Cupertino 2021 GHG Inventories

Final Community and Municipal Greenhouse Gas Emissions Inventories Report

prepared by

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Table of Contents

Tables

Figures

Appendices

1 Introduction

1.1 Report Overview and GHG Inventories Purpose

This Cupertino 2021 greenhouse gas (GHG) inventories report includes the following information by section:

- Section 1: Report sections overview and GHG inventory approach;
- Section 2: Cupertino's 2021 community GHG emissions inventory methodology, activity data, emissions factors, and results by sector;
- Section 3: Comparison of 2010, 2018, and 2021 community inventories;
- Section 4: Cupertino's 2021 municipal GHG emission inventory methodology, activity data, emissions factors, and results by sector; and
- Section 5: Comparison of 2010, 2015, and 2021 municipal inventories.

This report focuses on Cupertino's 2021 community and municipal GHG inventories.

The 2021 community GHG inventory was completed to track Cupertino CAP 2.0 GHG emissions reduction progress against the 2018 baseline community GHG inventory. Cupertino completed the original 2018 community GHG inventory in 2019. This 2018 inventory was then updated in 2022 by Rincon Consultants, Inc. (Rincon) to incorporate more recent transportation models and energy datasets. Updates were made specifically to on-road transportation, off-road vehicles, and nonresidential natural gas emissions.[1] During this update, the 2010 community GHG inventory's on-road transportation sector was also updated by Rincon.[2] The 2021 community GHG inventory uses the same models and methodologies, so it can be compared to the updated 2010 and 2018 GHG community inventories.

The 2021 municipal GHG inventory was completed to track changes in GHG emissions from Cupertino previous municipal GHG inventories (i.e., 2010 and 2015 municipal GHG inventories).

The report also includes an appendix titled *Future GHG Inventory Guidance*. This appendix provides guidance for how Cupertino can conduct future community GHG inventory updates.

[1] On-road transportation was updated to make use of the California Air Resources Board (CARB) Emission FACtor (EMFAC2021 v1.0.1) model. Off-road transportation was updated to leverage CARB's Off-Road (OFFROAD2021 v1.0.1) model. Nonresidential natural gas was updated to account for Apple's biofuel usage. See the *Future GHG Emissions Forecasts Memorandum* (dated 1/26/22) prepared by Rincon for additional details on the 2018 GHG inventory update.

[2] On-road transportation was updated to leverage the California Air Resources Boards' (CARB) Emission FACtor (EMFAC2021 v1.0.1) model.

2 2021 Community GHG Inventory

This 2021 community GHG emissions inventory includes GHG emissions from activities within Cupertino's jurisdictional boundaries during 2021.

A GHG emissions inventory provides a comprehensive understanding of a community's GHG emissions and is developed to serve the following purposes:

- Establish perspective of GHG emissions conditions in an applicable inventory year.
- Provide an understanding of where the highest sources of GHG emissions in the community originate and where the greatest opportunities for emissions reduction exist.
- Create a GHG emissions update from which the jurisdiction can track community emissions progress over time compared to past GHG emission inventories (i.e., 2010 and 2018 community GHG emissions inventories).

2.1 Community GHG Inventories Approach

GHG Emissions Accounting Protocol

Cupertino's 2010, updated 2018, and 2021 community GHG inventories were developed in alignment with accounting protocols provided by the Local Governments for Sustainability International Council for Local Environmental Initiatives (ICLEI)—as recommended by the Association of Environmental Professionals (AEP) and the California Office of Planning and Research (OPR)— [3] and the Greenhouse Gas Protocol (GHG Protocol). ICLEI protocols are designed for local-scale accounting of GHG emissions that contribute to climate change and provide authoritative guidance to account for GHG emissions accurately and consistently. The ICLEI U.S. Community Protocol for Accounting and Reporting Greenhouse Gas Emissions Version 1.2 (Community Protocol) serves to guide the measurement and reporting of GHG emissions in a standardized way and is used by other jurisdictions to support their own inventory, forecast, and climate action planning efforts. Use of Community Protocol methodology for GHG accounting aligns with statewide GHG inventory methods and focuses on analyzing sectors within jurisdictional control of cities or counties. The Community Protocol also includes steps to evaluate the relevance, completeness, consistency, transparency, and accuracy of data used in the GHG inventory. Cupertino's GHG inventories are also aligned with the GHG Protocol's Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC).

GHG emissions were calculated by multiplying the activity data in each included GHG emissions sector by an associated emission factor. Activity data refer to the relevant measured or estimated level of GHG-generating activity (e.g., energy consumed, vehicle miles traveled). Emission factors are conversion factors used to equate activity data to generated GHG emissions. The 2021 community GHG inventory provides a comprehensive understanding of the community's GHG emissions. The following sections contain further information on the scope of the inventory, calculation methodologies, data used, and results.

[3] Association of Environmental Professionals (AEP). 2013. AEP Climate Change Committee's "The California Supplement to the United States Community-Wide Greenhouse Gas (GHG) Emissions Protocol". Available at: https://califaep.org/docs/California_Supplement_to_the_National_Protocol.pdf

Emissions Geographic Boundary

Cupertino's community inventories cover the relevant emissions sources within the boundary of the City (i.e., City limits). The inventory, thereby, reflects emissions sectors over which the City of Cupertino has jurisdictional control and influence. Sectors where the jurisdiction has limited influence (e.g., industrial) are excluded from the 2010, 2018, and 2021 community GHG inventories, as the City of Cupertino does not have the power to develop measures to affect associated emissions.[4] This emissions boundary and select sectors align with Community Protocol standards and is recommended by State guidance for inventory, forecast, and targets accounting.[5]

Emissions Inventory Scope

The Community Protocol recommends reporting GHG emissions from five basic reporting activities in a community inventory that include:

- Use of electricity by the community
- Use of fuel in residential and commercial stationary combustion equipment (i.e., buildings)
- On-road passenger and freight motor vehicle travel
- Indirect electricity associated with water and wastewater treatment and distribution[6]
- Generation of solid waste by the community

The Community Protocol also provides recommendations for additional GHG emissions source reporting for activities that can be influenced by the City. Based on reporting practices in California, it is recommended that GHG emissions from off-road equipment fuel combustion and wastewater treatment processes are also included in community GHG emissions inventories. Cupertino also elected to include GHG emissions from carbon sequestration in the 2021 community GHG inventory to begin tracking progress from Cupertino's Climate Action Plan 2.0 zero waste and carbon sequestration measures (i.e., Measure W-3 and Measure CS-1). GHG emissions sources can be categorized more generally into the following five activity sectors:

- Building Energy (i.e., electricity and natural gas)
- Transportation (i.e., on-road vehicles and off-road equipment and vehicles)
- Solid Waste
- Wastewater
- Carbon Sequestration

All Cupertino community GHG inventories discussed in this report include an assessment of communitywide GHG emissions associated with the building energy, transportation, solid waste, and wastewater, while the 2021 community GHG inventory adds an assessment of the carbon sequestration as a new sector.

