VMT data for both the incorporated and unincorporated counties were disaggregated by vehicle type (passenger vehicles, light trucks, medium trucks, heavy trucks, and urban buses), using the output of CARB's EMission FACtor (EMFAC) model.[13] EMFAC2017 version 1.0.2 (CARB 2017a) is the primary data source for estimating project- and plan-level mobile source emissions in California and is recommended by BAAQMD for estimating on-road vehicle emissions (BAAQMD 2017). Emissions factors for each vehicle type were further calculated based on the EMFAC2017 model output.

[13] Accessed at: https://arb.ca.gov/emfac/2017/
The EMFAC2017 model was run for Santa Clara County for calendar year 2017, all fuel types, and using EMFAC2007 categories.

Off-road Transportation

Emissions associated with off-road transportation result from the use of various off-road equipment within the County and were calculated by multiplying the activity data (gallons of fuel used) by the appropriate emissions factor for each fuel type (kg CO_2e/gallon). Data for fuel usage by equipment type within the County were determined using output from CARB's OFFROAD2021 model. Equipment included in the OFFROAD2021 model included agricultural, airport ground support, commercial harbor craft, construction and mining, forestry, industrial, lawn and garden, light commercial, locomotive, oil drilling, pleasure craft, portable equipment, recreational, and transport refrigeration units. Fuel usage attributable to agricultural off-road equipment is included in the County's agricultural GHG inventory (see Section 0) and was therefore excluded from the County's community inventory to avoid double-counting. Emissions factors were determined based on equipment type, provided by EPA (2018). Results of the off-road analysis are shown in Table 7.

To determine the portion of off-road transportation emissions attributable to the unincorporated County only, apportioning factors were calculated for each equipment type and applied to the emissions totals in each category (Table 8). While the usage of some of the equipment included in the off-road transportation sector are not significantly influenced by the County, the County can still influence emissions in this sector through regulations and partnerships with the air district and others.

Table 6 GHG Emissions from On-road Transportation

Territory	Vehicle Type	Annual VMT (miles)	% VMT by Vehicle Type	Annual VMT by Vehicle Type (miles)	EF (g CO_2e/mile)	Emissions (MT CO_2e)
Incorporated County	Passenger	12,356,691,202	93.83%	11,594,888,292	330.78	3,835,311.58
Incorporated County	Light Trucks		2.60%	321,201,369	894.38	287,274.74
Incorporated County	Medium Trucks		1.34%	165,634,890	1,269.91	210,341.67
Incorporated County	Heavy Trucks		2.09%	258,848,921	1,740.73	450,585.25
Incorporated County	Urban Buses		0.13%	16,117,729	1,732.74	27,927.81
Unincorporated County	Passenger	106,488,205	93.83%	99,923,096	330.78	33,052.17
Unincorporated County	Light Trucks		2.60%	2,768,068	894.38	2,475.69
Unincorporated County	Medium Trucks		1.34%	1,427,418	1,269.91	1,812.69
Unincorporated County	Heavy Trucks		2.09%	2,230,723	1,740.73	3,883.08
Unincorporated County	Urban Buses		0.13%	138,900	1,732.74	240.68
Results Summary						
County	Passenger					3,868,363.75
County	Commercial					984,541.62
County Total						**4,852,905.37**
Unincorporated County	Passenger					33,052.17
Unincorporated County	Commercial					8,412.14
Unincorporated County Total						**41,464.31**

Unincorporated County totals are included in the County totals
VMT = vehicle miles travelled; EF = emission factor

Table 7 GHG Emissions from Off-road Transportation – County

Equipment Class	Gasoline (gallons)	Diesel (gallons)	Natural Gas (gallons)	Gasoline EF (kg CO_2e/ gallon)	Diesel EF (kg CO_2e/ gallon)	Natural Gas EF (kg CO_2e/ gallon)	County-wide Emissions (MT CO_2e)
Airport Ground Support	148,073	725,931	85,169	8.92	10.34	4.62	8,400
Commercial Harbor Craft	0	0	0	9.16	10.34	4.64	0
Construction and Mining	8,438,236	413,342	0	9.16	10.34	4.64	951
Forestry	13,566	0	0	9.16	10.34	4.64	140
Industrial	2,322,423	9,241,287	16,501,340	9.26	10.34	4.62	185,814
Lawn and Garden	88,664	4,727,325	0	9.26	10.34	4.62	44,709
Light Commercial	697,485	5,299,568	706,370	9.26	10.34	4.62	59,534
Locomotive	0	0	0	9.16	10.34	4.64	0
Oil Drilling	2,027	0	0	9.16	10.34	4.64	21
Pleasure Craft	0	477,344	0	9.16	10.34	4.64	4,374
Portable Equipment	8,221,486	0	0	9.16	10.34	4.64	85,002
Recreational	0	118,351	0	9.07	10.33	4.68	1,073
Transportation Refrigeration Unit	2,307,473	0	0	9.16	10.34	4.64	23,857
County Total[1]							**503,816**

Unincorporated County total is included in the County total

Note: entertainment equipment refers to equipment (e.g., generators) used for entertainment events, while recreational equipment refers to recreational motorized vehicles (e.g., dirt bikes).

[1] Total excludes agricultural GHG emissions which are accounted in this inventory under the agricultural sector of the community inventory

Table 8 GHG Emissions from Off-road Transportation – Unincorporated County

Equipment Class	County-wide Emissions ($MT\ CO_2e$)	Apportioning Factor Metric	Unincorporated	County	Apportioning Factor (%)	Emissions ($MT\ CO_2e$)
Airport Ground Support	8,399	2 out of 10 airports in the County are located in the unincorporated County (20%)[1]	N/A	N/A	20%	1,680
Commercial Harbor Craft	0	Employment	34,251	1,100,502	3%	0
Construction and Mining	90,891	Employment	34,251	1,100,502	3%	2,829
Forestry	140	N/A	N/A	N/A	N/A	0
Industrial	185,814	Employment	34,251	1,100,502	3%	5,783
Lawn and Garden	44,709	Households	28,044	661,875	4%	1,894
Light Commercial	59,534	Employment	34,251	1,100,502	3%	1,853
Locomotive	0	Employment	34,251	1,100,502	3%	-
Oil Drilling	21	Employment	34,251	1,100,502	3%	1
Pleasure Craft	4,374	Population	88,545	1,942,176	5%	199
Portable Equipment	85,002	Service Population	122,796	3,042,678	4%	3,431
Recreational	1,073	Population	88,545	1,942,176	5%	49
Transportation Refrigeration Unit	23,857	Employment	34,251	1,100,502	3%	743
Unincorporated County Total[2]						**18,461**

Note: entertainment equipment refers to equipment (e.g., generators) used for entertainment events, while recreational equipment refers to recreational motorized vehicles (e.g., dirt bikes).

[1] Determining an apportioning factor for the airport ground support equipment presented a challenge, due to a lack of data to inform what portion of the County's airport emissions could be attributable to the unincorporated County. The inventory therefore conservatively estimates that 20 percent of these emissions are attributable to the unincorporated county, as 2 out of 10 airports are located in the unincorporated County. This is likely an overestimate as the unincorporated County airports are small relative to other airports in the region (e.g., San Jose International Airport).

[2] [1] Total excludes agricultural GHG emissions which are accounted in this inventory under the agricultural sector of the community inventory

Waste

Emissions associated with the waste sector result from the decomposition of waste at a landfill and waste processing equipment. The County's waste is hauled to 13 different landfills, although data was collected for the entire County and was not broken down by landfill. Emissions from waste were calculated using ICLEI method SW.4, using the default emission factor for mixed waste and assuming operation of a landfill gas collection system (ICLEI 2019). Based on ICLEI 2019, a 10 percent oxidation rate and 75 percent landfill gas capture rate were assumed. Emissions generated at the landfill facilities from waste processing equipment were estimated using ICLEI method SW.5, where total tonnage of waste disposed is multiplied by the default emissions factor for natural gas equipment (ICLEI 2019).

Table 9 GHG Emissions from Waste

Territory	Waste (tons)	EF (MT CO_2e/ton)	LFG Collection Efficiency	Oxidation Rate	Emissions (MT CO_2e)
Emissions from Waste Decomposition (ICLEI method SW.4)					
Incorporated County	1,371,474	0.06	0.75	0.10	518,417.17
Unincorporated County	104,113	0.06	0.75	0.10	39,354.71
Emissions from Waste Processing Equipment (ICLEI method SW.5)					
Incorporated County	1,371,474	0.011	N/A	N/A	15,086.21
Unincorporated County	104,113	0.011	N/A	N/A	1,145.24
Results Summary					
County Total					**574,003.34**
Unincorporated County Total					**40,499.96**
Unincorporated County total is included in the County totals					

Water

GHG emissions from water delivery and treatment were calculated following ICLEI CP method WW.14. Activity data (acre-feet [AF] of water delivered) was provided by Santa Clara Valley Water District (SCVWD). Water delivery data was disaggregated by supply type (i.e., treated local surface water, untreated local surface water, treated imported water, untreated imported water, groundwater, and recycled water) for the incorporated and unincorporated County separately. Water volumes were used to calculated electricity usage by supply type, based on energy intensity factors for each supply type provided by SCVWD (SCVWD 2011). Energy intensity factors included energy usage for wastewater collection and treatment, per

SCVWD. Typically, energy emissions associated with wastewater collection and treatment are inventoried separately, using ICLEI method WW.15. However, due to the energy intensities provided by SCVWD including energy usage for wastewater collection and treatment, these emissions were included under the water sector for a more accurate depiction.

Electricity usage for each supply type was further converted to GHG emissions by applying the appropriate electricity emissions factor for each supply type. Emissions factors for each supply type were determined as follows:

- Treated/untreated local surface water and groundwater: used an electricity emissions factor of 0, based on the information that SCVWD procures 100 percent carbon-free electricity
- Treated/untreated imported water and recycled water: used an electricity emissions factor equal to that for the CAMX region from eGRID 2016, based on the uncertainty of procurement for this electricity

Energy usage and emissions associated with water delivery and treatment are associated with both local and non-local electricity usage. Electricity data used to calculate emissions for the energy sector was assumed to already include local electricity used for water delivery and treatment; therefore, non-local electricity emissions associated with water delivery and treatment for water sources imported from outside of the County were calculated separately and added to the inventory.[14] Local electricity emissions associated with water delivery and treatment for water sources located within the County are also calculated below but were excluded from the inventory emissions totals.

Wastewater

Emissions associated with wastewater treatment in the County arise from stationary combustion and processing at wastewater treatment plants. Four wastewater treatment plants operate in the County, including the Palo Alto Regional Water Quality Control Plan (Palo Alto RWQCP), San Jose and Santa Clara Regional Wastewater Facility (SJSC RWF), South County Regional Wastewater Authority (SCRWA), and Donald M. Somers Water Pollution Control Plant (DMS WPCP). Emissions from the Palo Alto RWQCP and SJSC RWF were calculated as part of the Palo Alto and San Jose 2017 inventories, respectively, per protocols in ICLEI, and were therefore, carried forward for this inventory. Emissions associated with the Palo Alto RWQCP represent N_2O emissions from the biological treatment process and release of nitrogen (Palo

[14] Similarly, it was assumed that energy usage from private well pumping would also be captured in the electricity sector. The water sector therefore excludes any emissions associated with private well pumping.

Alto 2018). Emissions associated with the SJSC RWF represent nitrification/denitrification emissions (ICLEI method WW.7), anaerobic digestion emissions (ICLEI methods WW.1.b, WW.2.b, and WW.3), and fugitive N_2O emissions from effluent discharge (ICLEI method WW.12) (San Jose 2019).

Emissions from the SCRWA and DMS WPCP were calculated for this inventory using ICLEI methods and based on information provided by each wastewater facility. Emissions associated with SCRWA represent nitrification/denitrification emissions (ICLEI method WW.7), and fugitive N_2O emissions from effluent discharge (ICLEI Method WW.12a), as shown in Table 11.

Table 10 GHG Emissions from Water Delivery and Treatment

Territory	Water Stream	Activity Data (AF)	Energy Intensity (kWh/AF)	Electricity (MWh)	EF (lbs CO_2e/MWh)	Emissions (MT CO_2e)
Incorporated County	Local surface water - treated	53,221	841	44,759	0.00	0.00
Incorporated County	Local surface water - untreated	803	754	606	0.00	0.00
Incorporated County	Groundwater	99,808	1,393	139,033	0.00	0.00
Incorporated County	Recycled Water	13,480	694	9,355	529.90	2,248.56
Incorporated County	Imported water - treated	67,209	1,695	113,920	529.90	27,381.87
Incorporated County	Imported water - untreated	1,978	1,608	3,181	529.90	764.53
Unincorporated County	Local surface water - treated	12,793	841	10,759	0.00	0.00
Unincorporated County	Local surface water - untreated	193	754	146	0.00	0.00
Unincorporated County	Groundwater	23,992	1,393	33,421	0.00	0.00
Unincorporated County	Recycled Water	3,240	694	2,249	529.90	540.51
Unincorporated County	Imported water - treated	16,156	1,695	27,384	529.90	6,582.07
Unincorporated County	Imported water - untreated	475	1,608	765	529.90	183.78
Results Summary						
Emissions from Local Electricity Use						
County Total						**2,789.07**
Unincorporated County Total						**540.51**
Emissions from Non-local Electricity Use						
County Total						**34,912.25**
Unincorporated County Total						**6,765.85**

Unincorporated County total is included in the County totals

Table 11 GHG Emissions from Wastewater Processing at SCRWA

ICLEI Method	Data	Source
WW.7 – Nitrification/Denitrification		
Population	100,081	Provided by SCRWA
Nitrogen loading factor	1	ICLEI default
WWTP EF for N/dN (g N_2O/person/year)	7	ICLEI default
Emissions (MT CO_2e)	185.65	Calculated
WW.12(a) – Fugitive N_2O emissions from Effluent Discharge		
Population	100,081	Provided by SCRWA
Nitrogen loading factor	1	ICLEI default
Average N-load (kg N/person/day)	0.026	ICLEI default
N uptake for cell growth (kg N/kg BOD)	0.05	ICLEI default for aerobic
BOD treated (kg BOD/person/day)	0.09	ICLEI default
Discharge EF (kg N_2O-N/kg sewage-N discharged)	0.005	ICLEI default for river discharge
Molecular weight ratio N_2O to N	1.57	ICLEI
Fraction of N removed	0.7	ICLEI default for N/dN processes
Emissions (MT CO_2e)	490.48	Calculated
Total SCRWA Emissions		
Emissions (MT CO_2e)	**676.13**	

EF = emission factor; N/dN = nitrification/denitrification; N = nitrogen load; BOD = biochemical oxygen demand

Emissions associated with DMS WPCP represent stationary digester gas emissions (ICLEI methods WW.1 and WW.2), lagoon treatment process emissions (ICLEI method WW.6), nitrification/denitrification emissions (ICLEI method WW.7), and fugitive N_2O emissions from effluent discharge (ICLEI Method WW.12), as shown in Table 12.

Table 12 GHG Emissions from Wastewater Processing at DMS WPCP

ICLEI Method	Data	Source
WW.1 and WW.2 – Stationary Emissions		
Digester gas production (scf/day)	197,864	Provided by DMS
CH_4 fraction of digester gas	0.575	Provided by DMS
BTU content of digester gas (BTU/scf)	1028	ICLEI default
N_2O EF (kg N_2O/BTU)	0.00063	ICLEI
CH_4 EF (kg CH_4/BTU)	0.0032	ICLEI
Methane emissions (MT CO_2e)	3.83	Calculated
Nitrogen emissions (MT CO_2e)	7.13	Calculated
Total emissions (MT CO_2e)	10.96	Calculated
WW.6 – Lagoon Treatment Process Emissions		
Treated BOD (kg BOD/day)	32.7	Provided by DMS
Fraction of BOD removed	50%	Provided by DMS
Max CH_4 production capacity for domestic wastewater (kg CH_4/kg BOD removed)	0.6	ICLEI default
CH_4 correction factor for anaerobic systems	0.8	ICLEI default
Emissions (MT CO_2e)	80.26	Calculated
WW.7 – Nitrification/Denitrification		
Population	150,599	Provided by DMS
Nitrogen loading factor	1.25	ICLEI default
WWTP EF for N/dN (g N_2O/person/year)	7	ICLEI default
Emissions (MT CO_2e)	349.20	Calculated
WW.12 – Fugitive N_2O emissions from Effluent Discharge		
Average N-load (kg N/day)	1,032	Provided by DMS
Discharge EF (kg N_2O-N/kg sewage-N discharged)	0.005	ICLEI default for river discharge
Molecular weight ratio N_2O to N	1.57	ICLEI
Emissions (MT CO_2e)	784.13	Calculated
Total DMS WPCP Emissions		
Emissions (MT CO_2e)	**1,224.55**	

scf = standard cubic feet; BTU = British thermal unit; EF = emission factor; N/dN = nitrification/denitrification; N = nitrogen load; BOD = biochemical oxygen demand

The ICLEI CP also recommends quantifying energy-related GHG emissions associated with wastewater collection and treatment (ICLEI method WW.15). However, as described above, these emissions are already captured under the water sector, since the energy intensity factors supplied by SCVWD included energy usage for wastewater delivery and treatment.

GHG emissions for all wastewater treatment plants within the County are shown below in Table 13. Emissions for the unincorporated County were apportioned based on the ratio of the unincorporated County service population to the County's total service population.

Table 13 GHG Emissions from Wastewater

Wastewater Treatment Plant	Emissions (MT CO_2e)
Palo Alto RWQCP[1]	2,567.00
SJSC RWF[2]	8,412.79
DMS WPCP	1,224.55
SCRWA	676.13
Results Summary	
County Total	**12,880.46**
Unincorporated County Total	**519.83**

Unincorporated County total is included in the County total
[1] Palo Alto 2017 Inventory (Palo Alto 2018)
[2] San Jose 2017 Inventory (San Jose 2019)

Agriculture

The County's agricultural inventory was developed separately from the and integrated into the 2017 community GHG inventory for this report. Information regarding the quantification methods and results for each agricultural GHG emissions sector is provided in Section 0.

4 Agricultural GHG Inventory

4.1 Inventory Summary

The County's Agricultural GHG emissions Inventory followed accounting methodologies utilized by the California Air Resources Board (CARB) for emissions associated with commercial agriculture practices. The GHG emissions from Santa Clara County's agriculture sector are broken down into six source categories: agriculture energy use, agricultural soil management, range management, enteric fermentation, manure management, and rice cultivation. The year 2017 was selected as the inventory year for the agricultural inventory to align with the community GHG inventory conducted for the Climate Roadmap 2030 which also used 2017 for its baseline inventory year. As of 2017 and historically, rice cultivation does occur in Santa Clara County and is therefore excluded from the County's GHG emissions inventory. Additionally, grid-supplied electricity and natural gas consumption do not pass 15/15 rules. Therefore, agricultural energy use excludes GHG emissions associated with grid-supplied energy, but includes emissions from offroad equipment fuel consumption.

Because most of the agricultural activity data was only available at a countywide scale (as opposed to only unincorporated areas), commercial agricultural GHG emissions for all of Santa Clara County were calculated. However, agricultural production in the incorporated areas consists primarily of small-scale operations such as backyard poultry and swine rearing (discussed further below) which are anticipated to result in minimal emissions contributions. Therefore, the emissions calculated in this report are expected to largely represent emissions resulting from the unincorporated County's commercial agriculture activities.

The 2017 GHG emissions from agriculture in the County were estimated at 53,594 MT of CO_2e. The breakdown of 2017 agriculture GHG emissions by source category is provided in Figure 1 and Table 14. Methods used to estimate emissions from the agriculture sector are provided in Sections 4.2 to 4.8.

Figure 1 Agriculture GHG Emissions by Source in Santa Clara County

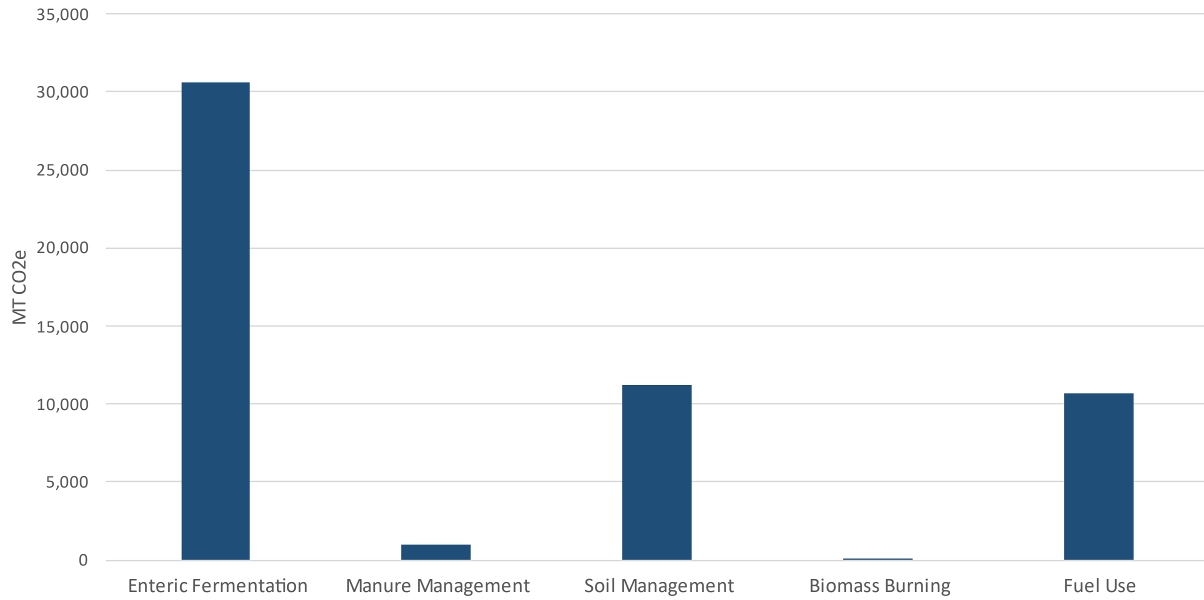


Table 14 County Agriculture Inventory Summary

Sector	MT CO_2e	Percentage
Enteric Fermentation	30,663	57.21%
Manure Management	1,020	1.91%
Soil Management	11,179	20.86%
Biomass Burning	21	0.04%
Fuel Use	10,709	19.98%
Total	**53,594**	**100.00%**

Notes: MT = metric tons

4.2 Background Information – Santa Clara County Livestock Management

4.2.1 Commercial Livestock Production Methods

There are no concentrated animal feedlot operations (CAFOs) located in Santa Clara County. Livestock production in Santa Clara County is almost exclusively grazing beef cattle on natural, minimally managed rangelands. Over 8000 beef cows produce calves each year and graze over 250,000 acres of private and publicly-owned rangelands (population numbers discussed further below). Cows are typically bred to calve in the fall and calves are weaned at 7 to 8 months of age, with most leaving County boundaries for finishing. In addition to these cattle populations, yearling cattle or stockers may be brought into the County to graze during the forage growing season which occurs from November to

May. Some replacement heifers and bulls are also developed and maintained on grazing land.

Santa Clara County beef cattle producers primarily rely on natural growing forage for feed; however, some will supplement cattle with local by-products including brewer's grain, culled vegetables, or food processing waste e.g. garlic, tortillas. Some of these feed sources are unique to Santa Clara County due to the agricultural processing operations and a large urban population. Cattle may also be fed protein supplements and hay at certain times of year. Although some cattle are fed by-products, cattle are not maintained in feed yards and manure remains spread throughout fields where the cattle graze.

While this report's focus is on greenhouse gas emissions from agriculture, it should be recognized that cattle grazing on Santa Clara County's natural lands is the primary method for managing vegetation. This method of cattle raising is critical to maintaining habitat for several threatened and endangered species, including combatting habitat degradation from dry atmospheric nitrogen deposition from vehicles (see the Santa Clara Valley Habitat Plan[15] for more information). Non-livestock grazing methods of managing rangeland vegetation such as mowing, disking, herbicides and prescribed fire are often not feasible, though should be considered in future inventories if feasibility increases and utilization of these methods increase in the County. Livestock grazing serves to reduce the need for annual mowing and disking of vegetation as required by the Santa Clara County Weed Abatement to reduce fire fuels.

4.2.2 Small-scale Livestock Production

Dairy Cattle

There is one very small commercial certified raw milk dairy cow operation in the County. Manure which includes bedding is removed, stockpiled, and applied to farm fields. Due to the small scale of this singular dairy producer in the County, there is limited information regarding dairy cattle livestock numbers in the County.

Swine and Poultry

Swine and poultry are both raised in small numbers in the County, typically by 'back-yard' producers. Many poultry producers are located within the incorporated area. They may keep chickens with bedding, and chicken waste along with soiled bedding may be composted, included with municipal green waste, or sent to landfill. The largest numbers of swine are raised by youth with most being raised on school ground or 4-H farms within the incorporated areas. Swine waste on these farms is typically removed from pens and sent to the landfill.

[15] https://scv-habitatagency.org/178/Santa-Clara-Valley-Habitat-Plan

Sheep and Goats

In addition to cattle grazing, contract grazing by sheep and goats occurs in Santa Clara County; much of the contracted sheep and goat grazing occurs in areas such as parks and along highways. Contract grazing involves utilizing a substantial number of sheep and goats (100 head or more) to intensively graze a region for a couple weeks. The herds are transient and do not reside in the County on a permanent basis. There are few small-scale sheep and goat producers that keep animals in the County year-round, but the numbers are limited, and most are not engaged in commercial production. Sheep and goats are generally pastured with manure remaining in the field.

Horses

Most horses in Santa Clara County are not used in agriculture but kept for pleasure or as companion animals. Some horses are kept in the incorporated areas of the County. Horse keeping permits may require a manure management plan. Most horses are kept in paddocks or stalls and manure is removed often with bedding. While some manure may be composted and given away or applied to farm fields, manure with bedding is often hauled to landfill. SB 1383 may require horse owners to change their management of horse manure.

4.3 Manure Management

The emissions from manure management, including stabilizing and storing manure, were estimated according to Annex 3.11 of the EPA's Inventory of U.S. Sources and Sinks[16] as referenced by CARB for the State's GHG inventory. These methods use the major livestock population, livestock excretion characteristics, and livestock-specific manure management systems in California to estimate the methane and nitrous oxide emissions from manure management. As carbon dioxide generated from manure management systems are biogenic, they are not typically accounted for and are excluded from the inventory. This section includes specifics about manure management in Santa Clara County as well as the calculation methodologies used to estimate overall GHG emissions resulting from this practice.

[16] U.S. Environmental Protection Agency (EPA). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011. Annex 3.11: Methodology for Estimating CH4 and N2O Emissions from Manure Management. 2013. Available at: https://www.epa.gov/sites/production/files/2015-12/documents/us-ghg-inventory-2013-annexes.pdf

4.3.1 County Livestock Populations

The County's livestock population for the 2017 agricultural GHG inventory only accounts for large-scale, commercially produced livestock for which reliable, replicable data regarding population sizes is available. Therefore, this inventory excludes livestock populations such as dairy cattle, swine, poultry, sheep, goats, and horses. As previously discussed, these livestock types are either primarily raised in small backyard operations that span between both the incorporated and unincorporated County or have very small populations for commercial production for which reliable data is not readily available. Therefore, only beef, stocker steer and heifers, calves, and bull cattle populations which are raised for large-scale commercial operations within the County are included in the following assessment.

While locally-applicable data is preferred for conducting agricultural inventories, information regarding livestock populations typically relies on voluntary reporting, or may be restricted to protect individual business operations.[17] In addition, most of the livestock other than cattle are not produced commercially in the County. The County's annually produced crop report[18] provides County-specific data regarding number of livestock sold and crop acres harvested, however, the report does not provide the total population of livestock types present in the County. Due to the lack of information regarding total livestock populations in the County's annual crop report, an allocation procedure was developed based on County livestock population data provided by the California Department of Food and Agriculture (CDFA). Table 15 provides a summary of the activity data, allocation methods, and final County cattle livestock population distributions utilized in the County's 2017 agricultural GHG inventory. "Other" cattle represents the combined stocker heifer, stocker steer, and calves in the County and are aggregated due to lack of information regarding their individual populations. As information regarding calf-specific populations is not available, this assessment assumes the "Other" cattle category is comprised of stocker heifer and stocker steer for a conservative estimation of GHG emissions in the County.

[17] https://www.cdfa.ca.gov/Statistics/PDFs/2017-18AgReport.pdf
[18] County of Santa Clara. 2022. Division of Agriculture Crop Reports, Newsletters & Monthly Agricultural Updates. Available at: https://ag.sccgov.org/crop-reports-newsletters-monthly-agricultural-updates

Table 15 County and State Livestock Populations Per Livestock Type

Livestock Type	CDFA Statistics Review (2017-2018)[1] County Population	CDFA Statistics Review (2017-2018)[1] Allocation Method	Final County Population
Cattle and calves	**13,200**		**13,200**
Beef cows	8,200	–	8,200
Milk cows[2]	–	–	–
Bulls	–	4.0%[3]	328
Other[4]	–	Summation	4,672

[1] California Department of Food and Agriculture (CDFA). 2018. 2017-2018 Statistics Review. Available at: https://www.cdfa.ca.gov/Statistics/

[2] Milk cow populations are withheld to protect proprietary information. Stakeholders confirm that there is a small dairy farm within the County that maintains a milk cow population of no more than 10 cattle. Due to the lack of information and small number of dairy cattle, the milk cow population is neglected in the allocation

[3] Bull population is allocated based on the recognized standard bull management practices in which bulls are typically maintained at a 25:1 ratio of cows to bulls according to: https://www.aphis.usda.gov/animal_health/nahms/beefcowcalf/downloads/beef0708/Beef0708_is_BullMgmt_1.pdf

[4] Other cattle includes stocker heifer, stocker steer, and calves.

4.3.2 County Manure Management Systems

According to anecdotal evidence provided by County staff, commercial cattle populations present in the County are raised on rangeland or unmanaged pastureland sourcing natural forage as a feed source and there are no other commercial manure management practices in the County. This aligns with state-wide manure management system distributions identified by CARB's Documentation of California's 2000-2020 GHG Inventory[19] which shows that 100 percent of beef cows, stocker heifer, stocker steer, and bulls are raised in pasture-based manure management systems. Therefore, the proportion of manure management system types used per livestock type as reported by CARB are determined to be representative and appropriate for the County operations and utilized for the following 2017 agricultural GHG inventory assessment. However, should future inventories expand to include non-commercial livestock populations (e.g. swine, horses, poultry) in the County, CARB's distribution of manure management practices may not be representative of County operations. Table 16 below provides the distribution of manure handled in each manure management system per livestock type according to CARB's California's 2000-2020 GHG Inventory.

[19] California Air Resources Board (CARB). 2020. Documentation of California's 2000-2020 GHG Inventory. Available at: https://ww2.arb.ca.gov/applications/california-ghg-inventory-documentation

Table 16 Livestock Manure Management Proportions in California

Livestock Category	Present in County?	Manure Management Practices									
		Anaerobic Digester	Anaerobic Lagoon	Daily Spread	Dry Lot	Deep Pit	Liquid/ Slurry	Pasture	Solid Storage	Poultry with Bedding	Poultry without Bedding
Cattle											
Dairy Cow	N	0.0119	0.5820	0.1060	–	0.0010	0.2020	0.0067	0.0910	–	–
Feedlot Heifers	N	–	–	–	0.9870	–	0.0130	–	–	–	–
Feedlot Steer	N	–	–	–	0.9870	–	0.0130	–	–	–	–
Beef Cows	Y	–	–	–	–	–	–	1.0000	–	–	–
Calves[1]	Y	–	–	–	–	–	–	1.0000	–	–	–
Stocker Heifer	Y	–	–	–	–	–	–	1.0000	–	–	–
Stocker Steer	Y	–	–	–	–	–	–	1.0000	–	–	–
Bulls	Y	–	–	–	–	–	–	1.0000	–	–	–
Other[2]	Y	–	–	–	–	–	–	1.0000	–	–	–

[1] Calves includes both beef and dairy calves.

[2] Other cattle includes heifer and steer stocker raised in pasture/rangeland environments

Data Source: CARB. 2020. Documentation of California's 2000-2020 GHG Inventory – Index. Agriculture, Forestry, and Other Land Use; Livestock; Manure Management. https://ww3.arb.ca.gov/cc/inventory/doc/doc_index.php

4.3.3 Methane Emissions

Methane emissions result from the decomposition of manure under anaerobic[20] conditions during storage and treatment processes. The main factors affecting methane emissions are the amount of manure produced and the portion that is subjected to anaerobic conditions, such as liquid-based systems (e.g., lagoons, pits, digesters).[21] Equation 1 and Table 17 show the equation, associated parameters, and data sources used to quantify methane emissions resulting from each manure management system used per livestock type in the County.

Equation 1 CH_4 Emissions from Manure Management

$$CH_{4\,manure} = Population_{livestock} \times WMS \times VS \times B_0 \times MCF \times Density_{CH4}$$

[20] Anaerobic conditions are characterized by the absence of free oxygen in the surrounding environment, though bound atomic oxygen may exist. This allows for organisms that do not use oxygen to propagate and results in increased emissions of CH_4.

[21] Intergovernmental Panel on Climate Change (IPCC). 2019. 2006 IPCC Guidelines for National Greenhouse Gas Inventories Chapter 10. Emissions From Livestock and Manure Management. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_10_Ch10_Livestock.pdf

Table 17 CH_4 Emissions Manure Management - Parameters and Data Sources

Definition	Parameter	Value		Source
Methane emissions per year	$CH_{4\ manure}$		kg CH_4/year	Calculated
Total population of a given livestock type	$Population_{livestock}$	See Table 15	Head	i. CDFA 2017-2018 Statistics Review[1] ii. USDA NASS 2017 Census[2]
Distribution of manure by waste manure management type for each livestock type	WMS	See Table 16	Percent	CARB Documentation of California's 2000-2020 GHG Inventory[3]
Volatile solid production rate	VS	See Table 18	kg VS/head	CARB Documentation of California's 2000-2020 GHG Inventory[3]
Maximum CH_4 production capacity	B_0	See Table 19	m3 CH_4/kg VS	CARB Documentation of California's 2000-2020 GHG Inventory[3]
Methane conversion factor for the livestock type, region, and waste manure management system	MCF	See Table 20	fraction	CARB Documentation of California's 2000-2020 GHG Inventory[3]
Density of methane at 25°C	$Density_{CH4}$	0.622	kg/m3	CARB Documentation of California's 2000-2020 GHG Inventory[3]

[1] California Department of Food and Agriculture (CDFA). 2018. CDFA 2017-2018 Statistics Review; Available at: https://www.cdfa.ca.gov/Statistics/

[2] United States Department of Agriculture (USDA). 2017. USDA NASS 2017 Census; Available at: https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/California/

[3] California Air Resources Board (CARB). 2020. Documentation of California's 2000-2020 GHG Inventory – Index. Agriculture, Forestry, and Other Land Use; Livestock; Manure Management. https://ww3.arb.ca.gov/cc/inventory/doc/doc_index.php.

Table 18 through Table 20 show the default values provided by CARB for volatile solid production, maximum CH_4 production, and methane conversion factors per livestock and manure management type. Where livestock population types are aggregated according to available County data, average values for default parameters were determined based on the aggregated livestock types.

Table 18 Volatile Solids Production of Livestock Per Manure Management System

	Type of Cattle								
	Dairy Cows	Beef Cows	Heifer (Feedlot)	Heifer (Stockers)	Steer (Feedlot)	Steer (Stockers)	Calves	Bulls	Other Cattle[1]
Anaerobic Digester	2,857	–	–	–	–	–	–	–	–
Anaerobic Lagoon	2,857	–	–	–	–	–	–	–	–
Daily Spread	2,857	–	–	–	–	–	–	–	–
Dry Lot	–	–	682	–	663	–	–	–	–
Deep Pit	2,857	–	–	–	–	–	–	–	–
Liquid/Slurry	2,857	–	682	–	682	–	–	–	–
Pasture	2,857	1,891	–	1,211	–	1,116	332	1,956	1,164
Solid Storage	2,857	–	–	–	–	–	–	–	–
Bedding (poultry only)	–	–	–	–	–	–	–	–	–
No bedding (poultry only)	–	–	–	–	–	–	–	–	–

Notes: All values are in kilograms of volatile solids per head of livestock (kg VS/head)

[1] Other cattle was calculated by averaging default values for heifers and steers stockers which are aggregated in the County's livestock population data.

Table 19 Maximum CH_4 Production of Livestock Per Manure Management System

	Type of Cattle								
	Dairy Cows	Beef Cows	Heifer (Feedlot)	Heifer (Stockers)	Steer (Feedlot)	Steer (Stockers)	Calves	Bulls	Other Cattle[1]
Anaerobic Digester	0.24	–	–	–	–	–	–	–	–
Anaerobic Lagoon	0.24	–	–	–	–	–	–	–	–
Daily Spread	0.24	–	–	–	–	–	–	–	–
Dry Lot	–	–	0.33	–	0.33	–	–	–	–
Deep Pit	0.24	–	–	–	–	–	–	–	–
Liquid/Slurry	0.24	–	0.33	–	0.33	–	–	–	–
Pasture	0.24	0.17	–	0.17	–	0.17	0.17	0.17	0.17
Solid Storage	0.24	–	–	–	–	–	–	–	–
Bedding (poultry only)	–	–	–	–	–	–	–	–	–
No bedding (poultry only)	–	–	–	–	–	–	–	–	–

Notes: All values are expressed as cubic meters of methane produced per kilogram of volatile solid (m3 CH_4/kg VS)

[1] Other cattle was calculated by averaging default values for heifers and steers stockers which are aggregated in the County's livestock population data.

Table 20 Methane Conversion Factor of Livestock Per Manure Management System in California

	Type of Cattle								
	Dairy Cows	Beef Cows	Heifer (Feedlot)	Heifer (Stockers)	Steer (Feedlot)	Steer (Stockers)	Calves	Bulls	Other Cattle[1]
Anaerobic Digester	0.181	–	–	–	–	–	–	–	–
Anaerobic Lagoon	0.731	–	–	–	–	–	–	–	–
Daily Spread	0.005	–	–	–	–	–	–	–	–
Dry Lot	–	–	0.015	–	0.015	–	–	–	–
Deep Pit	0.323	–	–	–	–	–	–	–	–
Liquid/Slurry	0.323	–	0.415	–	0.415	–	–	–	–
Pasture	0.015	0.015	–	0.015	–	0.015	0.015	0.015	0.015
Solid Storage	0.040	–	–	–	–	–	–	–	–
Bedding (poultry only)	–	–	–	–	–	–	–	–	–
No bedding (poultry only)	–	–	–	–	–	–	–	–	–

Notes: All values are expressed as fraction of methane produced

[1] Other cattle was calculated by averaging default values for heifers and steers stockers which are aggregated in the County's livestock population data

4.3.4 Nitrous Oxide Emissions

The degree of nitrous oxide emissions from manure is dependent on the storage and treatment methods of the manure management system as well as the quantity of nitrogen excreted by livestock. Total nitrous oxide emissions result from both the direct and indirect release of N_2O. Direct N_2O emissions occur via nitrification and denitrification[22] of nitrogen contained in manure. Indirect N_2O emissions result from the volatilization of ammonia and NO_x emissions to N_2O as well as runoff and leaching into soils due to manure storage in outdoor areas, feedlots, and pastures.[23] Equation 2 and Equation 3, and Table 21 show the equations, associated parameters, and data sources used to quantify N_2O emissions resulting from each manure management system used per livestock type in the County.