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[4] While industrial process GHG emissions are excluded from Cupertino's GHG inventories, industrial electricity and industrial natural gas emissions may be included due to data limitations. See Section 2.2.1 Building Energy for additional information.

[5] Governor's Office of Planning and Research (OPR). 2023. Chapter 8, Climate Change. Available at: https://www.opr.ca.gov/docs/OPR_C8_final.pdf

[6] The Community Protocol also recommends including the use of energy for potable water. However, in Cupertino's 2021 community inventory and previous inventories, it is assumed that electricity GHG emissions associated with water distribution are included in the use of electricity by the community. Likewise, the GPC does not direct cities to include emissions associated with water conveyance outside the jurisdictional boundary.

Global Warming Potential Emissions Multipliers

The Community Protocol assesses GHG emissions associated with the six internationally recognized GHGs, as outlined in Table 1. The 2021 inventory focuses on the three GHGs most relevant to the community's operations: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The other gases (i.e., hydrofluorocarbons, perfluorocarbons, and sulfur hexafluorides) are emitted primarily in private sector manufacturing and electricity transmission and are therefore omitted from the inventory. This approach is consistent with typical community inventory approaches, as such industrial emissions are typically outside of the City's jurisdictional control. Table 1 also includes the global warming potentials (GWP) for each gas. The 2021 inventory used 100-year global warming potentials (GWP) for each gas that are consistent with the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5),[7] which are the latest GWPs. The GWP refers to the ability of each gas to trap heat in the atmosphere. 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).

Table 1 2021 Inventory GHGs and GWPs

Greenhouse Gas	Primary Source	100-year GWP
Carbon dioxide (CO_2)	Combustion	1
Methane (CH_4)	Combustion, anaerobic decomposition of organic waste (e.g., in landfills, wastewater treatment plants)	28
Nitrous Oxide (N_2O)	Leaking refrigerants and fire suppressants	265
Hydrofluorocarbons	Leaking refrigerants and fire suppressants	4 - 12,400
Perfluorocarbons	Aluminum production, semiconductor manufacturing, HVAC equipment manufacturing	6,630 - 11,100
Sulfur Hexafluoride (SH6)	Transmission and distribution of power	23,500

Source: Intergovernmental Panel on Climate Change (IPCC). 2014. AR5 Synthesis Report: Climate Change 2014. Available at: https://www.ipcc.ch/report/ar5/syr/

2.2 2021 Community GHG Emissions Inventory Activity Data and Emissions Factors

2.2.1 Building Energy

Building Energy: Residential and Nonresidential Electricity

The community of Cupertino relies on electricity from Pacific Gas and Electric (PG&E) and Silicon Valley Clean Energy (SVCE). Cupertino also has direct access electricity, where customers elect to purchase electricity from wholesale providers. Apple is one such customer that purchases direct access electricity for their Cupertino campus. GHG emissions associated with electricity are intricately tied to the energy generation sources from which it is procured such as coal, natural gas, hydroelectric, wind, solar, biomass, and geothermal. Wind and solar are considered carbon-free

[7] Intergovernmental Panel on Climate Change (IPCC). 2014. AR5 Synthesis Report: Climate Change 2014. Accessed January 5, 2023 at: https://www.ipcc.ch/report/ar5/syr/

renewable sources, while biomass and geothermal emit GHGs but are deemed eligible renewables by the State as they produce noticeably fewer emissions compared to fossil-based sources. These eligible renewables can supply steady generation and thus typically provide additional benefit by increasing grid resilience, whereas carbon-free sources such as wind and solar are subject to variable conditions for energy generation.

Activity data for community electricity consumption was provided by SVCE for the residential sector. SVCE and Apple provided electricity consumption for the nonresidential sector (including commercial, industrial, and institutional subsectors).[8] While total electricity consumption and SVCE electricity consumption were available for both the residential and nonresidential sectors, due to the "15/15 Rule", PG&E and direct access electricity usage were not provided and had to be estimated for both sectors.[9] To estimate direct access usage, 2018 electricity data (i.e., the last year of available direct access usage data) was used as a proxy for 2021. The 2021 inventory thus assumes nonresidential direct access usage remained constant since 2018. PG&E usage was then estimated by subtracting known SVCE, estimated direct access, and (for the nonresidential sector) known Apple usage from the total known residential and nonresidential electricity usage. Because industrial electricity use was included as aggregated nonresidential activity data in the Cupertino 2010 and 2018 GHG inventories, inclusion of the GHG emissions associated with industrial land use in the 2021 Community GHG Inventory aligns with the previous inventories.

GHG emissions from residential and nonresidential electricity were calculated using Community Protocol Equation BE.2.1, noted below. To account for electricity only consumed by buildings, equation 2.1 subtracts electricity consumed by electric vehicles (EVs) from total purchased electricity by removing passenger car EV electricity use from residential electricity consumption and commercial EV electricity consumption from nonresidential consumption. Electricity use from passenger and commercial EVs are instead accounted for under the transportation sector of the inventory to provide a more accurate differentiation between building and transportation sector emissions. More information regarding EV energy use can be found in Section 2.2.2. Equation 2.1 and Table 2 provide the equation and data sources used to quantify GHG emissions associated with community electricity consumption.

EQUATION 2.1

BE.2.1 RESIDENTIAL/NONRESIDENTIAL ELECTRICITY SECTOR EMISSIONS

$$CO_2e_{electricity,j} = \sum_i \left(Elec_{i,j} - EV_{i,j}\right) \times \left[\left(EF_{elec,i,j,CO_2} \times GWP_{CO_2}\right) + \left(EF_{elec,i,j,CH_4} \times GWP_{CH_4}\right) + \left(EF_{elec,i,j,N_2O} \times GWP_{N_2O}\right)\right] \quad 2.1$$

[8] Due to the "15/15 Rule," nonresidential data could not be disaggregated to exclude industrial electricity. Industrial electricity consumption may therefore be included in the 2021 community inventory.

[9] The 15/15 Rule generally provides that aggregated or anonymized customers specific information must be made up of at least 15 customers and a single customer's load must be less than 15% of an assigned category.