Equation 2 Direct N_2O Emissions from Manure Management

$$N_2O_{Direct} = Population_{livestock} \times WMS \times Nex \times EF_{WMS} \times \frac{44}{28}$$

Equation 3 Indirect N_2O Emissions from Manure Management

$$N_2O_{Indirect} = Population_{livestock} \times WMS \times Nex \times \frac{44}{28} \times \left[\left(\frac{Frac_{gas,WMS}}{100} \times EF_{volatilization}\right) + \left(\frac{Frac_{runoff/leach,WMS}}{100} \times EF_{runoff/leach}\right)\right]$$

[22] Nitrification is the conversion of ammonia to nitrites and nitrates, while denitrification is the process of microbial reduction of nitrites and nitrates to gaseous nitrogen (e.g., N_2O or N_2)

[23] Intergovernmental Panel on Climate Change (IPCC). 2019. 2006 IPCC Guidelines for National Greenhouse Gas Inventories Chapter 10. Emissions From Livestock and Manure Management. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_10_Ch10_Livestock.pdf

Table 21 N_2O Emissions Manure Management - Parameters and Data Sources

Definition	Parameter	Value		Source
Total population of a given livestock type	$\boldsymbol{Population_{livestock}}$	See Table 15	Head	i. CDFA 2017-2018 Statistics Review[1] ii. USDA NASS 2017 Census[2]
Distribution of manure by waste manure management type for each livestock type	$\boldsymbol{WMS}$	See Table 16	Percent	CARB Documentation of California's 2000-2020 GHG Inventory[3]
Amount of N excreted in a manure management system for each livestock type	$\boldsymbol{Nex}$	See Table 22	kg N/head/year	CARB Documentation of California's 2000-2020 GHG Inventory
Conversion factor of N_2O-N to N_2O	$\boldsymbol{\frac{44}{28}}$	1.571	Fraction	CARB Documentation of California's 2000-2020 GHG Inventory
Direct N_2O				
Direct nitrous oxide emissions per year	$\boldsymbol{N_2O_{Direct}}$		kg N_2O/year	Calculated
Direct N_2O emission factor	$\boldsymbol{EF_{WMS}}$	See Table 23	kg N_2O-N /kg N	CARB Documentation of California's 2000-2020 GHG Inventory
Indirect N_2O				
Indirect nitrous oxide emissions per year	$\boldsymbol{N_2O_{Indirect}}$		kg N_2O/year	Calculated
Nitrogen lost through volatilization in each manure management system	$\boldsymbol{Frac_{gas,WMS}}$	See Table 24	fraction	CARB Documentation of California's 2000-2020 GHG Inventory
Emission factor for volatilization of redeposited N to N_2O	$\boldsymbol{EF_{volatilization}}$	0.010	kg N_2O-N /kg N	CARB Documentation of California's 2000-2020 GHG Inventory
Nitrogen lost through runoff and leaching in each manure management system; data is not available for leaching so the value reflects only runoff	$\boldsymbol{Frac_{runoff/leach,WMS}}$	See Table 25	fraction	CARB Documentation of California's 2000-2020 GHG Inventory

Definition	Parameter	Value		Source
Emission factor for runoff/leaching	$EF_{runoff/leach}$	0.0075	kg N_2O-N /kg N	CARB Documentation of California's 2000-2020 GHG Inventory

[1] California Department of Food and Agriculture (CDFA). 2018. CDFA 2017-2018 Statistics Review; Available at: https://www.cdfa.ca.gov/Statistics/

[2] United States Department of Agriculture (USDA). 2017. USDA NASS 2017 Census; Available at: https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/California/

[3] California Air Resources Board (CARB). 2020. Documentation of California's 2000-2020 GHG Inventory – Index. Agriculture, Forestry, and Other Land Use; Livestock; Manure Management. https://ww3.arb.ca.gov/cc/inventory/doc/doc_index.php.

Table 22 – Table 25 show the default values provided by CARB for nitrogen excretion rates, direct and indirect nitrogen emissions factors, and nitrogen loss factors per livestock and manure management type.

Table 22 Nitrogen Excretion Rate Per Livestock Type

Livestock Type	Nitrogen Excretion Rate (Nex) (g/year)
Cattle	
Dairy Cow	158,656
Feedlot Heifers	54,722
Feedlot Steer	54,722
Beef Cows	59,139
Calves	19,395
Stocker Heifer	38,642
Stocker Steer	33,466
Bulls	68,532
Other (heifer and steer stockers)[1]	36,054

Notes: g =grams

[1] Aggregated livestock population nitrogen excretions rates are determined by averaging nitrogen excretion of included livestock types

Table 23 Nitrogen Emissions Factors Per Manure Management System

Livestock Type	Direct Nitrogen Emissions Factor (g $N\text{-}N_2O$/g N)	Indirect Nitrogen Emissions Factors (g $N\text{-}N_2O$/g N)	
	EF_{WMS}	$EF_{volatilization}$	$EF_{runoff/Leach}$
Anaerobic Digester	0.0000	0.0100	0.0075
Anaerobic Lagoon	0.0000	0.0100	0.0075
Daily Spread	0.0000	0.0100	0.0075
Dry Lot	0.0200	0.0100	0.0075
Deep Pit	0.0020	0.0100	0.0075
Liquid/Slurry	0.0050	0.0100	0.0075
Pasture	0.0000	0.0100	0.0075
Solid Storage	0.0050	0.0100	0.0075
Bedding (poultry only)	0.0010	0.0100	0.0075
No bedding (poultry only)	0.0010	0.0100	0.0075

Notes: g =grams

Table 24 Indirect Nitrogen Loss Factor – Volatilization

	Type of Cattle								
	Dairy Cows	Beef Cows	Heifer (Feedlot)	Heifer (Stockers)	Steer (Feedlot)	Steer (Stockers)	Calves	Bulls	Other Cattle[1]
Anaerobic Digester	0.43	–	–	–	–	–	–	–	–
Anaerobic Lagoon	0.43	–	–	–	–	–	–	–	–
Daily Spread	0.10	–	–	–	–	–	–	–	–
Dry Lot	–	–	0.23	–	0.23	–	–	–	–
Deep Pit	0.24	–	–	–	–	–	–	–	–
Liquid/Slurry	0.26	–	0.26	–	0.26	–	–	–	–
Pasture	0.00	0.00	–	0.00	–	0.00	0.00	0.00	0.00
Solid Storage	0.27	–	–	–	–	–	–	–	–
Bedding (poultry only)	–	–	–	–	–	–	–	–	–
No bedding (poultry only)	–	–	–	–	–	–	–	–	–

[1] Other cattle was calculated by averaging default values for heifers and steers stockers which are aggregated in the County's livestock population data

Table 25 Indirect Nitrogen Loss Factor – Runoff/Leaching

	Type of Cattle								
	Dairy Cows	Beef Cows	Heifer (Feedlot)	Heifer (Stockers)	Steer (Feedlot)	Steer (Stockers)	Calves	Bulls	Other Cattle[1]
Anaerobic Digester	0.0080	–	–	–	–	–	–	–	–
Anaerobic Lagoon	0.0080	–	–	–	–	–	–	–	–
Daily Spread	0.0000	–	–	–	–	–	–	–	–
Dry Lot	–	–	0.0075	–	0.0390	–	–	–	–
Deep Pit	0.0000	–	–	–	–	–	–	–	–
Liquid/Slurry	0.0080	-	0.0075	–	0.0000	–	–	–	–
Pasture	0.0000	0.0000	–	0.0000	–	0.0000	0.0000	0.0000	0.0000
Solid Storage	0.0000	–	–	–	–	–	–	–	–
Bedding (poultry only)	–	–	–	–	–	–	–	–	–
No bedding (poultry only)	–	–	–	–	–	–	–	–	–

[1] Other cattle was calculated by averaging default values for heifers and steers stockers which are aggregated in the County's livestock population data

4.3.5 GHG Emissions: Manure Management

Total GHG emissions resulting from manure management practices are determined according to Equation 4 below.

Equation 4 Total GHG Emissions from Manure Management

$$CO_2e_{manure} = (CH_{4\,manure} \times GWP_{CH4}) + ([N_2O_{Direct} + N_2O_{Indirect}] \times GWP_{N2O}) \times \frac{1}{1000}$$

Table 26 Total GHG Emissions Manure Management – Parameters and Data Sources

Definition	Parameter	Value		Source
Carbon dioxide equivalents emissions from manure management per livestock type	$\boldsymbol{CO_2e_{manure}}$	See Table 27	MT CO_2e/year	Calculated
Annual methane emissions per livestock type from manure management	$\boldsymbol{CH_{4\,manure}}$	See Table 17	kg CH_4/year	Calculated
Annual direct nitrous oxide emissions per livestock type from manure management	$\boldsymbol{N_2O_{Direct}}$	See Table 21	kg N_2O/year	Calculated
Annual indirect nitrous oxide emissions per livestock type from manure management	$\boldsymbol{N_2O_{Indirect}}$	See Table 21	kg N_2O/year	Calculated
Conversion factor	$\boldsymbol{\frac{1}{1000}}$	0.0001	MT/kg	
Global warming potential of methane	$\boldsymbol{GWP_{CH4}}$	28		IPCC Fifth Assessment Report
Global warming potential of nitrous oxide	$\boldsymbol{GWP_{N2O}}$	265		IPCC Fifth Assessment Report
Notes: MT = metric tons; kg = kilograms				

The breakdown of emissions from manure management in the unincorporated County area in 2017 is detailed in Table 27. Beef cows were the largest source of total GHG emissions in 2017.

Table 27 Manure Management GHG Emissions per Livestock Type

Livestock Type	Methane ($MT\ CO_2e$)	Nitrous Oxide ($MT\ CO_2e$)	Total ($MT\ CO_2e$)	Percentage Total Emissions
Cattle	1,020.19	0.00	1,020.19	
Bulls	30.32	0.00	30.32	3.0%
Beef Cows	732.93	0.00	732.93	71.8%
Other[1]	258.88	0.00	258.88	25.2%
Swine	0.00	0.00	0.00	0.00%
Poultry	0.00	0.00	0.00	0.00%
Sheep & Goats	0.00	0.00	0.00	0.00%
Horses	0.00	0.00	0.00	0.00%
Total	**1,020.19**	**0.00**	**1,020.19**	

Notes: MT = metric tons

[1] Other cattle include steer and heifer stockers

4.4 Enteric Fermentation

Enteric fermentation is a part of the digestion process in ruminant livestock[24] which produces significant CH_4 emissions. The County's GHG emissions from enteric fermentation were estimated according to Annex 3.10 of the EPA's Inventory of U.S. Sources and Sinks[25] as referenced by CARB for the State's GHG inventory. This method determines livestock-specific CH_4 emission factors based on daily energy intake to estimate total emissions from enteric fermentation. Equation 5 and Table 28 provide the estimation method, parameters, and data sources used to quantify annual enteric fermentation per livestock type in the County. The emissions factors per livestock type used are listed in Table 29.

Equation 5 CH_4 Emissions from Enteric Fermentation

$$CH_{4\ enteric} = Population_{livestock} \times Emit_{livestock}$$

[24] Ruminant livestock (cows, sheep, goats) are herbivores with four stomach compartments. Feed is fermented and digested by rumen microbes which make volatile fatty acids which are absorbed and provide the main source of energy for ruminants. Rumen microbes also produce B vitamins, vitamin K, and amino acids. https://extension.umn.edu/dairy-nutrition/ruminant-digestive-system

[25] U.S. Environmental Protection Agency (EPA). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011. Annex 3.10: Methodology for Estimating CH4 and N2O Emissions from Manure Management. 2013. Available at: https://www.epa.gov/sites/production/files/2015-12/documents/us-ghg-inventory-2013-annexes.pdf

Table 28 CH_4 Emissions Enteric Fermentation – Parameters and Data Sources

Definition	Parameter	Value		Source
Methane emissions per year	$CH_{4\ enteric}$		kg CH_4/year	Calculated
Total population of a given livestock type	$Population_{livestock}$	See Table 15	Head	i. CDFA 2017-2018 Statistics Review[1] ii. USDA NASS 2017 Census[2]
Enteric fermentation emissions factor for a given livestock type	$Emit_{livestock}$	See Table 29	kg CH_4/head/year	CARB Documentation of California's 2000-2020 GHG Inventory[3]

[1] California Department of Food and Agriculture (CDFA). 2018. CDFA 2017-2018 Statistics Review; Available at: https://www.cdfa.ca.gov/Statistics/

[2] United States Department of Agriculture (USDA). 2017. USDA NASS 2017 Census; Available at: https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/California/

[3] California Air Resources Board (CARB). 2020. Documentation of California's 2000-2020 GHG Inventory – Index. Agriculture, Forestry, and Other Land Use; Livestock; Manure Management. https://ww3.arb.ca.gov/cc/inventory/doc/doc_index.php.

Table 29 Enteric Fermentation Emissions Factors Per Livestock Type in United States

Livestock Type	Emissions Factors ($Emit_{livestock}$) (kg CH_4/head/yr)
Cattle	
Dairy Calves	11.63
Dairy Cows	144.61
Dairy replacements 7-11 months	43.53
Dairy replacements 12-23 months	65.71
Bulls	98.69
Beef Calves	10.73
Beef Cows	95.45
Beef replacements 7-11 months	61.22
Beef replacements 12-23 months	70.56
Heifer feedlot	41.01
Heifer stockers	61.09
Steer feedlot	39.90
Steer stockers	58.80
Other[1]	59.95
Sheep	8.00
Goats	5.00
Horses	18.00
Swine	1.50

[1] Aggregated enteric fermentation emissions factors are determined by averaging emissions factors of steer and heifer stockers

4.4.1 GHG Emissions: Enteric Fermentation

Total GHG emissions from enteric fermentation were determined based on Equation 6 below.

Equation 6 Total GHG Emissions from Enteric Fermentation

$$CO_2e_{enteric} = (CH_{4\,enteric} \times GWP_{CH4}) \times \frac{1}{1000}$$

Table 30 Total GHG Emissions From Manure Management – Parameters and Data Sources

Definition	Parameter	Value		Source
Carbon dioxide equivalents emissions from enteric fermentation per livestock type	$\boldsymbol{CO_2e_{enteric}}$	See Table 31	MT CO_2e/year	Calculated
Annual methane emissions per livestock type from enteric fermentation	$\boldsymbol{CH_{4\,enteric}}$	See Table 28	kg CH_4/year	Calculated
Conversion factor	$\boldsymbol{\frac{1}{1000}}$	0.0001	MT/kg	
Global warming potential of methane	$\boldsymbol{GWP_{CH4}}$	28		IPCC Fifth Assessment Report
Notes: MT = metric tons, kg = kilograms				

Emissions from each livestock type is provided in Table 31. Beef cows were the largest source of GHG emissions from enteric fermentation in the County.

Table 31 Enteric Fermentation by Livestock Type

Livestock	Emissions (MT CO_2e)	Percentage Total Emissions
Cattle	**30,663**	
Bulls	906	3%
Beef Cows	21,915	71%
Other[1]	7,841	26%

Notes: MT = metric tons

[1] Other cattle includes steers and heifer stockers

4.5 Biomass Burning

4.5.1 Cropland Residue Burning

The CO_2, CH_4, and N_2O emissions from the open burning of agricultural biomass from cropland was estimated using the quantification method provided in CARB's 2000-2014 GHG Emission Inventory Technical Support Document[26] as referenced in CARB's Documentation of California's 2000-2020 GHG Inventory. GHG emissions from residue burning are estimated based on annual crop acreage burned per crop type, the mass of the crop residue, and the emissions factors per crop type for the release of CH_4, N_2O, and CO_2. Equation 7 and Table 32 show the equation, associated parameters, and data sources used to quantify GHG emissions resulting from residue burning in the unincorporated County.

Equation 7 GHG Emissions from Residue Burning

$$E_{GHG,crop} = A_{crop} \times 0.404685642 \times FB_{crop} \times MR_{crop} \times EF_{GHG,crop}$$

[26] California Air and Resources Board (CARB). 2016. California's 2000-2014 Greenhouse Gas Emission Inventory Technical Support Document. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/ghg_inventory_tsd_00-14.pdf

Table 32 GHG Emissions From Residue Burning – Parameters and Data Sources

Definition	Parameter	Value		Source
Emissions if a given GHG for residue burning of a specified crop type	$E_{GHG,crop}$	0	g GHG	Calculated
Harvested area of specified crop type	A_{crop}	0	acres	Santa Clara County 2017 Crop Report[1]
Conversion factor	0.404685642	0.4047	ha/acre	CARB Documentation of California's 2000-2020 GHG Inventory[2]
Fraction of harvested area on which crop residues are burned	FB_{crop}	0	unitless	BAAQMD Burn Permits[3] Santa Clara County 2017 Crop Report Santa Clara County Ecosystem Services 2021 Crop Report[4]
Mass of residue of specified crop type	MR_{crop}	N/A	g residue/ha	CARB Documentation of California's 2000-2020 GHG Inventory
Emission factor for a given GHG and specified crop type	$EF_{GHG,crop}$	N/A	g GHG/g residue	CARB Documentation of California's 2000-2020 GHG Inventory

Notes: ha = hectares, g = grams

[1] Santa Clara County. 2018. Santa Clara County 2017 Crop Report. Available at: https://ag.sccgov.org/sites/g/files/exjcpb456/files/2017%20Crop%20REport%202017%208%2029%2018%20final.pdf

[2] CARB. 2020. Documentation of California's 2000-2020 GHG Inventory – Index. Agriculture, Forestry, and Other Land Use; Aggregated Sources and Non-CO_2 Emissions Sources on Land; Emissions from Biomass Burning. Available at: https://ww3.arb.ca.gov/cc/inventory/doc/doc_index.php

[3] Bay Area Air Quality Management District (BAAQMD). Burn Permit data by County. Provided by email on July 5, 2022

[4] Santa Clara County. 2021. Santa Clara County Ecosystem Services 2021 Crop Report. Available at: https://ag.sccgov.org/sites/g/files/exjcpb456/files/document/2021CropReportFinal_a.pdf

According to available data provided by the County's 2017 Crop Report and burn permits provided by BAAQMD, residue burning associated with cropland management is not utilized in the County. The County's recently released 2021 Ecosystem Services Report identifies controlled burns associated with rangeland and park management in the County but does not report prescribed burns associated with cropland management. Therefore, no emissions associated with residue burning are accounted for the County's 2017 agricultural GHG inventory.

4.5.2 Pasture/Rangeland Burns

As discussed with regards to livestock management methods, rangeland (or grassland) is widely used throughout the County for raising cattle. While the County's rangeland is largely unmanaged, some rangeland areas are subjected to prescribed burns. While pasture and rangeland biomass burning is recognized as a potential emissions source in CARB's Documentation of

California's 2000-2020 GHG Inventory, the methodology is currently under development and is therefore unavailable.[27] To account for this prominent land-use in the County's agricultural inventory, this assessment utilized GHG accounting methods provided by the IPCC[28] which is a primary GHG quantification framework utilized in CARB's 2000-2020 GHG Inventories.

Equation 8 Total GHG Emissions from Rangeland Burning

$$L_{Fire,GHG} = \mathrm{A} \times M_B \times C_f \times EF_{GHG}$$

Table 33 Total GHG Emissions From Rangeland Burning - Parameters and Data Sources

Definition	Parameter	Value		Source
Amount of greenhouse gas emissions from fire	$L_{Fire,CH4}$	0.4115	MT CH_4	Calculated
Amount of greenhouse gas emissions from fire	$L_{Fire,N2O}$	0.0380	MT N_2O	Calculated
Amount of greenhouse gas emissions from fire	$L_{Fire,CO2}$	288.5500	MT CO_2	Calculated
Area burnt	$\mathbf{A}$	210.5000	ha	BAAQMD Burn Permits[1]
Mass of fuel available for combustion (including biomass sources)	M_B	2.1000	MT dm/ha	IPCC Volume 4, Chapter 2 (Table 2.4)[2]
Combustion Factor	C_f			
Emission Factor for methane	EF_{CH4}	0.0023	MT CH_4/MT dm burnt	IPCC Volume 4, Chapter 2 (Table 2.5)[3]
Emission Factor for nitrous oxide	EF_{N2O}	0.0002	MT N_2O/MT dm burnt	IPCC Volume 4, Chapter 2 (Table 2.5)[3]

Notes: MT = metric tons, ha = hectares, g = grams,

[1] Bay Area Air Quality Management District (BAAQMD). 2017 Burn Permit data by County. Provided by email on July 5, 2022

[2] 2006 IPCC Guidelines, Volume 4, Chapter 2 Generic Methodologies Applicable to Multiple Land-use Categories (Table 2.4). 2006. Available at: https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch02_Generic%20Methods.pdf

[27] https://ww2.arb.ca.gov/sites/default/files/ghg-inventory-doc/newdoc/docs3/3b1_forestandrangemngt_fireanddisturbances_rangeland_ch4_2020.htm

[28] https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

4.5.3 GHG Emissions: Biomass Burning

Total GHG emissions resulting from residue burning in the unincorporated County are determined according to Equation 9 below.

Equation 9 Total GHG Emissions from Biomass Burning

$$CO_2e_{burn,crop} = \left((E_{GHG,crop} \times GWP_{GHG}) \times \frac{1}{1000000} \right) + (L_{Fire,GHG} \times GWP_{GHG})$$

Table 34 Total GHG Emissions From Residue Burning - Parameters and Data Sources

Definition	Parameter	Value		Source
Carbon dioxide equivalents emissions from residue burning per crop type	$\boldsymbol{CO_2e_{burn,crop}}$	See Table 35	MT CO_2e/year	Calculated
Emissions if a given GHG for residue burning of a specified crop type	$\boldsymbol{E_{GHG,crop}}$	See Table 32	g GHG/year	Calculated
Conversion factor	$\boldsymbol{\frac{1}{1000000}}$	0.0000001	MT/g	
Amount of greenhouse gas emissions from fire	$\boldsymbol{L_{Fire,GHG}}$	See Table 33	MT GHG	Calculated
Global warming potential of methane	$\boldsymbol{GWP_{CH4}}$	28		IPCC Fifth Assessment Report
Global warming potential of nitrous oxide	$\boldsymbol{GWP_{N2O}}$	265		IPCC Fifth Assessment Report
Global warming potential of carbon dioxide	$\boldsymbol{GWP_{CO2}}$	1		IPCC Fifth Assessment Report
Notes: MT = metric tons, g = grams				

A breakdown of emissions from biomass burning in the unincorporated County area in 2017 is detailed in Table 35. As CO_2 from biomass burning is considered biogenic[29], the net emissions are considered neutral and therefore are quantified but not included in the County's Agriculture Inventory.

[29] Biogenic carbon dioxide refers to carbon dioxide that is was originally removed from the atmosphere by photosynthesis and is considered part of the natural carbon cycle. This is in contrast to fossil-based carbon dioxide which is geologically stored for millions of years and considered to be removed from the carbon cycle, except through the result of human extraction and combustion.

Table 35 Residue Burning Emissions by Crop Type

Crop Type	Biogenic Emissions ($MT\ CO_2e$)	Non-biogenic Emissions ($MT\ CO_2e$)	Percentage of Total Emissions (non-biogenic)
Barley	0.00	0.00	0.00%
Corn	0.00	0.00	0.00%
Rice	0.00	0.00	0.00%
Wheat	0.00	0.00	0.00%
Almond	0.00	0.00	0.00%
Walnut	0.00	0.00	0.00%
Rangeland	288.55	21.48	100.00%
Total	**288.55**	**21.48**	

Notes: MT = metric tons

4.6 Rice Cultivation

According to the County's 2017 Crop Report (see Table 35), rice is not harvested in the County and thus in 2017 there were no GHG emissions due to rice cultivation.

4.7 Soil Management

CARB's 2000-2020 GHG Inventories accounts for soil management practices such as limestone application, dolomite application, and organic, synthetic, or livestock manure fertilizer application. These management practices add minerals and nutrients to soil but lead to CO_2 and N_2O emissions as material is broken down or volatized, or experiences leaching or runoff from the soil. GHG emissions from these soil management practices result in different rates of emissions depending on environmental factors such as soil type and pH, or other management practices such as tilling and cover cropping which affect natural soil carbon stocks.[30]

4.7.1 Lime Application

Lime is applied to soil using limestone or dolomite materials and results in GHG emissions due to the breakdown of calcium carbonate into CO_2 emissions. The rate and magnitude of degradation is dependent on soil conditions, soil type, climate regime, and the type of mineral applied.[31] Equation 10 and Table 36 provide the equation, associated parameters,

[30] Intergovernmental Panel on Climate Change (IPCC). 2019. 2006 IPCC Guidelines for National Greenhouse Gas Inventories Chapter 11. N_2O Emissions From Managed Soils, and CO_2 Emissions From Lime and Urea Application. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_11_Ch11_N2O&CO2.pdf

[31] Cai et al. GREET Model Update of the CO_2 Emission Factor from Agricultural Liming. Available at: https://greet.es.anl.gov/files/co2-lming

data sources, and total emissions resulting from lime application in the County.

Equation 10 CO_2 Emissions from Lime Application

$$CO_{2\,lime} = Lime \times EF_C \times MW_{CO2:C} \times \frac{1}{1000000}$$

Table 36 GHG Emissions From Lime Application – Parameters, Data Sources, and Total Emissions

Definition	Parameter	Value		Source
Annual carbon dioxide emissions from soil liming	$\boldsymbol{CO_{2\,lime}}$	139.61	MT CO_2/year	Calculated
Annual total liming material applied to soils	$\boldsymbol{Lime}$	317.51	MT lime/year	CDFA 2017 Tonnage Report[1]
Carbon emission factor for lime application to soils	$\boldsymbol{EF_C}$	0.12	g C/g lime	CARB Documentation of California's 2000-2020 GHG Inventory[2]
Molecular weight ratio	$\boldsymbol{MW_{CO2:C}}$	3.66	g CO_2/g C	CARB Documentation of California's 2000-2020 GHG Inventory
Conversion factor	$\boldsymbol{\frac{1}{1000000}}$	0.0000001	MT/g	

Notes: MT = metric tons, g = grams

[1] California Department of Food and Agriculture (CDFA). 2017. CDFA Fertilizing Materials Tonnage Report January – December 2017. Available at: https://www.cdfa.ca.gov/is/ffldrs/pdfs/2017_Tonnage.pdf

[2] CARB. 2020. Documentation of California's 2000-2020 GHG Inventory – Index. Agriculture, Forestry, and Other Land Use; Aggregated Sources and Non-CO_2 Emissions Sources on Land; Emissions from Biomass Burning. Available at: https://ww3.arb.ca.gov/cc/inventory/doc/doc_index.php

4.7.2 Nitrogen Fertilizer Application

The application of fertilizer results in GHG emissions from the direct and indirect release of N_2O. Direct N_2O emissions occur via nitrification and denitrification[32] of excess nitrogen applied to the soil that does not get utilized by crops. Indirect N_2O emissions result from the volatilization of ammonia and NO_x emissions to N_2O as well as runoff and leaching from managed soils.[33] The release of direct and indirect nitrogen emissions are impacted by the soil type to which nitrogen fertilizer is applied as well as the soil management practices employed, such as tilling and cover cropping. Nitrogen can be applied as synthetic fertilizer, organic fertilizer, or as

[32] Nitrification is the conversion of ammonia to nitrites and nitrates, while denitrification is the process of microbial reduction of nitrites and nitrates to gaseous nitrogen (e.g., N_2O or N_2)

[33] Intergovernmental Panel on Climate Change (IPCC). 2019. 2006 IPCC Guidelines for National Greenhouse Gas Inventories Chapter 11. N_2O Emissions From Managed Soils, and CO_2 Emissions From Lime and Urea Application. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_11_Ch11_N2O&CO2.pdf

managed or unmanaged livestock manure and is accounted differently for each application type under CARB's 2000-2020 GHG Inventory.

Only total tons of nitrogen material applied per county for farm use was available for the County's nitrogen fertilizer application activity data. A nitrogen application factor per material type was developed based on reported state-wide tons of material and tons of nitrogen applied per material type. The nitrogen application factor was applied to the tons of material per material type applied in the County for farm use to determine the total tons of nitrogen activity data. As the majority of agricultural practices occur within the unincorporated County, 100 percent of reported farm use nitrogen is attributed to the County's 2017 agricultural GHG inventory. More detailed local data could be collected for future inventories to improve accuracy of the GHG emissions associated with various fertilizer types to improve alignment with CARB methodology.

Direct and Indirect N_2O emissions factors are based on CARB's reported emissions factors in their GHG Inventory. This emissions factor is derived from the DeNitrification-DeComposition (DNDC) Model which accounts for soil management practices and environmental conditions such as tilling intensity, type of soil, and crop acreage in the state. Equation 11 and Equation 12 as well as Table 37 provide the equations, associated parameters, data sources, and total emissions resulting from nitrogen fertilizer application in the County.

Equation 11 Direct N_2O Emissions From Fertilizer Application

$$N_2O_{Direct,soil} = F_{SN} \times EF_{DNDC,direct} \times \frac{1}{1000000}$$

Equation 12 Indirect N_2O Emissions From Fertilizer Application

$$N_2O_{Indirect,soil} = F_{SN} \times EF_{DNDC,indirect} \times \frac{1}{1000000}$$

Table 37 GHG Emissions From Fertilizer Application – Parameters, Data Sources, and Emissions

Definition	Parameter	Value		Source
Synthetic nitrogen applied as fertilizer annually	F_{SN}	2,874 (See Table 38)	tons/year	CDFA 2017 Tonnage Report[1]
Conversion factor	$\frac{1}{1000000}$	.0000001	MT/g	
Direct N_2O				
Direct nitrous oxide emissions per year	$N_2O_{Direct,soil}$	28	MT N_2O/year	Calculated
Direct N_2O emission factor	$EF_{DNDC,direct}$	9,861	g N_2O-N /ton N	CARB Documentation of California's 2000-2020 GHG Inventory[2]
Indirect N_2O				
Indirect nitrous oxide emissions per year	$N_2O_{Indirect,soil}$	13	MT N_2O/year	Calculated
Indirect N_2O emission factor	$EF_{DNDC,indirect}$	4,632	g N_2O-N /ton N	CARB Documentation of California's 2000-2020 GHG Inventory

Notes: MT = metric ton, g = grams

[1] California Department of Food and Agriculture (CDFA). 2017. CDFA Fertilizing Materials Tonnage Report January – December 2017. Available at: https://www.cdfa.ca.gov/is/ffldrs/pdfs/2017_Tonnage.pdf

[2] California Air Resources Board (CARB). 2020. Documentation of California's 2000-2020 GHG Inventory – Index. Agriculture, Forestry, and Other Land Use; Livestock; Manure Management. https://ww3.arb.ca.gov/cc/inventory/doc/doc_index.php.

Table 38 provides a summary of the data and methods used to determine the total tons of nitrogen applied in the County for farm use based on activity data provided in the CDFA's Tonnage Report.

Table 38 Total Nitrogen Fertilizer Applied in the County

Material Type	State Activity Data			County Activity Data	
	Material Applied (tons material)	Nitrogen Applied (tons N)	Nitrogen Factor (ton N/ ton material)[1]	Material Applied (tons material)	Nitrogen Applied (tons N)[2]
Identified by grade	735,947	275,732	0.3747	–	–
Ammonium nitrate	2,275	774	0.3402	0	0
N-P-K grades	537,408	–	–	–	–
Ammonium nitrate solution	54,121	10,824	0.2000	0	0
Anhydrous ammonia	11,183	9,170	0.8200	5	4
Ammonium polysulfide	1,312	262	0.1997	0	0
Aqua ammonia	142,949	28,590	0.2000	0	0
Ammonium sulfate	96,263	20,215	0.2100	190	40
Ammonium thiosulfate	55,126	6,615	0.1200	58	7
Calcium ammonium nitrate	173,441	29,485	0.1700	142	24
Calcium nitrate	28,323	4,249	0.1500	145	22
Nitrogen solution 28%	3,086	864	0.2800	0	0
Nitrogen solution 32%	467,925	149,694	0.3199	378	121
Sodium nitrate	3,879	621	0.1601	14	2
Sulfur coated urea	224	81	0.3616	0	0
Urea	58,292	45,651	0.7831	201	157
Urea solution	7,874	1,575	0.2000	0	0
Diammonium phosphate	522	94	0.1801	–	–
Ammonium phosphate sulfate	16,839	2,700	0.1603	–	–
Monoammonium phosphate	63,601	6,996	0.1100	–	–
Liquid ammonium polyphosphate	53,168	5,318	0.1000	–	–
Potassium nitrate	21,023	2,944	0.1400	–	–
Blood meal	45	5	0.1111	0	0
Sewage sludge	279,400	16,764	0.0600	–	–
Gypsum - all materials	1,649,925	–	–	–	–
Nitrogen materials - all other	–	–	1.000[3]	2,497	2,497
Total					**2,874**

Notes: MT = metric tons

Source: California Department of Food and Agriculture (CDFA). 2017. CDFA Fertilizing Materials Tonnage Report January – December 2017. Available at: https://www.cdfa.ca.gov/is/ffldrs/pdfs/2017_Tonnage.pdf

[1] Nitrogen Application Rate is calculated based on CDFA reported State-wide tons of material applied and tons of nitrogen applied per material type.

Material Type	State Activity Data: Material Applied (tons material)	State Activity Data: Nitrogen Applied (tons N)	State Activity Data: Nitrogen Factor (ton N/ ton material)[1]	County Activity Data: Material Applied (tons material)	County Activity Data: Nitrogen Applied (tons N)[2]

[2] Nitrogen Applied in the County is calculated based on CDFA reported tons of material applied for farm use within the County and the Nitrogen Application Rate.

[3] A nitrogen factor of 1.000 is applied to "NITROGEN MATERIALS - ALL OTHER" category as CDFA specified via phone on March 16, 2023 that the reported tons applied in the County for this category reflect tons of nitrogen rather than tons of material applied.

*Results my not sum due to rounding

4.7.3 GHG Emissions: Soil Management

Total GHG emissions resulting from soil management practices are determined according to Equation 13 below. The breakdown of emissions from soil management in the unincorporated County area in 2017 are shown in Table 39 and Figure 2.

Equation 13 Total GHG Emissions from Soil Management

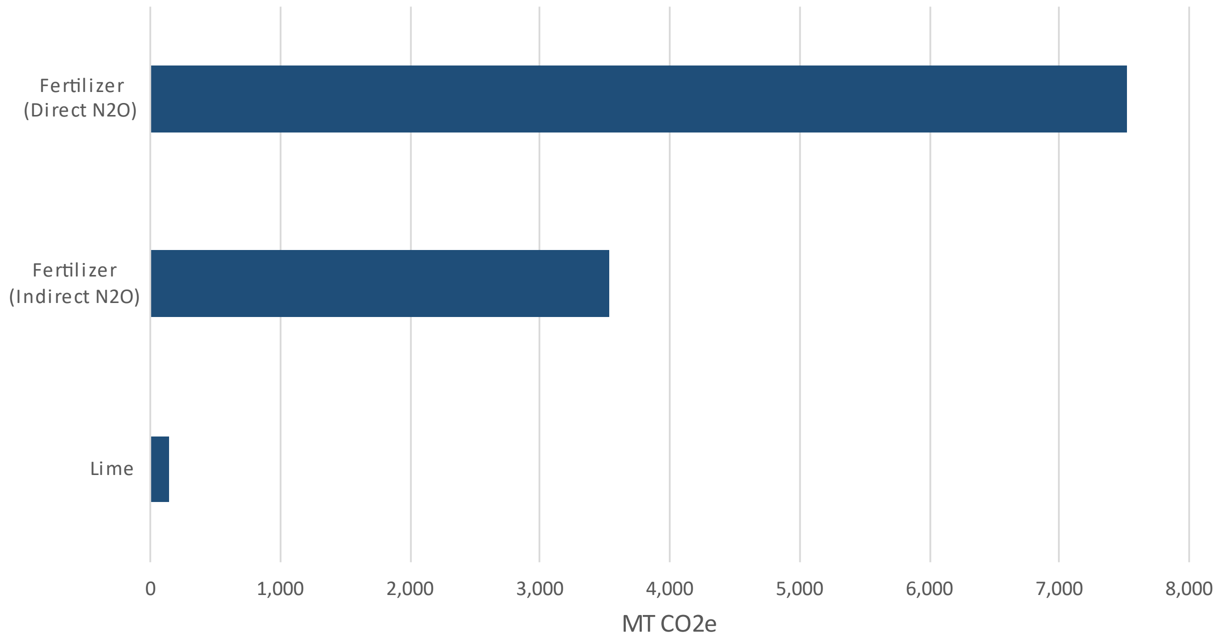
$$CO_2e_{soil} = (CO_{2\,lime} \times GWP_{CO2}) + ([N_2O_{Direct,soil} + N_2O_{Indirect,soil}] \times GWP_{N2O})$$

Table 39 Total GHG Emissions Soil Management – Parameters and Data Sources

Definition	Parameter	Value		Source
Total CO_2e emissions from soil management	$\boldsymbol{CO_2e_{soil}}$	11,179	MT CO_2e/year	Calculated
Annual carbon dioxide emissions from soil liming	$\boldsymbol{CO_{2\,lime}}$	140	MT CO_2/year	Calculated
Direct nitrous oxide emissions per year	$\boldsymbol{N_2O_{Direct,soil}}$	7,511	MT N_2O/year	Calculated
Indirect nitrous oxide emissions per year	$\boldsymbol{N_2O_{Indirect,soil}}$	3,528	MT N_2O/year	Calculated
Global warming potential of carbon dioxide	$\boldsymbol{GWP_{CO2}}$	1		IPCC Fifth Assessment Report
Global warming potential of nitrous oxide	$\boldsymbol{GWP_{N2O}}$	265		IPCC Fifth Assessment Report

Notes: MT = metric tons

Figure 2 Emissions From Soil Management



4.8 Fuel Use

4.8.1 Agriculture Equipment

Off-road mobile agriculture equipment (both diesel and gasoline-fueled) contribute GHG emissions due to the combustion of fuel in internal combustion engines. Off-road activity data from agricultural equipment use, measured in gallons of fuel consumed by fuel type, was added to the 2017 inventory using the OFFROAD2021 emissions database. OFFROAD2021 provides fuel usage results from off-road equipment operation at the county-wide level. As the majority of commercial agricultural practices are attributable the unincorporated County, 100 percent of off-road equipment fuel consumption under the agriculture category was allocated to the County's 2017 agriculture inventory. The remaining offroad emissions can be found in the community inventory. Equation 14 and Table 40 show the equation, associated parameters and data sources, and resulting total annual GHG emissions from agriculture off-road equipment use in the unincorporated County.

Equation 14 GHG Emissions from Off-Road Equipment

$$Emissions_{GHG,fuel} = Consumption_{fuel} \times EF_{GHG,Fuel} \times GWP_{GHG}$$

Table 40 GHG Emissions From Off-road Equipment – Parameters, Data Sources, and Total Emissions

Definition	Parameter	Value		Source
Emissions of a given GHG by type of fuel	$\boldsymbol{Emissions_{GHG,fuel}}$	See Table 41	MT CO_2e/year	Calculated
Amount of fuel combusted	$\boldsymbol{Consumption_{fuel}}$	See Table 41	gallons	CARB OFFROAD2021 Model[1]
Default emission factor of a given GHG by type of fuel	$\boldsymbol{EF_{GHG,Fuel}}$	See Table 41	MT CO_2e/gallon	EPA Emission Factor Hub (2020)[2]
Global warming potential of a given GHG	$\boldsymbol{GWP_{GHG}}$	See Table 1		IPCC Fifth Assessment Report

Notes: MT = metric tons

[1] California Air and Resources Board (CARB). 2021. OFFROAD2021 Model. Available at: https://arb.ca.gov/emfac/emissions-inventory/51d77d270365a26603ffbe85c5bdf52fc868341d

[2] Environmental Protection Agency (EPA). 2020. 2020 GHG Emission Factors Hub. Available at: https://www.epa.gov/sites/default/files/2021-04/documents/emission-factors_mar2020.pdf

Fuel consumption per fuel type and associated GHG emissions from agricultural off-road equipment use in the unincorporated County area in 2017 is provided in Table 41.