Table 2 Emissions Parameters and Data Sources – Community Electricity Use BE.2.1

Definition	Parameter	Value	Unit	Data Source
Annual GHG emissions from electricity consumption per building type	$CO_2e_{electricity,j}$	See Table 16	MT CO_2e/year	Calculated
Electricity consumption per building type per energy provider	$Elec_{i,j}$	See Table 16	kWh/year	▪ SVCE Electricity Report[1] ▪ Apple[2]
Attributed electric vehicle electricity consumption (i.e., EV adjustment)	$EV_{i,j}$	See Table 16	kWh/year	EMFAC2021[3]
Electricity carbon dioxide emission factor based on energy provider	EF_{elec,i,j,CO_2}	See Table 16	MT CO_2/kWh	▪ PG&E emission factor sourced from The Climate Registry[4] ▪ SVCE emission factors calculated from California Energy Commission Power Content Label[5] ▪ Direct access emission factor calculated using state level data from CARB[6] ▪ Apple direct access emission factor sourced from Apple[7]
Electricity methane emission factor based on energy provider	EF_{elec,i,j,CH_4}	See Table 16	MT CH_4/kWh	▪ PG&E emission factor sourced from EPA's Emissions & Generation Resource Integrated Database (eGRID)[8] ▪ SVCE emission factors included in carbon dioxide emission factor[5] ▪ Direct access emission factor calculated using state level data from CARB[6] ▪ Apple direct access emission factor sourced from Apple[7]
Electricity nitrous oxide emission factor based on energy provider	EF_{elec,i,j,N_2O}	See Table 16	MT CH_4/kWh	▪ PG&E emission factor sourced from EPA's eGRID[8] ▪ SVCE emission factors included in carbon dioxide emission factor[5] ▪ Direct access emission factor calculated using state level data from CARB[6] ▪ Apple direct access emission factor sourced from Apple[7]
Global warming potential of carbon dioxide	GWP_{CO_2}	1	N/A	IPCC AR5
Global warming potential of methane	GWP_{CH_4}	28	N/A	IPCC AR5
Global warming potential of nitrous oxide	GWP_{N_2O}	265	N/A	IPCC AR5
Energy Providers	i	PG&E, SVCE, and	Categoric al	N/A

Definition	Parameter	Value	Unit	Data Source
		Direct Access		
Building type	*j*	Residential Nonresidential[8]	Categorical	N/A

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent; kWh = kilowatt hour

1. SVCE Electricity Report provided by the City in workbook named "Cupertino GHG Inventory_2021_energy_20240205.xlsx."

2. 2021 Annual Renewable Electricity Use Report provided by Apple.

3. California Air and Resources Board (CARB). 2023. Emission FACtor (EMFAC2021 v1.0.2) Model. Available at: https://arb.ca.gov/emfac/emissions-inventory/.

4. The Climate Registry. TCR Utility-Specific Emission Factors. Available at: https://docs.google.com/spreadsheets/d/1MY2dNo_5VXCvppDA3nIpnMDhH3FG2MlxBcLiOggj-xQ/edit#gid=283732541.

5. SVCE provides electricity through their Green Start and Green Prime options—each with a different emission factor. A weighted SVCE emission factor was calculated for the residential and nonresidential sector for the 2021 GHG inventory. The Green Start and Green Prime emission factors were sourced from the CEC's Power Content Label. These emission factors were weighted for each sector based on the percent of total SVCE load in Cupertino that is Green Prime (provided by SVCE in workbook named "Cupertino GHG Inventory_2021_energy_20240205.xlsx.

California Energy Commission (CEC). 2021 Power Content Label: Silicon Valley Clean Energy. Available at: https://www.energy.ca.gov/filebrowser/download/4672.

6. The direct access emission factors were calculated by dividing total statewide electricity GHG emissions by the total state electricity consumption for 2021. Statewide electricity GHG emissions were sourced from CARB. Statewide electricity consumption was sourced from the CEC. The carbon dioxide emission factor accounts for methane and nitrous oxide emissions because the CEC provides emission factors in carbon dioxide equivalents.

CARB. California Greenhouse Gas Inventory for 2000-2021—by Category as Defined in the 2008 Scoping Plan (2023). Available at: https://ww2.arb.ca.gov/sites/default/files/2023-12/ghg_inventory_scopingplan_sum_2000-21.pdf.

CEC. 2021 Total System Electric Generation. Available at: https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2021-total-system-electric-generation.

7. Apple. 2021 Annual Renewable Electricity Use Report. Provided by the City of Cupertino.

8. Nonresidential includes electricity consumption from commercial, industrial, and institutional sources.

Building Energy: Residential and Nonresidential Natural Gas

GHG emissions from natural gas result from the stationary combustion of natural gas in both the residential and nonresidential building sectors (including commercial, industrial, and institutional subsectors).[10] Cupertino's residential and nonresidential natural gas is supplied by PG&E. Apple also purchases biofuel through a book and claim agreement to power their fuel cell at the Cupertino campus.[11] While the gas which arrives at Apple is delivered via PG&E infrastructure and included in Cupertino's total nonresidential natural gas usage, Apple owns the biofuel fuel attribute (which can be bought and sold separately from the fuel itself) which has an emission factor of zero. Thus, total nonresidential natural gas usage from PG&E is adjusted to exclude the natural gas usage attributed to Apple's biofuel. Because industrial natural gas use was included as aggregated nonresidential activity data in the Cupertino 2010 and 2018 GHG inventories, inclusion of the GHG emissions associated with industrial land use in the 2021 Community GHG Inventory aligns with the previous inventories.

Emissions from residential and nonresidential natural gas use were calculated using Community Protocol Equation BE.1.1, noted below. Methane and nitrous oxide emissions are considered de

[10] Due to the "15/15 Rule," nonresidential data could not be disaggregated to exclude industrial natural gas.

[11] Book and claim is a chain-of-custody model where a sustainability claim made by a producer is separated from the physical flow of these goods. This model allows producers to record emissions savings from their products, and customers to claim those benefits for climate disclosures elsewhere.

minimis as is consistent with Cupertino's 2010 and 2018 GHG inventories and The Climate Registry. Equation 2.2 and Table 3 provide the equation used, associated parameters, and data sources used to quantify GHG emissions associated with community natural gas consumption in residential and nonresidential buildings.

EQUATION 2.2

BE.1.1 RESIDENTIAL/NONRESIDENTIAL NATURAL GAS SECTOR EMISSIONS

$$CO_2e_{NatGas,i} = \left(Fuel_{NG,i}\right) \times \left(EF_{NG,CO_2} \times GWP_{CO_2}\right) \times 10^{-1} \times 10^{-3} \quad 2.2$$

Table 3 Emissions Parameters and Data Sources – Community Natural Gas Use BE.1.1

Definition	Parameter	Value	Unit	Data Source
Annual GHG emissions from stationary combustion of natural gas per building type	$CO_2e_{NatGas,i}$	See Table 16	MT CO_2e/year	Calculated
Natural gas consumed per building type	$Fuel_{NG,i}$	See Table 16	therms/year	▪ SVCE Natural Gas Report[1] ▪ Apple[2]
Carbon dioxide emission factor for natural gas combustion	EF_{NG,CO_2}	See Table 16	kg CO_2/MMBtu natural gas	▪ EPA Emission Factors Hub[3] ▪ Apple[4]
Global warming potential of carbon dioxide	GWP_{CO_2}	1	N/A	IPCC AR5
Conversion factor	10^{-1}	0.1	MMBtu/therm	N/A
Conversion factor	10^{-3}	0.001	MT/kg	N/A
Building type	i	Residential Nonresidential[5]	Categorical	N/A

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent; therms = thermal unit; MMBtu = metric million British thermal unit; kg = kilograms

1. SVCE Electricity Report provided by the City in workbook named "Cupertino GHG Inventory_2021_energy_20240205.xlsx."

2. Apple. Environmental Progress Reports for fiscal years 2021 and 2022.

3. EPA. 2021 GHG Emission Factors Hub. Available at: https://www.epa.gov/climateleadership/ghg-emission-factors-hub.

4. The emission factor for Apple's biofuel is considered zero, as is consistent with the 2018 GHG inventory update and book and claim accounting methodology.

5. Nonresidential includes natural gas consumption from commercial, industrial, and industrial sources.

Building Energy: Fugitive Natural Gas

Fugitive emissions from natural gas include GHG emissions that are not physically controlled by the Cupertino community, but result from intentional or unintentional releases, commonly arising from the production, processing, transmission, storage, and use of natural gas. These natural gas releases, or leaks, occur upstream of the delivery endpoints located in Cupertino and are already not reflected in reported total natural gas consumed from SVCE. While natural gas leakage is technically outside of the Cupertino jurisdictional boundaries, the leakage is directly affected by the amount of natural gas consumption in the community and should be included as an emissions sector in community GHG inventories.

To account for fugitive natural gas emissions, the 2021 Cupertino GHG inventory utilizes the ICLEI ClearPath methodology which is consistent with the 2010 and 2018 GHG inventories. This methodology assumes a 0.3 percent natural gas leakage rate and provides default factors for the energy density and GHG content of natural gas.

The fugitive emissions from natural gas leaks were calculated using Equation 2.3 which aligns with energy calculation principles set forth by the Community Protocol and the guidance provided under Community Protocol Section BE.5 Upstream Emissions from Energy Use. Table 4 shows the parameters and data sources associated with Equation 2.3 which were used to quantify GHG emissions from fugitive natural gas emissions.

EQUATION 2.3

NATURAL GAS FUGITIVE SECTOR EMISSIONS

$$CO_2e_{NG\ fugitive,i} = Fuel_{NG,i} \times \left[\left(EF_{NG\ fugitive,i,CO_2} \times GWP_{CO_2}\right) + \left(EF_{NG\ futivie,i,CH_4} \times GWP_{CH_4}\right)\right] \quad 2.3$$

Table 4 Emissions Parameters and Data Sources – Community Fugitive Natural Gas Emissions

Definition	Parameter	Value	Unit	Data Source
Annual GHG emissions from fugitive natural gas leaks per building type	$CO_2e_{NG\ fugitive,i}$	See Table 16	MT CO_2e/year	Calculated
Natural gas consumed per building type	$Fuel_{NG,i}$	See Table 16	therms/year	▪ SVCE Natural Gas Report[1] ▪ Apple[2]
Carbon dioxide emission factor for fugitive natural gas leakage	$EF_{NG\ fugitive,CO2}$	See Table 16	MT CO_2/therm	Calculated[3]
Methane emission factor for fugitive natural gas leakage	$EF_{NG\ fugitive,CH4}$	See Table 16	MT CH_4/therm	Calculated[4]
Global warming potential of carbon dioxide	GWP_{CO_2}	1	N/A	IPCC AR5
Global warming potential of methane	GWP_{CH_4}	28	N/A	IPCC AR5
Building type	i	Residential Nonresidential[5]	Categorical	N/A

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent; therms = thermal unit

1. SVCE Electricity Report provided by the City in workbook named "Cupertino GHG Inventory_2021_energy_20240205.xlsx."

2. Apple. Environmental Progress Reports for fiscal years 2021 and 2022.

Definition	Parameter	Value	Unit	Data Source

3. The fugitive carbon dioxide emission factor is from ICLEI ClearPath. ClearPath assumes a natural gas leakage rate of 0.3 percent, natural gas energy density of 1028 British thermal units (btu)/standard cubic feet (scf), a natural gas density of 0.8 kilograms (kg)/cubic meter, and one percent carbon dioxide content in natural gas. Since Apple's biofuel has an emission factor of zero, it is also assumed to have a fugitive emission factor of zero.

4. The fugitive methane emission factor is from ICLEI ClearPath. ClearPath assumes a natural gas leakage rate of 0.3 percent, natural gas energy density of 1028 btu/scf, a natural gas density of 0.8 kg/cubic meter and 93.4 percent methane content in natural gas. Since Apple's biofuel has an emission factor of zero, it is also assumed to have a fugitive emission factor of zero.

5. Nonresidential includes natural gas consumption from commercial, industrial, and industrial sources.

2.2.2 Transportation

Transportation: On-road

On-road vehicles in the community produce GHG emissions from the mobile combustion of fossil fuels (i.e., internal combustion engines) and up-stream from the production of electricity (i.e., electric vehicles). GHG emissions from the on-road transportation sector were calculated in accordance with Community Protocol TR.1.A and TR.2.B. The methodology leverages on-road transportation emission factors and EV penetration data from California Air Resource Board's (CARB) 2021 EMission FACtor (EMFAC2021) model.[12] EMFAC2021 provides data on the county-wide data level and does not differentiate data by the individual city. This assessment assumes county-wide data reported by EMFAC2021 is representative of city-level on-road transportation emission factors and EV penetration rates.

The Community Protocol recommends using the regional travel demand models to differentiate passenger and commercial vehicle miles travelled activity data attributed to the community. This assessment utilizes vehicle miles travelled (VMT) data provided by the Metropolitan Transportation Commission's (MTC) travel demand model using Plan Bay Area 2050 data.[13] It is important to note that Cupertino's 2010 and 2018 community GHG inventories used the MTC travel demand model based on Plan Bay Area 2040 data. The updated model provides more accurate calculations but shows an artificial increase of VMT due to the methodology changes.

MTC generates attributable daily average passenger and commercial VMT for participating communities in the Bay Area. For passenger VMT, MTC provides VMT data based on the origin-destination methodology. MTC provides daily passenger VMT from trips occurring within Cupertino city limits (internal-internal), traversing city limits (internal-external), and trips which are entirely outside city limits (external-external).[14] Per Community Protocol equation TR.1.A, 100 percent of the internal-internal passenger trips and 50 percent of the internal-external trips are attributed to Cupertino's passenger daily VMT. For commercial VMT, MTC provides daily commercial VMT pursuant to the boundary method. MTC provides aggregated daily commercial VMT data representative of all travel on the roads, regardless of trip origin and inclusive of passthrough trips. Both daily passenger and commercial VMT data were annualized based on a factor (i.e., 342.41) provided by MTC to determine annual VMT activity data for Cupertino.

[12] California Air and Resources Board (CARB). Emission FACtor (EMFAC2021 v1.0.2) Model (2023). Available at: https://arb.ca.gov/emfac/emissions-inventory/5e0cb7d6006cc10661f4b3ffb9c120a486d46ea6.

[13] MTC. VMT Data Portal 2.0. Available at http://capvmt.mtcanalytics.org/.

[14] MTC provides daily VMT data for the year 2015 and forecasted daily VMT data 2025. The Cupertino community inventory interpolates the VMT data between the years to estimate daily VMT data for 2021.

Equation 2.4 and Table 5 define the equations, parameters, and data sources used to convert resulting VMT activity data to GHG emissions from on-road transportation fuel combustion.