Table 41 Off-road Emissions Per Fuel Type

Fuel Type	Fuel Consumption (gallons)	Emission Factors (MT CO_2e/gallon)	GHG Emissions (MT CO_2e)
Gasoline	0	0.0092	0
Diesel	1,019,112	0.0104	10,545
Natural Gas	0	0.0047	0
Total			10,545

Notes: MT = metric tons

4.8.2 Diesel Irrigation Pumps

CARB's GHG Inventories for the State account for fuel combustion in the agricultural sector but does not specify a quantification method for specific equipment types. To estimate emissions associated with diesel combustion in irrigation pumps, CARB's Appendix D Emission Inventory Methodology[34] was used and is expected to be consistent with the State's GHG Inventory methods. Emissions from the use of irrigation pumps is estimated based on the number of pumps in the County, average horsepower and hours of operation, and CO_2 emission factor for diesel combustion. CARB did not provide specific estimates for CH_4 and N_2O emissions, therefore only CO_2

[34] California Air and Resources Board (CARB). 2006. Appendix D Emissions Inventory Methodology. Available at: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/agen06/append.pdf

emissions are quantified for this inventory sector. Equation 15 and Table 42 show the equation, associated parameters and data sources, and resulting total annual GHG emissions from the use of irrigation pumps in the unincorporated County.

Equation 15 CO_2 Emissions from Diesel Irrigation Pumps

$$E_{pumps} = Pop \times EF \times Hrs \times HP \times \%Load \times GWP_{CO2}$$

Table 42 GHG Emissions From Irrigation Pumps – Parameters, Data Sources, and Total Emissions

Definition	Parameter	Value		Source
GHG emissions from irrigation pump use	E_{pumps}	164	MT CO_2e/year	Calculated
Population of diesel agricultural irrigation pump engines	Pop	3		Bay Area Air Quality Management District (BAQMD)[1]
CO_2 emission factor	EF	568	g CO_2/bhp-hr	CARB Appendix D Emissions Inventory Methodology[2]
Average annual use in hours	Hrs	1,000	hrs	CARB Appendix D Emissions Inventory Methodology
Average brake horsepower of engine	HP	148	hp	CARB Appendix D Emissions Inventory Methodology
Average engine load factor	$\%Load$	65	%	CARB Appendix D Emissions Inventory Methodology
Global warming potential of carbon dioxide	GWP_{CO2}	1		IPCC Fifth Assessment Report

Notes: MT = metric tons; bhp-hr = brake horsepower-hour; hrs = hours; hp = horsepower

[1] Bay Area Air Quality Management District Public Records Request. Provided by email on July 5th, 2022

[2] California Air and Resources Board (CARB). 2006. Appendix D Emissions Inventory Methodology. Available at: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/agen06/append.pdf

4.9 2017 Agriculture Inventory Summary

Figure 3 and Figure 4 provide a summary of the County's 2017 Agricultural GHG Emissions Inventory for each sector included in the inventory scope. Enteric fermentation was the largest source of emissions in the County's 2017 agricultural GHG inventory, which is to be expected as gases released directly from livestock poses a difficult mitigation challenge in the agriculture industry. Off-road equipment account for approximately 24 percent of the County's emissions and pose a significant opportunity for potential GHG emission reductions in the County's future agricultural inventories. Irrigation pumps and residue burning GHG emissions collectively contributed less than 1 percent of the total GHG emissions and are considered insignificant emissions sources in the County's 2017 agricultural GHG inventory. A summary of total GHG emissions and percent contribution by sector and subsectors is provided in Table 43 and Table 44, respectively.

Figure 3 GHG Emissions by Sector in Santa Clara County

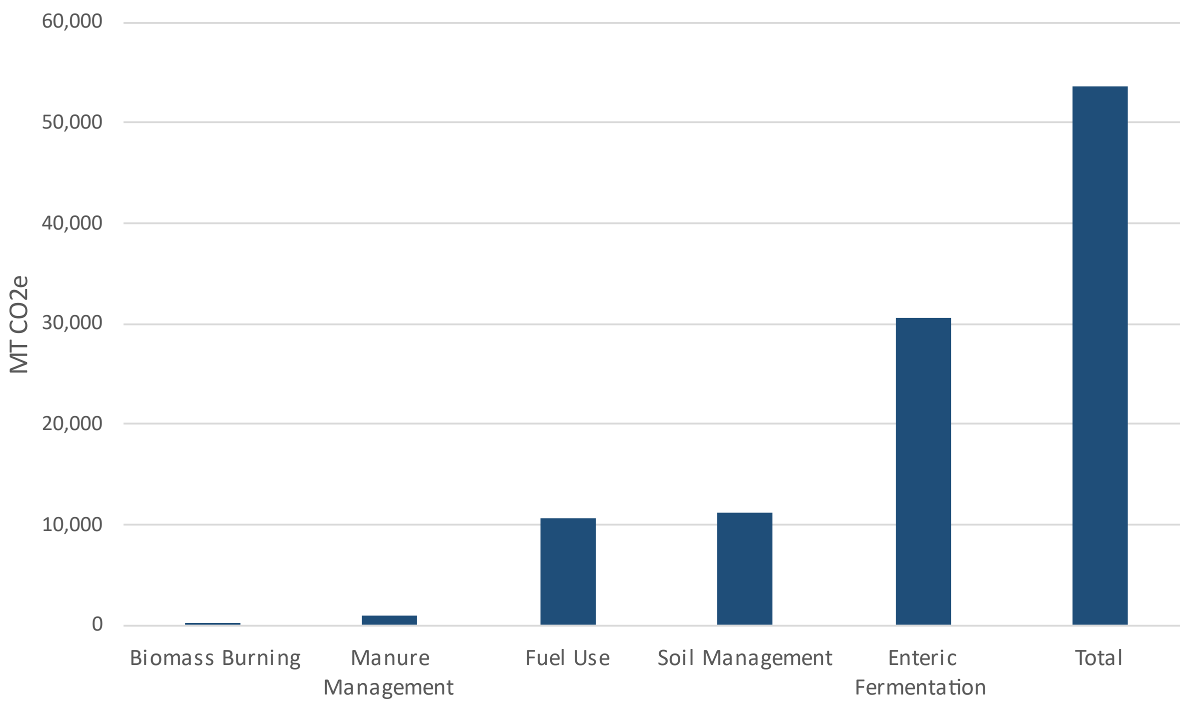


Figure 4 Proportion of GHG Emissions by Sector

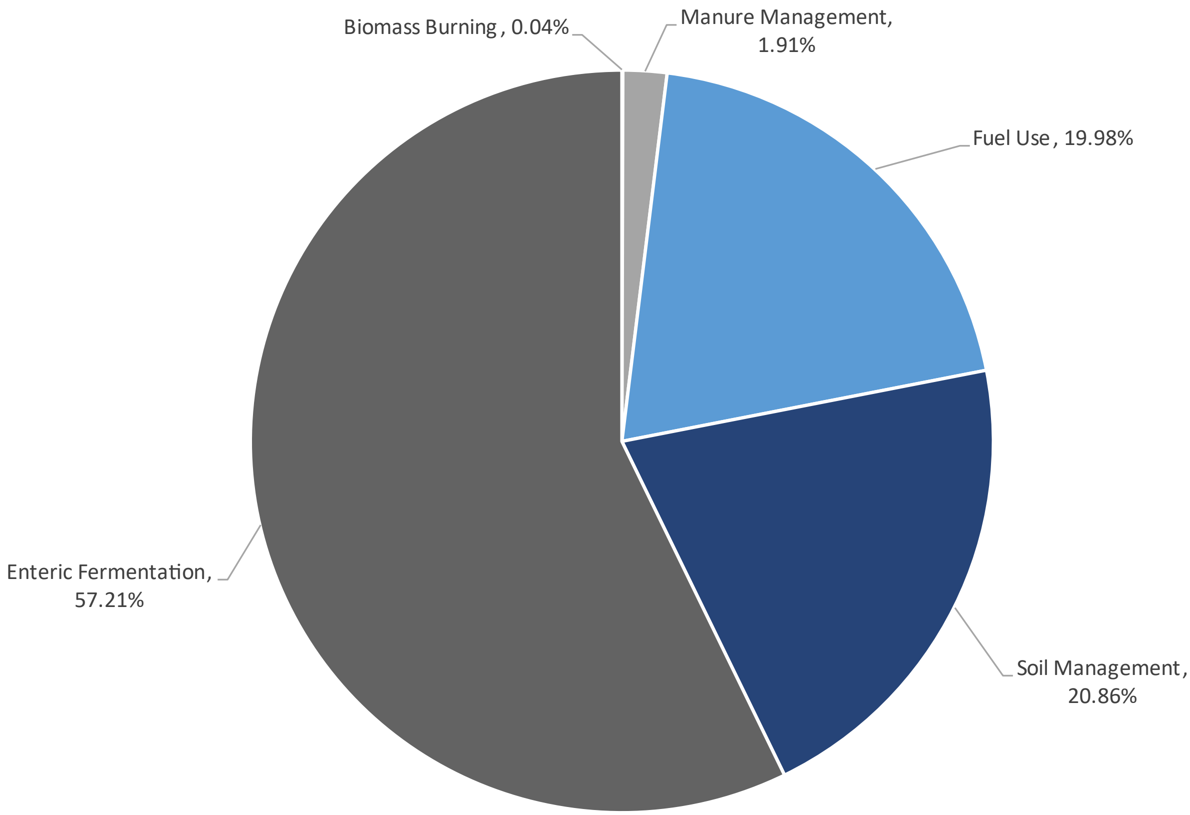


Table 43 County Agriculture Inventory Summary by Sector

Sector	MT CO_{2e}	Percent
Enteric Fermentation	30,663	57.21%
Manure Management	1,020	1.91%
Soil Management	11,179	20.86%
Biomass Burning	21	0.04%
Fuel Use	10,709	19.98%
Total	**53,594**	**100.00%**

Notes: MT = metric tons

Table 44 County Agriculture Inventory Summary by Subsector

Sector	Subsector	GHG Emissions [MT CO_2e]
Enteric Fermentation	Bulls	906
	Beef Cows	21,915
	Other (heifer and steer stockers)	7,842
	Swine	N/A
	Pullets	N/A
	Turkeys	N/A
	Layers (hens)	N/A
	Sheep	N/A
	Goats	N/A
	Horses	N/A
Manure Management	Bulls	30
	Beef Cows	733
	Other (heifer and steer stockers)	257
	Swine	N/A
	Pullets	N/A
	Turkeys	N/A
	Layers (Hens)	N/A
	Sheep	N/A
	Goats	N/A
	Horses	N/A
Soil Management	Liming Application	140
	Nitrogen Application (Direct)	7,511
	Nitrogen Application (Indirect)	3,528
Biomass Burning - Cropland	Barley	0.00
	Corn	0.00
	Rice	0.00
	Wheat	0.00
	Almond	0.00
	Walnut	0.00
	Pasture/Rangeland	21
Fuel Use	Pumps	164
	Off-road Equipment	10,545

Notes: MT = metric tons
*Results may not sum due to rounding

5 2017 Inventory Summary

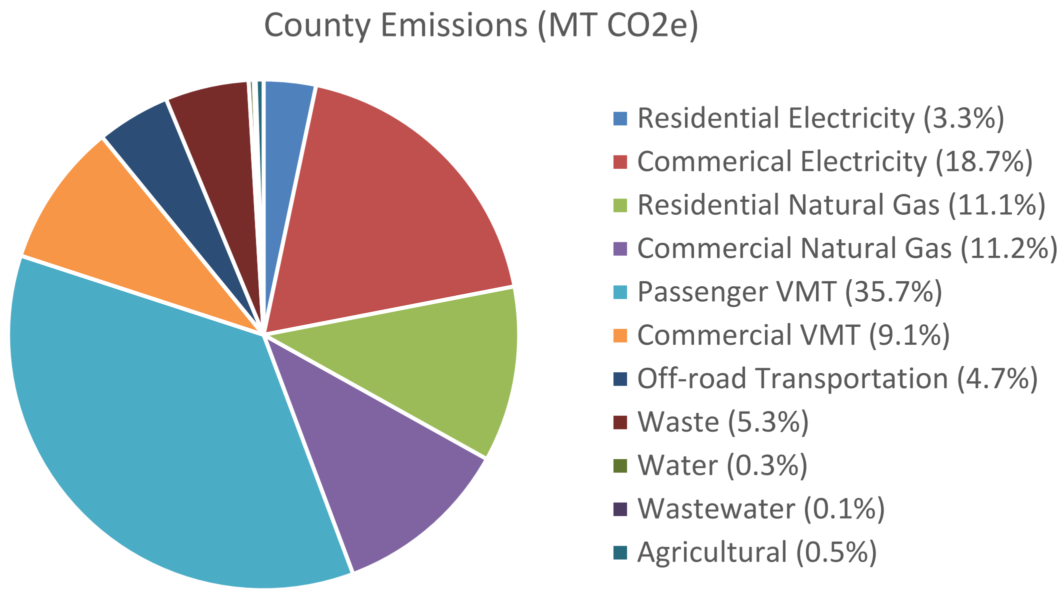
The results for all except agricultural GHG emissions sectors for the 2017 County inventory are shown below. A separate GHG analysis was conducted to assess commercial agriculture GHG emissions which is provided in Section 0.

Table 45 2017 GHG Emissions Inventory Summary

GHG Emissions Sector	County Emissions ($MT\ CO_2e$)	Unincorporated County Emissions ($MT\ CO_2e$)
Residential Electricity	357,750.48	14,276.00
Commercial Electricity	2,020,766.29	94,308.00
Residential Natural Gas	1,205,905.66	48,502.61
Commercial Natural Gas	1,214,603.56	126,473.65
Passenger VMT	3,868,363.75	33,052.17
Commercial VMT	984,541.62	8,412.14
Off-road VMT	503,816.20	18,461.04
Waste	574,003.34	40,499.96
Water	34,912.25	6,765.85
Wastewater	12,880.46	519.83
Agriculture	53,593.87	53,593.87
Total	**10,831,137.48**	**444,865.11**
Per Capita Emissions		
Population (2017)	1,942,176	88,545
Per Capita Emissions ($MT\ CO_2e$/person)	**5.58**	**5.02**

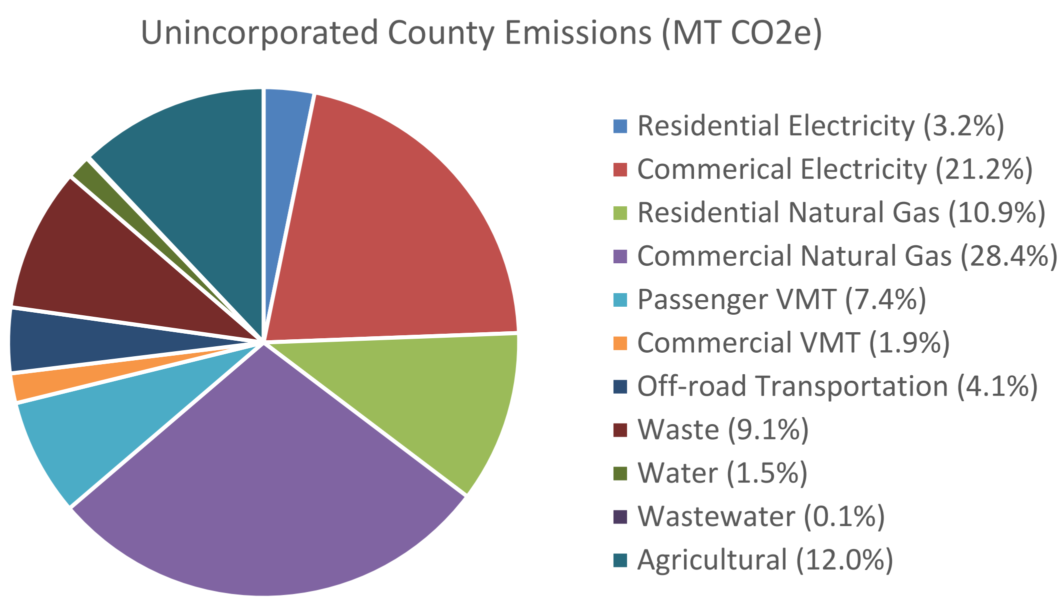
County-wide, the on-road transportation sector, including passenger and commercial VMT, accounted for almost half of GHG emissions. Residential and commercial natural gas were also large GHG emissions sources, followed by commercial electricity, waste, residential electricity, water, and wastewater (Figure 5).

Figure 5 2017 County-wide GHG Emissions



Slightly different trends were observed for the unincorporated County, where natural gas contributed the most to GHG emissions, followed by commercial electricity, waste, on-road transportation, residential electricity, water, and wastewater. Stanford's energy use (electricity and natural gas) was estimated to account for approximately 12 percent of the unincorporated County's total emissions.

Figure 6 2017 Unincorporated County GHG Emissions



5.1 1990 Back-cast

Current defensible methodologies for setting GHG emissions targets establish a percent reduction from 1990 emissions levels consistent with the State goals in SB 32 and EO-B-55-18. Most jurisdictions do not have a 1990 inventory due to lack of sufficiently reliable data to conduct such an inventory. Therefore, alternative methodologies have been established to back-cast from 2005-2008 data years to 1990, consistent with CEQA defensibility. However, the County does not have sufficient data to establish a 2005-2008 inventory. Other jurisdictions, such as the City of South Pasadena, have established a relationship between GHG emissions at the State-level for their inventory year (in the County's case, 2017), compared to the State's emissions in 1990, as a way to back-cast to 1990 using best available data. This approach assumes that the County's GHG emissions have tracked approximately with the State's GHG emissions, when controlled for community emissions sources. While not a perfect approximation, this approach is defensible and ensures consistency with State goals. The calculation is done by using published state-wide emissions results from CARB, after removing emissions from emissions sectors not included in the County inventory or the emissions back-cast (i.e., agricultural, industrial, and high GWP emissions sectors). For example, the State emitted 283.4 million MT CO_2e in 2017[35], compared to 305.4 million MT CO_2e in 1990[36] in the relevant emissions sectors – a 7.20% decrease between 1990 and 2017. This change factor was applied to the County's 2017 inventory emissions, excluding agriculture, to back-cast to 1990 (Table 46). Agricultural emissions were excluded from the back-cast as the County's agricultural sector emissions are not anticipated to follow state-wide historical GHG emissions trends due to significantly reduced commercial agricultural production in the County between 1990 and 2017 as described by County staff. However, there is limited reliable data regarding this decline and historical GHG emissions in the County to adequately scale the County's agricultural GHG emissions to 1990 levels. To provide a conservative estimation of the County's total 1990 GHG emissions, 2017 agricultural GHG emissions were removed from the County's 2017 total GHG emissions prior to applying the state-wide change factor and subsequently added to the County's resulting 1990 back-cast to approximate the County's total 1990 GHG emissions. This strategy establishes a conservative estimation of GHG emissions reductions in the County since 1990 and thereby sets conservative GHG emissions reduction targets that do not promote the decline of agriculture in order to achieve GHG emission reduction goals.

[35] The State's GHG emissions inventory for 2017 was accessed through CARB's website at https://ww2.arb.ca.gov/ghg-inventory-data

[36] The State's GHG emissions inventory for 1990 was published in CARB's California 1990 Greenhouse Gas Emissions Level and 2020 Emissions Limit Staff Report (CARB 2007)

Thus, the “best available data” (i.e., the 2017 inventory) was used to determine a 1990 baseline from which to develop GHG reduction targets that are consistent with State standards.[37]

Table 46 1990 GHG Emissions Back-cast

Territory	County	Unincorporated County
2017 Community GHG Emissions (MT CO_2e)[1]	10,777,543.62	391,271.25
2017 to 1990 State GHG Emissions Change Factor (%)[2]	7.20%	7.20%
1990 Community GHG Emissions (MT CO_2e)	11,553,922.00	419,457.13
2017 Agricultural GHG Emissions (MT CO_2e)	53,593.87	53,593.87
1990 GHG Emissions (MT CO_2e)[3]	**11,607,515.87**	**473,050.99**
1990 Population	1,497,577.00	106,173.00
1990 Per Capita Emissions (MT CO_2e/person)	**7.75**	**4.46**

[1] 2017 GHG Emissions excludes agricultural GHG emissions as this sector is not an included emissions source in the GHG Emissions Change Factor developed based on state-wide emissions. Changes in agricultural GHG emissions state-wide are not considered reflective of changes in the County, therefore agricultural GHG emissions from 2017 are added to the 1990 back-cast as a flat sum to serve as a conservative estimate of the County’s total 1990 GHG emissions.