EQUATION 2.4

TR.1.A & TR.2.B ON-ROAD TRANSPORTATION COMBUSTION EMISSIONS

$$CO_2e_{onroad,i} = VMT_i \times \left[\left(EF_{auto,i,CO_2} \times GWP_{CO_2}\right) + \left(EF_{auto,i,CH_4} \times GWP_{CH_4}\right) + \left(EF_{auto,i,N_2O} \times GWP_{N_2O}\right)\right] \quad 2.4$$

Table 5 Emissions Parameters and Data Sources – Community On-road Transportation TR.1.A and TR.2.B

Definition	Parameter	Value	Unit	Data Source
Total annual community on-road GHG emissions per vehicle class	$CO_2e_{Onroad,i}$	See Table 16	MT CO_2e/year	Calculated
Annual VMT	VMT_i	See Table 16	miles	MTC[1]
Carbon dioxide emission factor for on-road vehicles per vehicle class	EF_{auto,i,CO_2}	See Table 16	MT CO_2/mile	EMFAC2021 v1.0.2[2]
Methane emission factor for on-road vehicles per vehicle class	EF_{auto,i,CH_4}	See Table 16	MT CH_4/mile	EMFAC2021 v1.0.2[2]
Nitrous oxide emission factor for on-road vehicles per vehicle class	EF_{auto,i,N_2O}	See Table 16	MT N_2O/mile	EMFAC2021 v1.0.2[2]
Global warming potential of carbon dioxide	GWP_{CO_2}	1	N/A	IPCC AR5
Global warming potential of methane	GWP_{CH_4}	28	N/A	IPCC AR5
Global warming potential of nitrous oxide	GWP_{N_2O}	265	N/A	IPCC AR5
Vehicle class	i	Passenger Commercial	Categorical	

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent; VMT = vehicle miles travelled

1. Daily internal-internal and internal-external passenger VMT was sourced from MTC's VMT Data Portal 2.0 available at http://capvmt.mtcanalytics.org/. 100 percent of internal-internal trips and 50 percent of internal-external trips were attributed to Cupertino. An annualization factor of 342.41 was provided by Harold Brazil at MTC via email on 1/31/24 and applied to daily VMT to calculate annual passenger VMT.

Daily commercial VMT was provided by Harold Brazil at MTC via email on 1/31/24. The same annualization factor (i.e., 342.41) was applied to daily VMT to calculate annual commercial VMT.

2. CARB. Emission FACtor (EMFAC2021 v1.0.2) Model (2023). Available at: https://arb.ca.gov/emfac/emissions-inventory/5e0cb7d6006cc10661f4b3ffb9c120a486d46ea6.

In addition to mobile combustion emissions accounted under Community Protocol Equations TR.1.A and TR.2.B, GHG emissions from electric vehicles were included in the 2021 community GHG inventory for a more accurate accounting of on-road transportation trends and for consistency with the 2018 community GHG inventory. This was achieved by modifying Equation 2.4 to account for EV modeshare estimates based on total VMT (see Equation 2.5). Note that Equation 2.4 was not

adjusted above to account for EV share of VMT data due to use of the EMFAC2021 weighted emissions factors which attribute GHG emissions to be zero for EV activity data. Due to this zero emissions attribution, application of the EMFAC2021 emissions factor to total VMT data in Equation 2.4 in effect excludes EV GHG emissions. As such, GHG emissions associated with EV VMT quantified according to Equation 2.5 below do not result in double counting of emissions resulting from Equation 2.4 methodology. The equation, parameters, and data sources used to estimate GHG emissions attributable to on-road EV activity is provided in Equation 2.5 and Table 6 below.

EQUATION 2.5

ON-ROAD TRANSPORTATION ELECTRIC VEHICLE EMISSIONS

$$CO_2e_{onroad,EV,i} = VMT_i \times EV_{share,i} \times EPM_i \times \left[\left(EF_{weighted\ elec,j,CO_2} \times GWP_{CO_2}\right) + \left(EF_{weighted\ elec,j,CH_4} \times GWP_{CH_4}\right) + \left(EF_{weighted\ elec,j,N_2O} \times GWP_{N_2O}\right)\right] \quad 2.5$$

Table 6 Emissions Parameters and Data Sources – Community On-road Transportation EV

Definition	Parameter	Value	Unit	Data Source
Total annual community on-road EV GHG emissions per vehicle class	$CO_2e_{Onroad,EV,i}$	See Table 16	MT CO_2e/year	Calculated
Annual VMT	VMT_i	See Table 16	miles	MTC[1]
Percent share of VMT attributable to EVs	$EV_{share,i}$	See Table 16	%	EMFAC2021 v1.0.2[2]
Average rate of electricity consumption per EV-mile per vehicle class	EPM_i	Passenger: 0.3749 Commercial: 1.7432	kWh/mile	EMFAC2021 v1.0.2[2]
Weighted average carbon dioxide electricity emissions factor per building type	$EF_{weighted\ elec,j,CO_2}$	See Table 16	MT CO_2/kWh	Calculated from Table 2
Weighted average methane electricity emissions factor per building type	$EF_{weighted\ elec,j,CH_4}$	See Table 16	MT CH_4/kWh	Calculated from Table 2
Weighted average nitrous oxide electricity emissions factor per building type	$EF_{weighted\ elec,j,N_2O}$	See Table 16	MT N_2O/kWh	Calculated from Table 2
Global warming potential of carbon dioxide	GWP_{CO_2}	1	N/A	IPCC AR5

Definition	Parameter	Value	Unit	Data Source
Global warming potential of methane	GWP_{CH_4}	28	N/A	IPCC AR5
Global warming potential of nitrous oxide	GWP_{N_2O}	265	N/A	IPCC AR5
Vehicle class	i	Passenger Commercial	Categorical	N/A
Building type	j	Residential Nonresidential[3]	Categorical	

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent; EV = electric vehicles; VMT = vehicle miles travelled; kWh = kilowatt hour

1. Daily internal-internal and internal-external passenger VMT was sourced from MTC's VMT Data Portal 2.0 available at http://capvmt.mtcanalytics.org/. 100 percent of internal-internal trips and 50 percent of internal-external trips were attributed to Cupertino. An annualization factor of 342.41 was provided by Harold Brazil at MTC via email on 1/31/24 and applied to daily VMT to calculate annual passenger VMT.

Daily commercial VMT was provided by Harold Brazil at MTC via email on 1/31/24. The same annualization factor (i.e., 342.41) was applied to daily VMT to calculate annual commercial VMT.

2. CARB. Emission FACtor (EMFAC2021 v1.0.2) Model (2023). Available at: https://arb.ca.gov/emfac/emissions-inventory/5e0cb7d6006cc10661f4b3ffb9c120a486d46ea6.

3. It is assumed passenger vehicles charge on residential electricity and commercial vehicles on nonresidential electricity. This assumption is consistent with the updated 2018 GHG inventory.