[2] Change factor calculated as the percent difference between 1990 and 2017 state-level emissions. the State emitted 283.4 million MT CO_2e in 2017 compared to 305.4 million MT CO_2e in 1990 in the relevant emissions sectors – a 7.20% decrease between 1990 and 2017.

[3] Includes the scaled 2017 GHG Emissions based on the state-wide 2017 to 1990 GHG Emissions Change Factor as well as a flat sum of the County’s 2017 agricultural GHG emissions

[37] The concept of “best available data” is referenced by the Greenhouse Gas Protocol (World Resources Institute 2014)

6 Forecast

The baseline inventory (e.g., the County's GHG inventory for 2017) sets a reference point for a single year. However, annual emissions change over time due to external factors such as population and job growth. A GHG forecast accounts for projected growth using growth rates and presents an estimate of the level of GHG emissions in a future year. Calculating the difference between the forecasted GHG emissions and the reduction targets determines the gap to be closed through the jurisdiction's climate action policies. This section presents two forecast scenarios: a business as usual (BAU) forecast scenario and an adjusted forecast scenario:

- **BAU** forecast scenario projects the expected growth in all emission sectors based on job and population growth alone.
- **Adjusted** forecast accounts for job and population growth and additionally quantifies and incorporates all state regulations that are expected to help reduce the County's GHG emissions through 2030 and 2045, as discussed in Section 2.2. The adjusted forecast provides a more accurate picture of future emissions growth and the responsibility of the County and its stakeholders once State regulations to reduce GHG emissions have been implemented.

The County and most of the cities within the County have additionally instituted local policies and programs that will reduce GHG emissions even further within the County beyond state-level regulations. However, these local policies and programs were not included in the adjusted forecast, as it is currently unclear to what extent the expected reductions from these policies and programs will actually be achieved and on what timeline.[38]

6.1 Forecast Years

The GHG forecast uses benchmark years of 2025, 2030, 2035, and 2045, consistent with currently codified GHG reduction targets or executive orders which are expected to be codified in future. The forecast years align with the following targets:

- 2025 (interim target year)
- 2030 (SB 32)
- 2035 (interim target year)

[38] The exception to this is the already-implemented Community Choice Aggregation within San Jose – San Jose Clean Energy – because this program has already been implemented and provides demonstrated GHG emissions reductions for San Jose that continue to be predictable through 2045.

- 2045 (EO B-55-18 and SB100)

The 2030 target is required for consistency with SB 32, while the remainder of the targets identify a clear path and milestones of progress toward the State's long-term reduction goal of carbon neutrality.

6.2 Activity Data and Growth Factors

Data used to develop the BAU and adjusted forecasts included activity data from the 2017 inventory, demographics projections (population and jobs) from California Department of Finance (DOF) and Association of Bay Area Governments (ABAG), renewables procurement projections from the relevant electricity providers, building efficiency projections from the California Energy Commission (CEC), and EMFAC2017 model output for the forecast years.

Table 47 Activity Data for Forecasting

Sector	Data	Unit	Source
Demographics	Population and employment by city	Residents, Jobs	**2017-2020 population data** – California DOF Historical Population Estimates for Cities, Counties, and the State database[1] **2025-2040 population and 2017-2040 jobs data** – ABAG Projections 2040 statistical compendia[2,3]
Energy	Renewable Portfolio Standard energy mix changes	Percent	SB 100
Energy	Building efficiency projections	Percent	CEC (2018)
Transportation	On-road VMT emissions factors	g CO_2e/mile	CARB EMFAC2017 model output for 2025, 2030, 2035, and 2045
Transportation	Off-road fuel use projections	Gallons	CARB OFFROAD2021 model output for 2025, 2030, 2035, and 2040

[1] Accessed at: https://www.dof.ca.gov/Forecasting/Demographics/Estimates/

[2] Accessed at: http://projections.planbayarea.org/data

[3] Population and job projections for 2045 were not available from ABAG, but were calculated based on the assumption of a similar growth rate between 2040 and 2045 as between 2035 and 2040.

The BAU and adjusted forecasts are primarily driven by the anticipated population and jobs growth for the County provided by ABAG. Regardless of the impacts of State legislation, changes in population and jobs data are the primary indicators of how activity data for different emissions sectors will change. Expected population and jobs growth through 2045 for both the County and unincorporated County are shown in Figure 7 and Figure 8. Population and job projections for 2045 were not available from ABAG, but were calculated based on the assumption of a similar growth rate between 2040 and 2045 as between 2035 and 2040.

Figure 7 County Demographics Projections

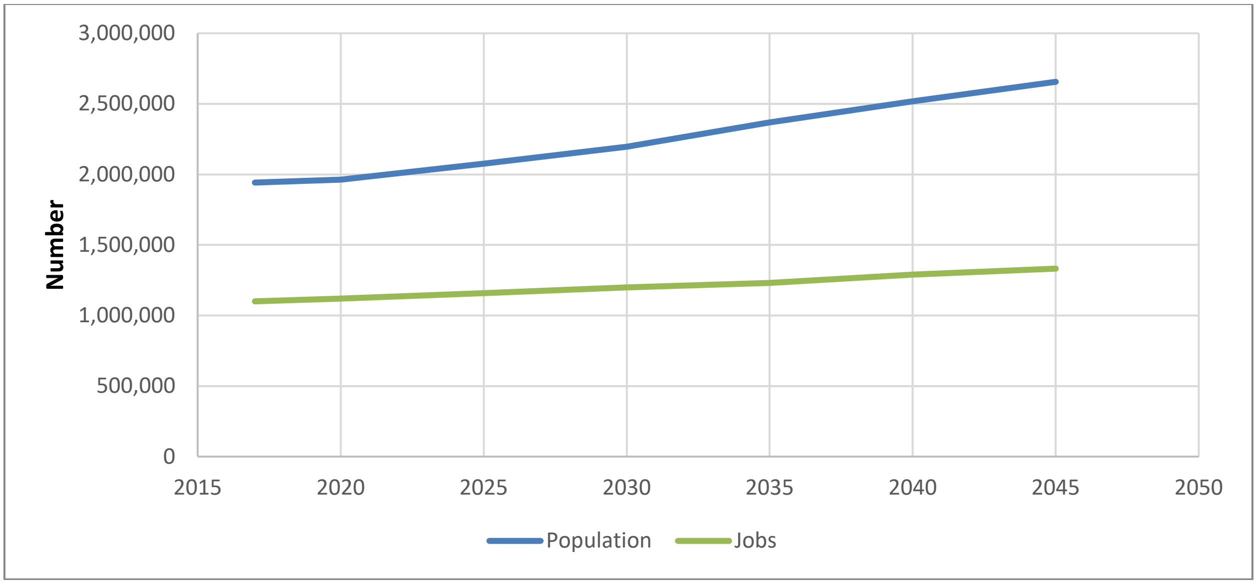
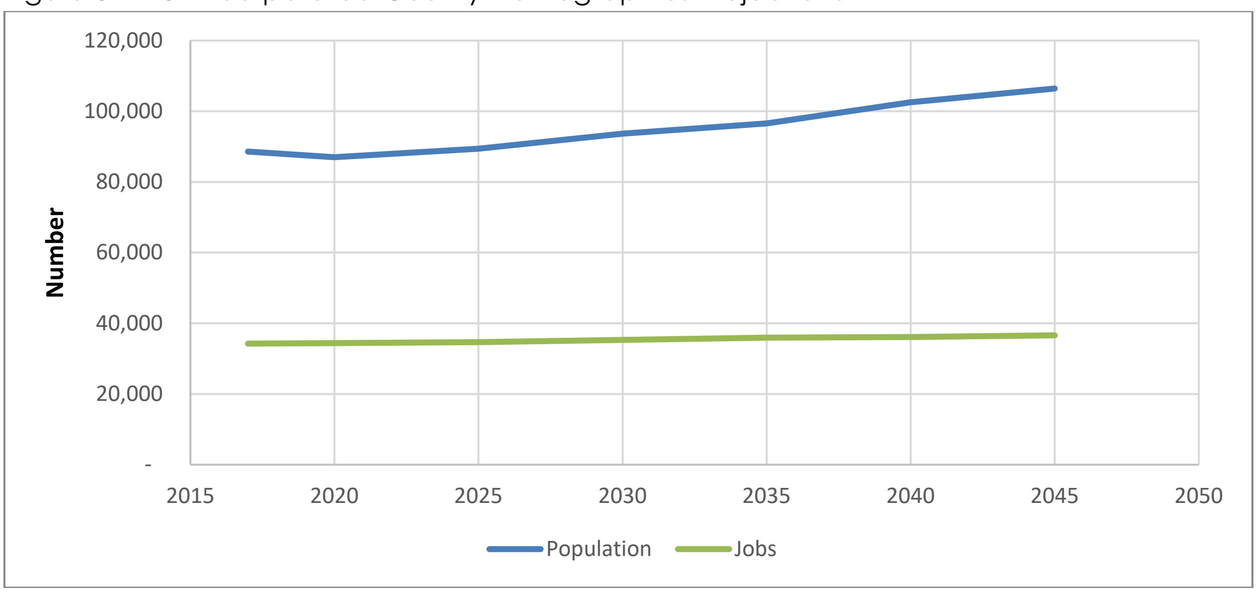


Figure 8 Unincorporated County Demographics Projections



In order to model growth in each emissions sector based on population and jobs projections, growth factors (e.g., residential kWh per person or commercial therms per job) were developed based on the 2017 inventory and the population and jobs data for 2017 (Table 48).

Table 48 Growth Factors for Forecasting

GHG Emissions Sector	Growth Factor	Value
Energy – electricity	Residential electricity per capita – SVCE incorporated service area (kWh/resident)	2,032.09
Energy – electricity	Residential electricity per capita – unincorporated County (kWh/resident)	2,143.64
Energy – electricity	Commercial electricity per job – SVCE service area (kWh/job)	11,323.23
Energy – electricity	Residential electricity per capita – Palo Alto (kWh/resident)	2,188.59
Energy – electricity	Commercial electricity per job – Palo Alto (kWh/job)	6,385.92
Energy – electricity	Residential electricity per capita – San Jose (kWh/resident)	1,717.28
Energy – electricity	Commercial electricity per job – San Jose (kWh/job)	4,607.31
Energy – electricity	Direct access electricity per service person – San Jose (kWh/sp)	842.74
Energy – electricity	Residential electricity per capita – Santa Clara (kWh/resident)	1,564.90
Energy – electricity	Commercial electricity per job – Santa Clara (kWh/job)	22,682.80
Energy – natural gas	Residential natural gas per capita – incorporated County (therms/resident)	117.56
Energy – natural gas	Commercial natural gas per capita – incorporated County (therms/job)	192.14
Energy – natural gas	Residential natural gas per capita – unincorporated County (therms/resident)	103.13
Energy – natural gas	Commercial natural gas per capita – unincorporated County (therms/job)	695.21
Transportation	Passenger vehicle mileage per capita – incorporated County (miles/resident)	6,255.23
Transportation	Commercial vehicle mileage per job – incorporated County (miles/job)	178.62
Transportation	Passenger vehicle mileage per capita – unincorporated County (miles/resident)	1,128.50
Transportation	Commercial vehicle mileage per job – unincorporated County (miles/job)	47.92
Waste	Emissions per service person - incorporated County (MT CO_2e/sp)	0.18
Waste	Emissions per service person - unincorporated County (MT CO_2e/sp)	0.33
Water	Local electricity per service person – incorporated County (kWh/sp)	66.36
Water	Non-local electricity per service person – incorporated County (kWh/sp)	40.10
Water	Local electricity per service person – unincorporated County (kWh/sp)	379.28
Water	Non-local electricity per service person – unincorporated County (kWh/sp)	229.23
Wastewater	Emissions per service person – County (MT CO_2e/sp)	0.0042

6.3 Business-as-usual Forecast Methods and Results

The BAU forecast provides an estimate of how GHG emissions would change in the forecast years if consumption trends continue as in 2017, absent any new regulations or policies that would reduce GHG emissions. Under the BAU forecast, the County's emissions are projected to continue increasing through 2045 for both the County as a whole and the unincorporated County. This increase is the result of increases in off-road fuel usage projected by the OFFROAD2021 model, and increases in electricity usage, natural gas usage, on-road VMT, waste, water usage, and wastewater caused by projected population and jobs increases.

The BAU forecast was completed according to the following methods:

- **Electricity:** The growth factor for each electricity source in Table 48 (in units of kWh per resident, job, or service person) was multiplied by the corresponding population or jobs projection for each year, then multiplied by the T&D loss factor[39] and corresponding emissions factor used in the 2017 inventory.
- **Natural gas:** The growth factor for each natural gas source in Table 48 (in units of therms per resident or job) was multiplied by the corresponding population or jobs projection for each year, then multiplied again by the natural gas emissions factor used in the 2017 inventory.
- **On-road transportation:** The growth factor for each VMT source in Table 48 (in units of miles per resident or job) was multiplied by the corresponding population or jobs projection for each year. Annual VMT by vehicle type was then multiplied by its corresponding emissions factor from the 2017 inventory.
- **Off-road transportation:** The analysis completed for the 2017 inventory was completed for each forecast year using OFFROAD2021 model outputs. Emissions factors used in the 2017 inventory were used for each forecast year.
- **Waste:** The growth factor for waste in Table 48 (in units of MT CO_2e per service person) for each jurisdiction (i.e., incorporated and unincorporated) was multiplied by the corresponding service person projection for each year.
- **Water:** The growth factors for water in Table 48 (in units of kWh per service person) for each water stream were multiplied by the corresponding service person projection for each year, then multiplied by the corresponding electricity emissions factor used in the 2017 inventory.

[39] The T&D loss factor for 2025-2045 was assumed to be 4.80%, per the latest EPA eGRID publication (eGRID 2018).

- **Wastewater:** The growth factor for wastewater in Table 48 (in units of MT CO_2e per service person) was multiplied by the corresponding service person projection for each year for each jurisdiction (i.e., incorporated and unincorporated).
- **Agriculture:** The analysis completed for the 2017 inventory was completed for each forecast year for agricultural off-road transportation using OFFROAD2021 model outputs. Emissions factors used in the 2017 inventory were used for each forecast year. Growth factors were not applied to other agricultural sectors such as enteric fermentation, manure management, soil management, and fuel use from pumps and remained consistent for each forecast year.

The calculations used to complete the BAU forecast are included in Appendix A. The results of the analysis are shown in Table 49.

Table 49 BAU Forecast GHG Emissions Summary (MT CO_2e)

Emissions Sector	2017	2025	2030	2035	2045
County					
Residential Electricity	357,750	357,421	377,394	406,907	455,795
Commercial Electricity	2,020,766	2,153,072	2,294,681	2,369,629	2,539,425
Residential Natural Gas	1,205,906	1,289,641	1,364,214	1,471,011	1,650,397
Commercial Natural Gas	1,214,604	1,275,464	1,317,304	1,352,255	1,457,342
Passenger VMT	3,868,364	4,144,619	4,385,644	4,735,286	5,315,510
Commercial VMT	984,542	1,042,920	1,086,011	1,132,985	1,241,532
Off-road Transportation	514,362	591,171	653,438	694,987	768,427
Waste	574,003	609,417	639,224	677,028	749,786
Water	34,912	36,827	38,584	40,713	44,948
Wastewater	12,880	13,697	14,371	15,234	16,884
Agriculture	53,594	55,761	55,276	54,826	54,023
Total	**10,841,683**	**11,570,010**	**12,226,141**	**12,950,861**	**14,294,069**
Unincorporated County					
Residential Electricity	14,276	14,491	15,176	15,654	17,252
Commercial Electricity	94,308	102,114	105,109	107,506	114,437
Residential Natural Gas	48,503	48,966	51,279	52,895	58,293
Commercial Natural Gas	126,474	127,910	130,384	132,673	135,129
Passenger VMT	33,052	33,368	34,944	36,046	39,724
Commercial VMT	8,412	8,503	8,737	8,927	9,318
Off-road Transportation	18,461	21,137	23,317	24,861	27,593
Waste	40,500	40,907	42,521	43,699	47,168
Water	6,766	6,834	7,103	7,300	7,880
Wastewater	520	525	546	561	605
Agriculture	53,594	55,761	55,276	54,826	54,023
Total	**444,865**	**460,517**	**474,393**	**484,948**	**511,423**

The results of the BAU forecast are also shown in Figure 9 for the County and in Figure 10 for the unincorporated County below.

Figure 9 BAU Forecast – County

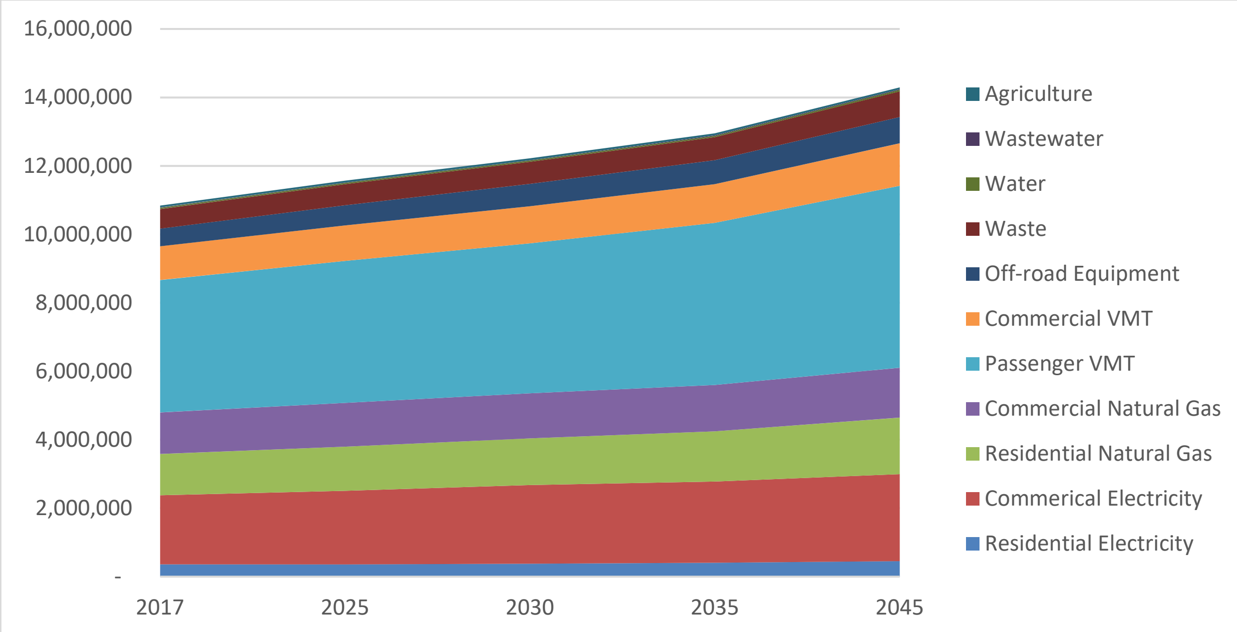
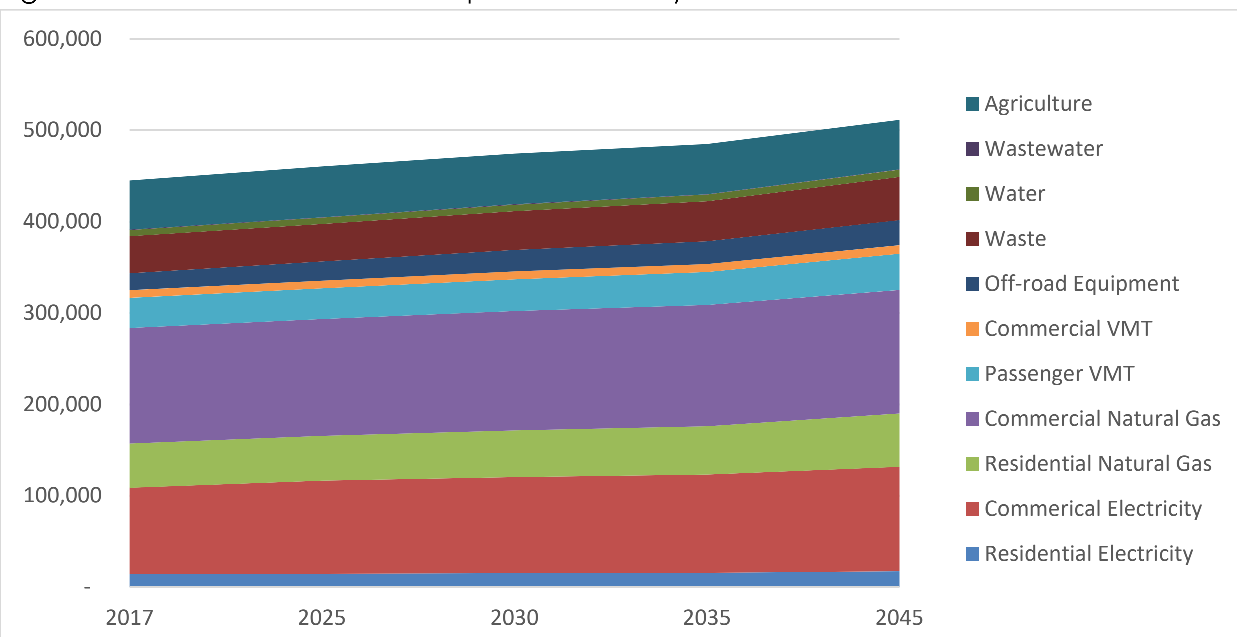


Figure 10 BAU Forecast – Unincorporated County



6.4 Adjusted Forecast Methods and Results

The adjusted forecast adjusts the BAU forecast to include the legislative actions and associated emissions reductions occurring at the State and federal levels, as summarized in Section 2.2. Under the adjusted scenario, GHG emissions are expected to decrease overall through 2045. Electricity and water emissions in particular will see a strong downward trend, approaching near-zero in 2045 due to SB 100, requiring 100 percent renewables portfolio standard by 2045, and Title 24 requirements resulting in decreased electricity use in new buildings as well. On-road transportation emissions will decrease over the next 10 to 15 years due to existing fuel efficiency requirements and fleet turnover rates, as modelled by EMFAC2017. As most current regulations expire in 2025 or 2030, emissions standards will experience diminishing returns while actual car usage continues to increase, leading to lower rates of emissions reductions. Natural gas emissions are expected to continue increasing with population, although to a lesser extent than under the BAU forecast scenario, due to Title 24 requirements resulting in decreased natural gas use in new residential buildings. Off-road transportation, waste, and wastewater emissions will also increase under the adjusted forecast scenario, as no legislative reductions were applied to these sectors.

The methods used to complete the adjusted forecast are summarized in the sections below, and calculations are included in Appendix A. The results of the analysis are shown in Table 50.

Table 50 Adjusted Forecast GHG Emissions Summary (MT CO_2e)

Emissions Sector	2017	2025	2030	2035	2045
County					
Residential Electricity	357,750	181,342	140,140	96,997	0
Commercial Electricity	2,020,766	1,279,183	1,011,397	691,194	0
Residential Natural Gas	1,205,906	1,283,779	1,353,132	1,452,453	1,619,282
Commercial Natural Gas	1,214,604	1,275,464	1,317,304	1,352,255	1,457,342
Passenger VMT	3,868,364	3,219,995	2,972,563	2,955,735	3,129,282
Commercial VMT	984,542	890,785	842,403	821,988	846,849
Off-road Transportation	514,362	591,171	653,438	694,987	768,427
Waste	574,003	609,417	639,224	677,028	749,786
Water	34,912	25,749	20,515	14,432	0
Wastewater	12,880	13,697	14,371	15,234	16,884
Agriculture	53,594	55,761	55,276	54,826	54,023
Total	**10,841,683**	**9,426,346**	**9,019,763**	**8,827,130**	**8,641,876**
Unincorporated County					
Residential Electricity	14,276	1,025	786	532	0
Commercial Electricity	94,308	23,976	18,360	12,441	0
Residential Natural Gas	48,503	48,934	51,085	52,588	57,608
Commercial Natural Gas	126,474	127,910	130,384	132,673	135,129
Passenger VMT	33,052	25,924	23,685	22,499	23,386
Commercial VMT	8,412	7,262	6,777	6,474	6,355
Off-road Transportation	18,461	21,137	23,317	24,861	27,593
Waste	40,500	40,907	42,521	43,699	47,168
Water	6,766	4,778	3,777	2,588	0
Wastewater	520	525	546	561	605
Agriculture	53,594	55,761	55,276	54,826	54,023
Total	**444,865**	**358,140**	**356,513**	**353,742**	**351,868**

The results of the Adjusted forecast are also shown in Figure 11 for the County and in Figure 12 for the unincorporated County below.

Figure 11 Adjusted Forecast – County

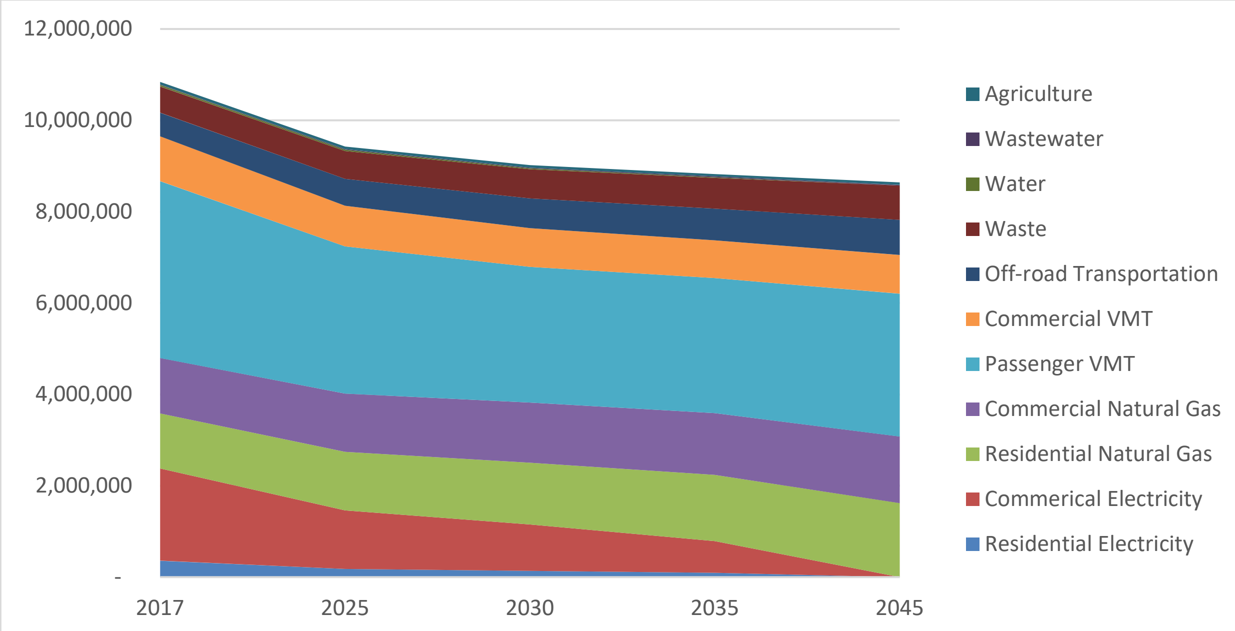
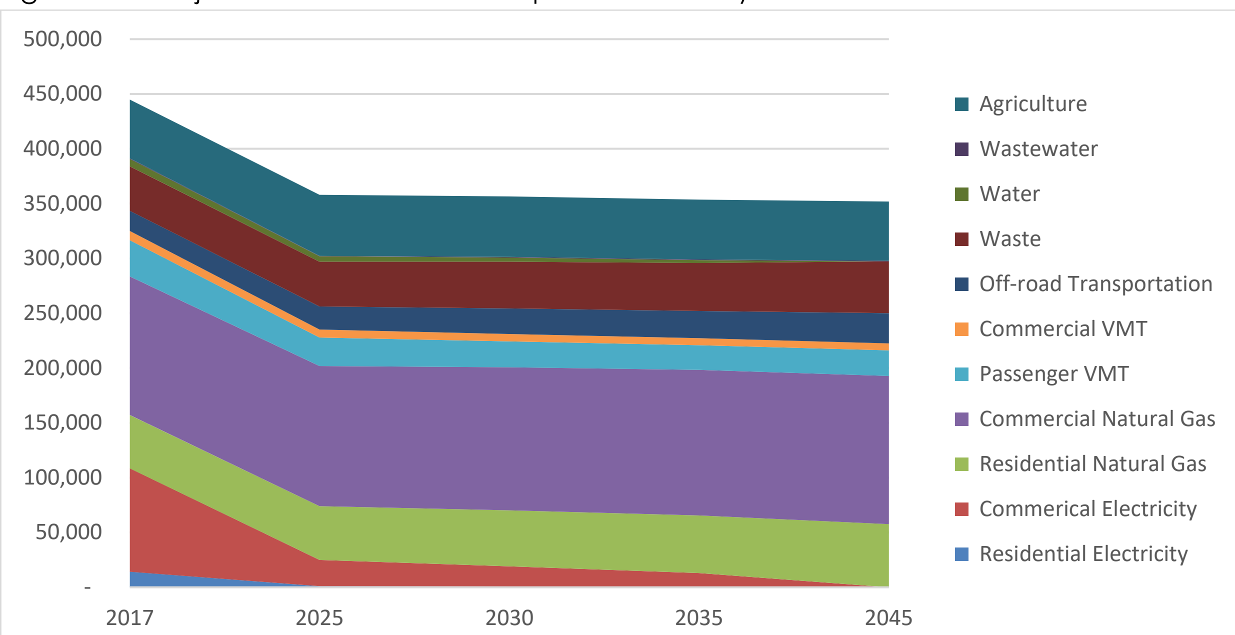


Figure 12 Adjusted Forecast – Unincorporated County



Energy

Electricity

Projected GHG emissions from electricity were calculated by multiplying the growth factor for each electricity source in Table 48 (in units of kWh per resident, job, or service person) by the corresponding population or jobs projection for each year. New residential electricity usage was then reduced by 53 percent for each forecast year, and new commercial electricity usage was reduced by 30 percent for each forecast year, to model efficiency increases from the 2019 Building Energy Efficiency Standards from Title 24 (CEC 2018). Resulting electricity usage for each electricity source was then multiplied by the T&D loss factor[40] and corresponding emissions factor. Emissions factors were calculated based on the most recent emissions factor for each electricity source available,[41] which were adjusted for future years based on SB 100 RPS requirements.

The emissions factor for San Jose electricity changed due to San Jose transitioning from PG&E to San Jose Clean Energy (SJCE) in 2019. An emissions factor for SJCE electricity was provided directly by SJCE, and projected forward for the forecast years based on SB 100 RPS requirements, using the same methods as for the other electricity emissions factors.

Natural Gas

Projected GHG emissions from natural gas were calculated by multiplying the growth factor for each natural gas source in Table 48 (in units of therms per resident or job) by the corresponding population or jobs projection for each year. New residential natural gas usage was then reduced by 7 percent for each forecast year, to model efficiency increases from the 2019 Building Energy Efficiency Standards from Title 24 (CEC 2018). No reductions were applied to new commercial natural gas usage, as the CEC specifies that nonresidential buildings will reduce energy usage primarily through lighting upgrades (CEC 2018). Resulting natural gas usage for each natural gas source was then multiplied by the emissions factor for natural gas, which is expected to remain constant in future years.

Transportation

On-road Transportation

Similar to the BAU forecast, projected GHG emissions from on-road transportation were calculated by multiplying the growth factor for each vehicle type in Table 48 (in units of miles per resident or job) by the corresponding population or jobs projection for each year. Annual VMT by vehicle type was then multiplied by its corresponding emissions factor, derived for each forecast year based on EMFAC2017 model output for 2025, 2030, 2035, and 2045.

[40] The T&D loss factor for 2025-2045 was assumed to be 4.80%, per the latest EPA eGRID publication (eGRID 2018).
[41] Sources for the most recent electricity emission factor available were identical to those used for the 2017 inventory.

The EMFAC2017 model incorporates the legislative requirements and regulations regarding transportation in California, including the Advanced Clean Car Standards (EMFAC 2018).

Off-road Transportation

No adjustments to the BAU forecast for off-road transportation were incorporated into the adjusted forecast.

Waste

No adjustments to the BAU forecast for waste were incorporated into the adjusted forecast.

Water

Projected GHG emissions from water were calculated by multiplying the growth factors for water in Table 48 (in units of kWh per service person) for each water stream by the corresponding service person projection for each year, then multiplied by the corresponding electricity emissions factor. Electricity emissions factors were calculated based on the most recent emissions factor for each electricity source available, which were adjusted for future years based on SB 100 RPS requirements.

Wastewater

No adjustments to the BAU forecast for wastewater were incorporated into the adjusted forecast.

Agriculture

No adjustments to the BAU forecast for agriculture were incorporated into the adjusted forecast.

6.5 Forecast Summary and Comparison

A comparison of the BAU and Adjusted forecasts is shown in Table 51. Reductions expected from legislative programs at the State level are shown in Table 52.[42]

[42] As noted at the beginning of this section above, while local programs and policies are not included in the forecast analysis, the County and the local cities are working on programs such as adopting reach codes, developing implementation plans for SB 1383, and others.

Table 51 BAU versus Adjusted Forecast (MT CO_2e)

Emissions	2017	2025	2030	2035	2045
County					
BAU Emissions (MT CO_2e)	10,831,137	11,570,010	12,226,141	12,950,861	14,294,069
Adjusted Emissions (MT CO_2e)	10,831,137	9,426,346	9,019,763	8,827,130	8,641,876
Population	1,942,176	2,076,386	2,196,336	2,367,737	2,656,241
BAU Per Capita Emissions (MT CO_2e/person)	5.58	5.57	5.57	5.47	5.38
Adjusted Per Capita Emissions (MT CO_2e/person)	5.58	4.54	4.11	3.73	3.25
Unincorporated County					
BAU Emissions (MT CO_2e)	444,865	460,517	474,393	484,948	511,423
Adjusted Emissions (MT CO_2e)	444,865	358,140	356,513	353,742	351,868
Population	88,545	89,391	93,614	96,564	106,419
BAU Per Capita Emissions (MT CO_2e/person)	5.02	5.15	5.07	5.02	4.81
Adjusted Per Capita Emissions (MT CO_2e/person)	5.02	4.01	3.81	3.66	3.31

Table 52 Legislative Reductions (MT CO_2e)

Legislative Reduction Program	2017	2025	2030	2035	2045
County					
Title 24 & SB 100	0	1,066,906	1,549,688	2,033,184	3,071,282
Transportation Legislation	0	1,076,758	1,656,690	2,090,548	2,580,911
Total	**0**	**2,143,665**	**3,206,378**	**4,123,732**	**5,652,193**
Unincorporated County					
Title 24 & SB 100	0	93,692	104,660	115,207	140,254
Transportation Legislation	0	8,685	13,220	16,000	19,301
Total	**0**	**102,377**	**117,880**	**131,207**	**159,555**

These reductions are visually represented in Figure 13 and Figure 14 below.

Figure 13 BAU versus Adjusted Forecast – County

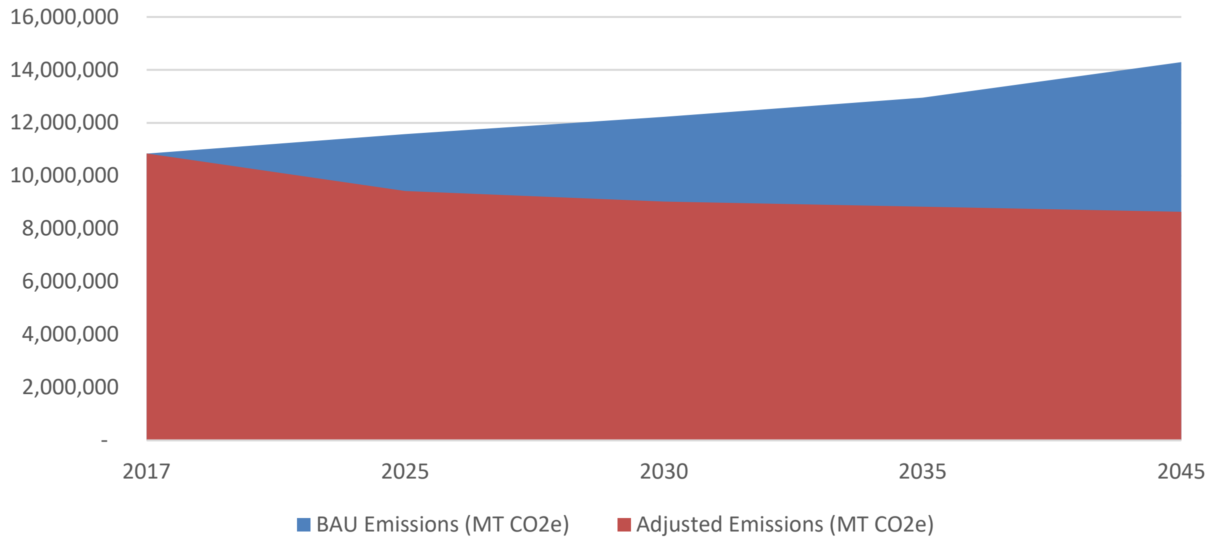
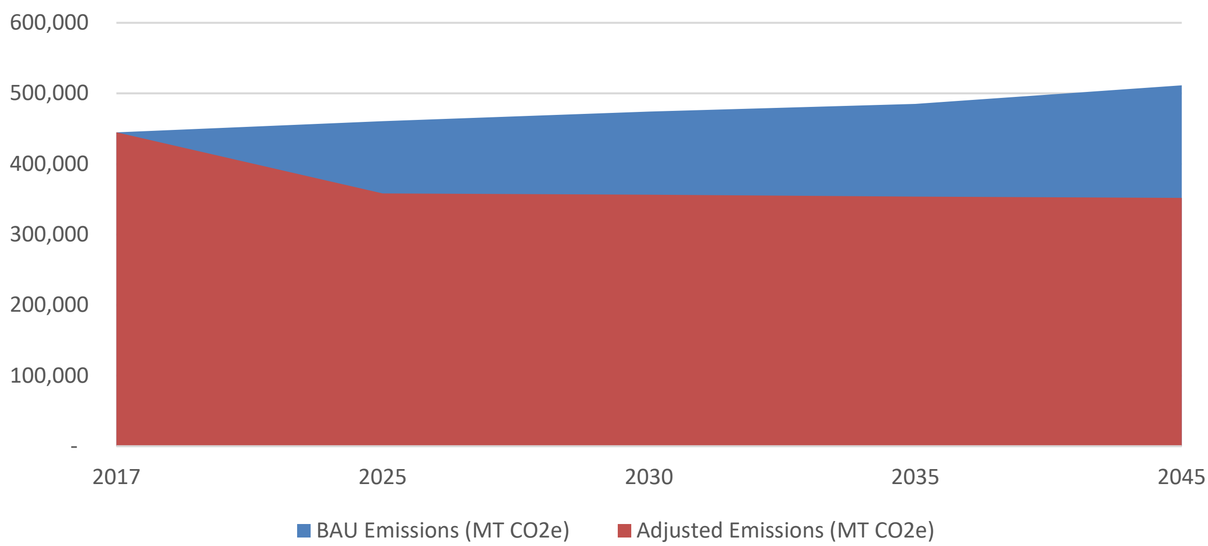


Figure 14 BAU versus Adjusted Forecast – Unincorporated County



7 Provisional Target Setting

Once a GHG inventory and forecast are complete, GHG emissions reduction targets can be set that are consistent with the State goals in SB 32 and EO B-55-18. While the County will not be able to unilaterally adopt countywide targets without collaboration with the 15 cities within the County, countywide targets are nevertheless provided in this section for informational purposes, in the event the County chooses to pursue countywide target setting in the future. Potential target pathways are also provided for the unincorporated area of the County, along with Rincon's recommendation for which target to adopt.