Transportation: Off-road Equipment and Vehicles

Off-road equipment and vehicles in the community generate GHG emissions from the mobile combustion of fossil fuels. Off-road fuel usage results from equipment operation for sectors such as construction, lawn and garden, or recreational equipment. The methodology leverages fuel usage from CARB's 2021 Off-Road (OFFROAD2021) model.[15] The OFFROAD2021 model published in 2023 is in alignment with Community Protocol standards, though the model only reports off-road equipment fuel consumption on a county-wide basis. Attribution factors per equipment type used to allocate Cupertino off-road fuel usage were determined based on demographic data relating to population size and number of jobs (see Table 8 for additional details).

Community Protocol Equation TR.8 was used to quantify GHG emissions from off-road equipment fuel consumption and is shown under Equation 2.6 below. Table 7 lists the parameters, values, and data sources used to quantify emissions in accordance with the Community Protocol.

EQUATION 2.6

TR.8 OFF-ROAD EQUIPMENT AND VEHICLES SECTOR EMISSIONS

$$CO_2e_{offroad,j} = \sum_i Fuel_{offroad,i,j} \times AF_i \times \left[\left(EF_{j,CO_2} \times GWP_{CO_2}\right) + \left(EF_{j,CH_4} \times GWP_{CH_4}\right) + \left(EF_{j,N_2O} \times GWP_{N_2O}\right)\right] EF_{j,CO2} \quad (2.6)$$

[15] CARB. Off-Road (OFFROAD2021 v1.0.5) model (2023). Available at: https://arb.ca.gov/emfac/offroad/emissions-inventory/5e0cb7d6006cc10661f4b3ffb9c120a486d46ea6.

Table 7 Emissions Parameters and Data Sources – Community Off-Road Equipment and Vehicles TR.8

Definition	Parameter	Value	Unit	Data Source
Annual GHG emissions from offroad equipment and vehicles	$CO_2e_{offroad,j}$	See Table 16	MT CO_2e/year	Calculated
Annual fuel consumption in the County per sector per fuel type	$Fuel_{offroad,i,j}$	See Table 16	Gallons/year	OFFROAD2021[1]
Fuel attribution factor per equipment type	AF_i	See Table 8	Percent	▪ California Department of Finance[2] ▪ California Employment Development Department[3]
Carbon dioxide emission factor per fuel type	EF_{j,CO_2}	See Table 16	MT CO_2/gallon	EPA Emission Factors Hub[4]
Methane emission factor per fuel type	EF_{j,CH_4}	See Table 16	MT CH_4/gallon	EPA Emission Factors Hub[4]
Nitrous oxide emission factor per fuel type	EF_{j,N_2O}	See Table 16	MT N_2O/gallon	EPA Emission Factors Hub[4]
Global warming potential of carbon dioxide	GWP_{CO_2}	1	N/A	IPCC AR5
Global warming potential of methane	GWP_{CH_4}	28	N/A	IPCC AR5
Global warming potential of nitrous oxide	GWP_{N_2O}	265	N/A	IPCC AR5
Equipment Type	i	See Table 8	Categorical	OFFROAD2021[1]
Fuel type	j	Gasoline Diesel Natural Gas	Categorical	OFFROAD2021[1]

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent

1. CARB. Off-Road (OFFROAD2021 v1.0.5) model (2023). Available at: https://arb.ca.gov/emfac/offroad/emissions-inventory/5e0cb7d6006cc10661f4b3ffb9c120a486d46ea6.

2. California Department of Finance. E-5 Population and Housing Estimates for Cities, Counties, and the State, 2020-2023. Available at: https://dof.ca.gov/forecasting/demographics/estimates/e-5-population-and-housing-estimates-for-cities-counties-and-the-state-2020-2023/.

3. California Employment Development Department. Unemployment Rates (Labor Force). Available at: https://labormarketinfo.edd.ca.gov/cgi/dataanalysis/AreaSelection.asp?tableName=labforce.

4. EPA. 2021 GHG Emission Factors Hub. Available at: https://www.epa.gov/climateleadership/ghg-emission-factors-hub.

The demographic attribution metrics and percent of attribution used for each off-road equipment type is shown in Table 8. The attribution metrics are calculated by dividing Cupertino's demographic metric by Santa Clara County's demographic metric to estimate the share of off-road fuel usage attributable to Cupertino. The attribution metric type (i.e., population, jobs, or service population) for each equipment type are consistent with those used for the updated 2018 GHG inventory.

Table 8 Community Off-road Equipment and Vehicles Sector Attributions

Equipment Type	Attribution Metric	Attribution	Data Source
Agricultural	Excluded	0.00%	N/A
Airport Ground Support	Excluded	0.00%	N/A
Commercial Harbor Craft	Excluded	0.00%	N/A
Construction and Mining	Jobs	2.80%	California Employment Development Department[1]
Forestry	Excluded	0.00%	N/A
Industrial	Jobs	2.80%	California Employment Development Department[1]
Lawn and Garden	Service Population[2]	3.06%	▪ California Employment Development Department[1] ▪ California Department of Finance[3]
Light Commercial	Jobs	2.80%	California Employment Development Department[1]
Locomotive	Jobs	2.80%	California Employment Development Department[1]
Oil Drilling	Excluded	0.00%	N/A
Pleasure Craft	Excluded	0.00%	N/A
Portable Equipment	Jobs	2.80%	California Employment Development Department[1]
Recreational	Population	3.19%	California Department of Finance[2]
Transport Refrigeration Unit	Jobs	2.80%	California Employment Development Department[1]

Notes:

1. California Department of Finance. E-5 Population and Housing Estimates for Cities, Counties, and the State, 2020-2023. Available at: https://dof.ca.gov/forecasting/demographics/estimates/e-5-population-and-housing-estimates-for-cities-counties-and-the-state-2020-2023/.

2. Service population represents the combined population and number of jobs.

3. California Employment Development Department. Unemployment Rates (Labor Force). Available at: https://labormarketinfo.edd.ca.gov/cgi/dataanalysis/AreaSelection.asp?tableName=labforce.

2.2.3 Solid Waste

GHG emissions associated with the waste sector result from the decomposition of waste in the landfill. Recology provides solid waste, recycling, and mixed organic waste collection services for Cupertino. Since the City has not conducted a new waste characterization study, the waste characterization study and resulting emission factor from the updated 2018 GHG inventory was used for the 2021 GHG inventory. GHG emissions from waste decomposition were calculated using GPC Equation 8.3 which is consistent with the Community Protocol Method SW.4.1. Equation 2.7 and Table 9 provide the calculation method, associated parameters, and data sources used to quantify GHG emissions in accordance with these equations. As is consistent with the 2018 waste characterization study, GHG emissions associated with hauling waste within the city limits, including exhaust from garbage trucks, are assumed to be included within the on-road transportation sector.