The inventory is used to develop the GHG emission targets for each target year, which can then be compared to the forecast results to determine how much reduction beyond those achieved by the State falls to the responsibility of the local jurisdiction. This "gap" between the forecast and the targets determines the magnitude of action the County and its stakeholders will need to take while developing the Climate Roadmap.

Setting GHG reduction targets for climate action planning that align with the State's goals will allow the County to develop its own emissions reduction trajectory. Target setting is an iterative process that must be informed by the reductions that can realistically be achieved through the development of feasible GHG emissions reduction measures. As such, the targets identified herein should be re-evaluated on a periodic basis and adjusted as more data and information become available to the County.

In accordance with the 2017 Scoping Plan Update, target pathways can be set using either efficiency (MT CO_2e per capita or per service population per year) or absolute (total community-wide MT CO_2e per year) metrics. With CARB's publication of the 2017 Scoping Plan Update, the State recognized the inherent issues with setting an emission reduction target pathway using absolute metrics for jurisdictions with high expected growth patterns and adopted the efficiency metric as an acceptable form of target setting. This allows jurisdictions to meet a per capita target rather than an absolute emissions target, and maintain consistency with SB 32.

The County, therefore, has several potential target pathways to show consistency with State targets. The following pathways are described as a starting place for adopting both 2030 and 2045 targets. Emissions targets that reach a 40% reduction from 1990 levels (on a per capita or mass emissions reduction basis) and then moves to carbon neutrality by 2045 would be consistent with state goals. Four potential target pathways are discussed below:

- **SB 32 Target:** achieve the minimum reductions required by SB 32 by 2030 (40 percent below 1990 levels) and then carbon neutrality in 2045.
- **Absolute Pathway:** reduce absolute emissions to 40 percent below absolute emissions levels and to zero in 2045. This would require steep reductions through 2030 with steeper reductions through 2045, regardless of population levels.
- **Efficiency Pathway:** reduce per capita emissions to 40 percent below per capita emission levels in 1990 and to zero in 2045. This would require similarly steep reductions through 2030 and 2045, but targets would account for unexpected population changes.
- **EO B-55-18 Target:** move linearly from current emissions levels to carbon neutrality in 2045.
- **Absolute Pathway:** linearly reduce absolute emissions to zero in 2045. This would require consistent community-wide reductions from 2017 through 2045, regardless of population changes.
- **Efficiency Pathway:** linearly reduce per capita emissions to zero in 2045. This would require consistent community-wide reductions from 2017 through 2045, but targets would account for unexpected population changes.

The sections below provide a complete numerical comparison of each target pathway available for both the County and unincorporated area of the County.

County Gap Analysis

The table and figure below provide a comparison of the adjusted forecast for the County to each of the target pathways that would align with State goals. The gap between the adjusted forecast and each pathway is the magnitude of GHG emissions that will need to be reduced by local jurisdictional programs. As mentioned above, the countywide target pathways presented in this section are provided for informational purposes only; Rincon cannot make a recommendation for adopting a county-wide target pathway at this time.

Table 53 Target Pathways – County

Target Pathway	2025	2030	2035	2045
Mass GHG Emissions (MT CO_2e)				
Adjusted Forecast	9,426,346	9,019,763	8,827,130	8,641,876
SB 32 Absolute Pathway	8,451,674.12	6,964,509.52	4,643,006.35	0
SB 32 Efficiency Pathway[1]	8,729,235.29	7,349,121.49	5,281,764.38	0
EO-B-55-18 Absolute Pathway	7,736,526.77	5,802,395.08	3,868,263.39	0
EO-B-55-18 Efficiency Pathway[2]	8,271,141.31	6,561,715.62	4,715,861.05	0
Per Capita GHG Emissions (MT CO_2e/person)				
Adjusted Forecast	4.54	4.11	3.73	3.25
SB 32 Absolute Pathway[3]	4.07	3.17	1.96	0.00
SB 32 Efficiency Pathway	4.20	3.35	2.23	0.00
EO-B-55-18 Absolute Pathway[4]	3.73	2.64	1.63	0.00
EO-B-55-18 Efficiency Pathway	3.98	2.99	1.99	0.00

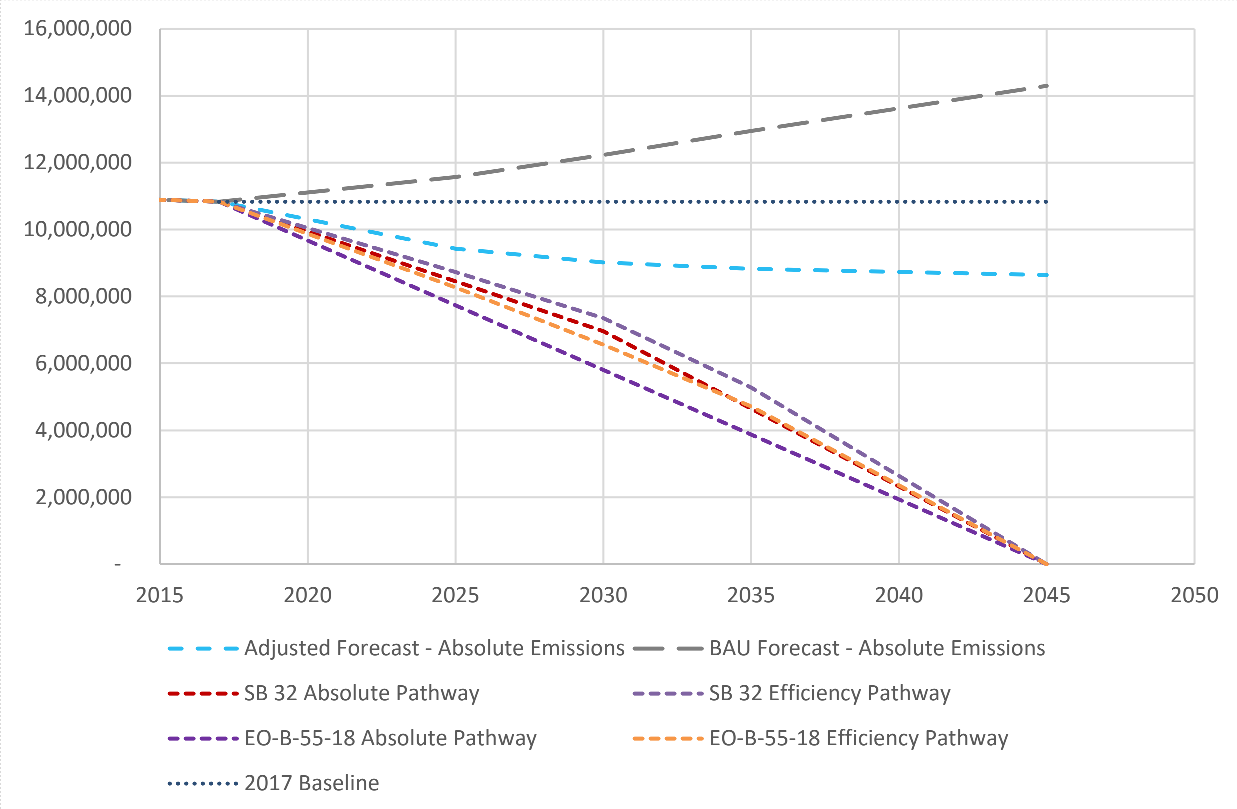
[1] The SB 32 efficiency pathway is calculated by reducing the 1990 per capita emissions by 40% through 2030, then to zero through 2045. These are translated to absolute emissions by multiplying the per capita emissions by total population projected for each year. This produces different results from the SB 32 absolute pathway.

[2] The EO B-55-18 efficiency pathway is calculated by reducing the per capita emissions linearly to zero through 2045. These are translated to absolute emissions by multiplying the per capita emissions by total population projected for each year. This produces different results from the EO B-55-18 absolute pathway.

[3] The SB 32 absolute pathway is calculated by reducing 1990 absolute emissions by 40% through 2030, then to zero through 2045. These are translated into per capita emissions by dividing the absolute emissions by total population projected for each year. This produces different results from the SB 32 efficiency pathway.

[4] The EO B-55-18 absolute pathway is calculated by reducing the absolute emissions linearly to zero through 2045. These are translated to per capita emissions by dividing the absolute emissions by total population projected for each year. This produces different results from the EO B-55-18 efficiency pathway.

Figure 15 Target Pathways – County



Unincorporated County Gap Analysis

The table and figure below provide a comparison of the adjusted forecast for the unincorporated County to each of the target pathways available to align with State goals. The gap between the adjusted forecast and each pathway is the magnitude of GHG emissions that will need to be reduced by local jurisdictional programs.

Table 54 Target Pathways – Unincorporated County

Target Pathway	2025	2030	2035	2045
Mass GHG Emissions (MT CO_2e)				
Adjusted Forecast	358,140	356,513	353,742	351,868
SB 32 Absolute Pathway	345,767	283,831	189,220	0
SB 32 Efficiency Pathway[1]	338,565	282,200	194,062	0
EO-B-55-18 Absolute Pathway	317,761	238,321	158,880	0
EO-B-55-18 Efficiency Pathway[2]	320,798	251,964	173,269	0
Per Capita GHG Emissions (MT CO_2e/person)				
Adjusted Forecast	4.01	3.81	3.66	3.31
SB 32 Absolute Pathway[3]	3.87	3.03	1.96	0.00
SB 32 Efficiency Pathway	3.79	3.01	2.01	0.00
EO-B-55-18 Absolute Pathway[4]	3.55	2.55	1.65	0.00
EO-B-55-18 Efficiency Pathway	3.59	2.69	1.79	0.00

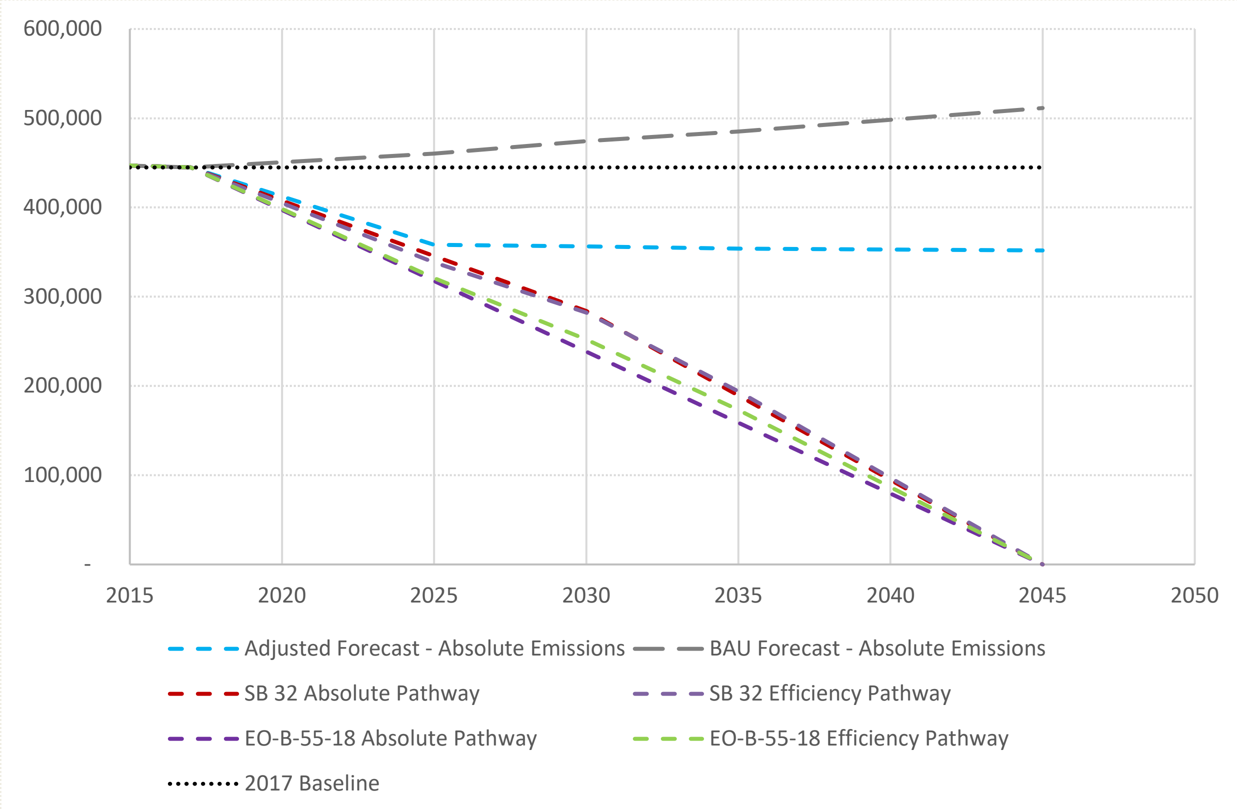
[1] The SB 32 efficiency pathway is calculated by reducing the 1990 per capita emissions by 40% through 2030, then to zero through 2045. These are translated to absolute emissions by multiplying the per capita emissions by total population projected for each year. This produces different results from the SB 32 absolute pathway.

[2] The EO B-55-18 efficiency pathway is calculated by reducing the per capita emissions linearly to zero through 2045. These are translated to absolute emissions by multiplying the per capita emissions by total population projected for each year. This produces different results from the EO B-55-18 absolute pathway.

[3] The SB 32 absolute pathway is calculated by reducing 1990 absolute emissions by 40% through 2030, then to zero through 2045. These are translated into per capita emissions by dividing the absolute emissions by total population projected for each year. This produces different results from the SB 32 efficiency pathway.

[4] The EO B-55-18 absolute pathway is calculated by reducing the absolute emissions linearly to zero through 2045. These are translated to per capita emissions by dividing the absolute emissions by total population projected for each year. This produces different results from the EO B-55-18 efficiency pathway.

Figure 16 Target Pathways – Unincorporated County



The County notes that the forecast and gap analysis provided in this report, for both the County and unincorporated County, do not include the work already underway by the County to reduce GHG emissions, as these efforts will be quantified and accounted for as part of the measure development effort of the Climate Roadmap. While all pathway options require GHG emissions reductions relative to the adjusted forecast (blue solid line) the least stringent target pathway the County could adopt would be the SB 32 Absolute Pathway (red dashed line), which requires the unincorporated County to reduce GHG emissions minimally through 2030, but requires more aggressive action later to meet the 2045 carbon neutrality goal. The most stringent target pathway the County could adopt would be the EO B-55-18 absolute pathway (purple dashed line), which requires higher reductions through 2030, but steady action through 2045. To balance the tradeoffs of these two approaches and best position the unincorporated County for carbon neutrality by 2045, while maintaining flexibility for unanticipated population growth, Rincon recommends that the County adopt the EO B-55-18 efficiency pathway, which will require steady per capita emissions reductions through 2045.

8 Conclusion

The agricultural inventory provided in this document will assist decision makers and stakeholders in identifying opportunities to reduce agriculture GHG emissions throughout the unincorporated County. As previously detailed, the unincorporated County emitted approximately 53,594 MT of CO_2e from agriculture activities in 2017. The Inventory provides an emissions baseline that the County can use to set future emissions reduction targets for commercial agriculture emissions. Additionally, the agriculture inventory will be included in the County's future Climate Roadmap 2030 and serve to help the County determine appropriate measures which will be effective in reducing emissions from agricultural practice and encourage management practices that pull carbon dioxide from the atmosphere.

This document has provided a comprehensive community emissions inventory, BAU forecast, adjusted forecast, and target pathways consistent with State goals for both the County as a whole and the unincorporated area of the County separately. While the County will not be able to adopt a countywide target without collaboration with the 15 cities in its jurisdiction, Rincon recommends that the County adopt the EO B-55-18 efficiency pathway for the unincorporated area of the County going forward.

9 References

Bay Area Air Quality Management District. California Environmental Quality Act Air Quality Guidelines. May 2017.

Cai et al. GREET Model Update of the CO2 Emission Factor from Agricultural Liming. October 2014. https://greet.es.anl.gov/files/co2-lming

California Air Resources Board. California 1990 Greenhouse Gas Emissions Level and 2020 Emissions Limit. 16 Nov. 2007, ww3.arb.ca.gov/cc/inventory/pubs/reports/staff_report_1990_level.pdf.

California Air Resources Board. Climate Change Scoping Plan: A Framework for Change. Dec. 2008, ww2.arb.ca.gov/sites/default/files/classic//cc/scopingplan/document/adopted_scoping_plan.pdf.

California Air Resources Board. Air Resources Board Approves First of New Generation of Clean Cars. 26 Dec. 2012, ww2.arb.ca.gov/news/air-resources-board-approves-first-new-generation-clean-cars.

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

California Air Resources Board. Climate Pollutants Fall below 1990 Levels for First Time. 11 July 2017, ww2.arb.ca.gov/news/climate-pollutants-fall-below-1990-levels-first-time.

California Air Resources Board. Documentation of California's 2000-2020 GHG Inventory. October 2022. https://ww2.arb.ca.gov/applications/california-ghg-inventory-documentation

California Air and Resources Board. California's 2000-2014 Greenhouse Gas Emission Inventory Technical Support Document. 2016. https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/ghg_inventory_tsd_00-14.pdf

California Air Resources Board. Documentation of California's 2000-2020 GHG Inventory Fire and other disturbances - Rangeland. October 2022. https://ww2.arb.ca.gov/sites/default/files/ghg-inventory-doc/newdoc/docs3/3b1_forestandrangemngt_fireanddisturbances_rangeland_ch4_2020.htm

California Air and Resources Board. Appendix D Emissions Inventory Methodology Agricultural Irrigation Pumps - Diesel. 2006. https://ww2.arb.ca.gov/sites/default/files/barcu/regact/agen06/append.pdf.

California Energy Commission. 2019 Building Energy Efficiency Standards: Frequently Asked Questions. Mar. 2018, www.energy.ca.gov/sites/default/files/2020-03/Title_24_2019_Building_Standards_FAQ_ada.pdf.

California Department of Food and Agriculture. California Agricultural Statistics Review 2017-2018. https://www.cdfa.ca.gov/Statistics/PDFs/2017-18AgReport.pdf

City of Palo Alto. City of Palo Alto Earth Day 2017 Report: On-Road Transportation Greenhouse Gas Emissions Inventory. 28 Feb. 2017.

City of Palo Alto. Earth Day Report 2018. Apr. 2018.

City of San Jose. 2017 Inventory of Community Greenhouse Gas Emissions. Apr. 2019.

City of Santa Clara. Climate Action Plan 2018 Annual Report. July 2018.

County of Santa Clara. Division of Agriculture Crop Reports, Newsletters & Monthly Agricultural Updates. 2023. https://ag.sccgov.org/crop-reports-newsletters-monthly-agricultural-updates

ICLEI – Local Governments for Sustainability USA. U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions Version 1.2. July 2019.

International Panel on Climate Change. Fifth Assessment Report. 2014.

Intergovernmental Panel on Climate Change. 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Chapter 10 Emissions From Livestock and Manure Management. 2019. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_10_Ch10_Livestock.pdf

Intergovernmental Panel on Climate Change. 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4. 2023. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

Intergovernmental Panel on Climate Change (IPCC). 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Chapter 11 N2O Emissions From Managed Soils, and CO2 Emissions From Lime and Urea Application. 2019. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_11_Ch11_N2O&CO2.pdf

Santa Clara Valley Water District. From Watts to Water: Climate Change Response through Saving Water, Saving Energy, and Reducing Air Pollution. May 2011.

Silicon Valley Clean Energy. Buildings Baseline Study SVCE Service Territory. September 2020.

United States Environmental Protection Agency. Understanding Global Warming Potentials. 9 Sept. 2020, www.epa.gov/ghgemissions/understanding-global-warming-potentials.

U.S. Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011 Annex 3.11: Methodology for Estimating CH4 and N2O Emissions from Manure Management. 2013. https://www.epa.gov/sites/production/files/2015-12/documents/us-ghg-inventory-2013-annexes.pdf

World Resources Institute. Global Protocol for Community-Scale Greenhouse Gas Emission Inventories. 2014.

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