EQUATION 2.7

GPC 8.3 SOLID WASTE EMISSIONS

$$CO_2e_{Waste} = GWP_{CH_4} \times (1 - CE) \times (1 - OX) \times M \times EF \quad 2.7$$

Table 9 Emissions Parameters and Data Sources – Community Solid Waste GPC 8.3

Definition	Parameter	Value	Unit	Data Source
Annual community generated waste GHG emissions	CO_2e_{Waste}	3,764	MT CO_2e/year	Calculated
Methane global warming potential	GWP_{CH_4}	28	N/A	IPCC AR5
Default landfill gas collection efficiency	CE	0.75	Fraction	GHG Protocol GPC
Oxidation rate	OX	0.10	Fraction	GHG Protocol GPC
Total mass of waste entering landfill	M	17,250	MT	Recology[1]
Emission factor	EF	0.0807	MT CH_4/MT waste	Calculated from Cupertino's Residential Waste Pilot Study and CalRecycle's 2014 Disposal Facility-Based Characterization of Solid Waste in California[2]

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent

1. Total tonnage disposed provided by Recology in workbook titled "2021 Solid Waste - Recology South Bay Monthly Report.xlsx."

2. The emission factor is consistent with that used in the 2018 GHG inventory. GPC Equations 8.1 and 8.4 were used to calculate the emission factor with inputs from the 2018 waste characterization study. See original *Greenhouse Gas Emissions Inventory Methodology* report prepared by the City for details.

2.2.4 Wastewater

Management of wastewater produces emissions through every stage of the process from collection to final use or discharge. Cupertino's wastewater is treated at the San José-Santa Clara Regional Wastewater Facility (SJ-SC RWF) which provides treatment services for Cupertino as well as Santa Clara region. The facility is located outside of Cupertino's boundaries. For this reason, GHG emissions from the facility are scaled to Cupertino's population using demographic data.

GHG emissions from Cupertino's wastewater treatment are a result of stationary combustion of digester gas and process emissions which occur with lagoons and effluent discharge at the SJ-SC RWF. To remain consistent with the 2010 and 2018 GHG inventories, a combination of available protocol equations was used to best match the data inputs and treatment processes at the SJ-SC RWF for the 2021 GHG inventory. The set of methods used to quantify stationary combustion emissions is outlined in Equation 2.8 in accordance with ICLEI's Local Government Operations Protocol, Version 1.1 (LGOP) and Table 10 as well as Equation 2.9 and Table 11 in accordance with the Community Protocol, below.[16]

[16] ICLEI. Local Government Operations Protocol (2010). Version 1.1. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/cc/protocols/lgo_protocol_v1_1_2010-05-03.pdf.

EQUATION 2.8

LGOP 10.2 WASTEWATER DIGESTER GAS STATIONARY COMBUSTION EMISSIONS (CH_4)

$$CO_2e_{WW,Stat,CH4} = (SP \times Digester\ Gas \times f_{CH4} \times D_{CH4} \times (1 - DE) \times 0.0283 \times 365.25 \times 10^{-6}) \times GWP_{CH4} \times (P \div SP) \quad 2.8$$

Table 10 Emissions Parameters and Data Sources – Community Wastewater LGOP 10.2

Definition	Parameter	Value	Unit	Data Source
Total annual GHG emitted by devices designed to combust digester gas	$CO_2e_{WW,Stat,CH4}$	See Table 16	MT CO_2e/year	Calculated
Service population	SP	1,517,000	People served	SJ-SC RWF[1]
Digester gas produced per person per day	$Digester\ Gas$	1	ft^3/person/day	ICLEI LGOP
Fraction of methane in digester gas	f_{CH4}	0.65	Fraction	ICLEI LGOP
Density of methane	D_{CH4}	662	g/m^3	ICLEI LGOP
Methane destruction efficiency	DE	0.99	Fraction	ICLEI LGOP
Conversion factor	0.0283	0.0283	m^3/ft^3	ICLEI LGOP
Conversion factor	365.25	365.25	Days/year	ICLEI LGOP
Conversion factor	10^{-6}	0.000001	MMBtu/BTU	N/A
Global warming potential of methane	GWP_{CH4}	28		IPCC AR5
Population	P	60,183	People	California Department of Finance[2]

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent; ft^3 = cubic feet; BTU = British thermal unit; MMBtu = one million British thermal units; g = grams; m^3 = cubic meters;

1. SJ-SC RWF. 2021 Annual Self-Monitoring Report.

2. California Department of Finance. E-5 Population and Housing Estimates for Cities, Counties, and the State, 2020-2023. Available at: https://dof.ca.gov/forecasting/demographics/estimates/e-5-population-and-housing-estimates-for-cities-counties-and-the-state-2020-2023/.

EQUATION 2.9

WW.2 (ALT) WASTEWATER DIGESTER GAS STATIONARY COMBUSTION EMISSIONS (N_2O)

$$CO_2e_{WW,Stat,N2O} = (SP \times Digester\ Gas \times f_{CH4} \times BTU_{CH4} \times 10^{-6} \times EF_{N2O} \times 365.25 \times 10^{-3}) \times GWP_{N2O} \times (P \div SP) \quad 2.9$$

Table 11 Emissions Parameters and Data Sources – Community Wastewater WW.2.(alt)

Definition	Parameter	Value	Unit	Data Source
Total annual GHG emitted by devices designed to combust digester gas	$CO_2e_{WW,Stat,N2O}$	See Table 16	MT CO_2e/year	Calculated
Service population	SP	1,517,000	People served	SJ-SC RWF[1]
Digester gas produced per person per day	$Digester\ Gas$	1	ft³/person/day	ICLEI Community Protocol
Fraction of methane in digester gas	f_{CH4}	0.65	Fraction	ICLEI Community Protocol
Default higher heating value of methane	BTU_{CH4}	1,028	BTU/ft³	ICLEI Community Protocol
Conversion factor	10^{-6}	0.000001	MMBtu/BTU	N/A
Nitrous Oxide emissions factor	EF_{N2O}	0.00063	kg N_2O/MMBtu	ICLEI Community Protocol
Conversion factor	365.25	365.25	Days/year	ICLEI Community Protocol
Conversion factor	10^{-3}	0.001	MT/kg	N/A
Global warming potential of nitrous oxide	GWP_{N2O}	265	N/A	IPCC AR5
Population	P	60,183	People	California Department of Finance[2]

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent; ft³ = cubic feet; BTU = British thermal unit; MMBtu = one million British thermal units; kg = kilograms.

1. SJ-SC RWF. 2021 Annual Self-Monitoring Report.

2. California Department of Finance. E-5 Population and Housing Estimates for Cities, Counties, and the State, 2020-2023. Available at: https://dof.ca.gov/forecasting/demographics/estimates/e-5-population-and-housing-estimates-for-cities-counties-and-the-state-2020-2023/.

Equation 2.10 shows the calculation method used to quantify methane emissions from lagoons in accordance with Community Protocol WW.6. Table 12 show the parameter definitions, default factors, and data sources used.

EQUATION 2.10

WW.6 METHANE EMISSIONS FROM LAGOONS

$$CO_2e_{WW,lagoons} = (BOD_5 \times (1 - F_{BOD5}) \times Max \times CF_{CH4} \times 365.25 \times 10^{-3}) \times GWP_{CH4} \times (P \div SP) \quad 2.10$$

Table 12 Emissions Parameters and Data Sources – Community Wastewater WW.6

Definition	Parameter	Value	Unit	Data Source
Total annual GHG emitted by lagoons	$CO_2e_{WW,lagoons}$	See Table 16	MT CO_2e/year	Calculated
Amount of BOD_5 treated per day	BOD_5	103,715	kg BOD_5/day	SJ-SC RWF[1]
Fraction of BOD_5 removed in primary treatment	F_{BOD5}	0.325	Fraction	San Jose 2014 GHG inventory[2]
Maximum methane producing capacity for domestic wastewater	Max	0.6	kg CH_4/kg BOD_5 removed	ICLEI Community Protocol
Methane correction factor for anaerobic systems	CF_{CH4}	0.8	Fraction	ICLEI Community Protocol
Conversion factor	365.25	365.25	Days/year	ICLEI Community Protocol
Conversion factor	10^{-3}	0.001	MT/kg	N/A
Global warming potential of methane	GWP_{CH4}	28		IPCC AR5
Population	P	60,183	People	California Department of Finance[3]
Service population	SP	1,517,000	People served	SJ-SC RWF[1]

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent; kg = kilograms; BOD_5 = five-day biochemical oxygen demand.

1. SJ-SC RWF. 2021 Annual Self-Monitoring Report.

2. It is assumed the fraction of BOD_5 removed in primary treatment has not changed since 2014 and is sourced from San Jose's GHG Inventory. This value is consistent with that used in Cupertino's updated 2018 GHG inventory.

3. California Department of Finance. E-5 Population and Housing Estimates for Cities, Counties, and the State, 2020-2023. Available at: https://dof.ca.gov/forecasting/demographics/estimates/e-5-population-and-housing-estimates-for-cities-counties-and-the-state-2020-2023/.

Equation 2.11 shows the calculation method used to quantify nitrous oxide emissions from effluent discharge in accordance with Community Protocol WW.12. Table 10 show the parameter definitions, default factors, and data sources used.

EQUATION 2.12

WW.12 EFFLUENT DISCHARGE

$$CO_2e_{WW,effluent} = (N - Load \times EF_{effluent} \times 365.25 \times 10^{-3} \times 44/28) \times GWP_{N2O} \times (P \div SP) \quad 2.11$$

Table 13 Emissions Parameters and Data Sources – Community Wastewater WW.12

Definition	Parameter	Value	Unit	Data Source
Total annual GHG emitted by effluent discharge processes	$CO_2e_{WW,effluent}$	See Table 16	MT CO_2e/year	Calculated
Average total nitrogen per day	$N - Load$	3,705	kg N/day	Calculated from SJ-SC RWF[1]

Definition	Parameter	Value	Unit	Data Source
Emission factor	$EF_{effluent}$	0.005	kg N2O-N/kg sewage-N discharged	ICLEI Community Protocol
Conversion factor	365.25	365.25	Days/year	ICLEI Community Protocol
Conversion factor	10^{-3}	0.001	MT/kg	N/A
Molecular weight ratio	$44/28$	1.57	Fraction	ICLEI Community Protocol
Global warming potential of nitrous oxide	GWP_{N20}	265		IPCC AR5
Population	P	60,183	People	California Department of Finance[2]
Service population	SP	1,517,000	People served	SJ-SC RWF[1]

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent; kg = kilograms; N = nitrogen.

1. SJ-SC RWF's *2021 Annual Self-Monitoring Report* only provides the inorganic load (i.e., 3431 kg inorganic N/day). The City understands organic nitrogen is usually seven to nine percent of the inorganic nitrogen. For this reason, an additional eight percent (i.e., the average of seven and nine percent) was added to the inorganic nitrogen value to account for organic nitrogen.

2. California Department of Finance. E-5 Population and Housing Estimates for Cities, Counties, and the State, 2020-2023. Available at: https://dof.ca.gov/forecasting/demographics/estimates/e-5-population-and-housing-estimates-for-cities-counties-and-the-state-2020-2023/.

2.2.5 Carbon Sequestration

Compost Application

The 2021 GHG inventory includes carbon sequestration from compost application in the community. Because the 2010 and 2018 GHG inventories did not include this subsector, the carbon sequestration from compost application is not aggregated into the 2021 GHG inventory emissions total. Instead, the carbon sequestration from compost application is provided for informational purposes only to help Cupertino track from their Climate Action Plan 2.0 zero waste measure (i.e., Measure W-3).

Since the protocols do not include equations to quantify carbon sequestration in community inventories, best practices were used to develop the carbon sequestration equation for compost application. Equation 2.12 and Table 14Table 9 provide the calculation method, associated parameters, and data sources used to quantify GHG emissions in accordance with these equations.

EQUATION 2.12

COMPOST APPLICATION

$$CO_2e_{Compost} = Compost \div CF \times EF_{feedstock,CO_2} \quad 2.12$$

Table 14 Emissions Parameters and Data Sources – Community Compost Application

Definition	Parameter	Value	Unit	Data Source
Total annual GHG sequestered by compost application	$CO_2e_{Compost}$	See Table 16	MT CO_2e/year	Calculated
Compost applied	$Compost$	700	Short tons	Cupertino Public Works[1]

Definition	Parameter	Value	Unit	Data Source
Conversion factor	CF	0.58	Short tons compost/short tons feedstock	CARB[2]
Annual carbon sequestration potential of feedstock	$EF_{feedstock,CO_2}$	0.23	MT CO_2/ton of feedstock	CARB[2]

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent.

1. Provided by Cupertino Public Works via email on 1/22/24.

2. CARB. Method for Estimating Greenhouse Gas Emission Reductions from Diversion of Organic Waste from Landfills to Compost Facilities (2017). Available at: https://ww2.arb.ca.gov/sites/default/files/classic/cc/waste/cerffinal.pdf.

Trees Planted

The 2021 GHG inventory includes carbon sequestration from trees in the community. This subsector accounts for the net change in trees within the community based on trees planted and trees removed during the inventory year. Because the 2010 and 2018 GHG inventories did not include this subsector, the carbon sequestration from trees is not aggregated into the 2021 GHG inventory emissions total. Instead, carbon sequestration from trees is provided for informational purposes only to help Cupertino track from their Climate Action Plan 2.0 carbon sequestration measure (i.e., Measure CS-1).

Since the protocols do not include equations to quantify carbon sequestration in community inventories, best practices were used to develop the carbon sequestration equation for trees. Equation 2.13 and Table 15provide the calculation method, associated parameters, and data sources used to quantify GHG emissions in accordance with these equations.

EQUATION 2.13

TREES PLANTED

$$CO_2e_{Trees} = (Trees\ Planted\ - Trees\ Removed) \times EF_{Trees,CO_2} \quad 2.13$$

Table 15 Emissions Parameters and Data Sources – Community Trees Planted

Definition	Parameter	Value	Unit	Data Source
Total annual GHG sequestered by trees	CO_2e_{Trees}	See Table 16	MT CO_2e/year	Calculated
Trees planted	$Trees\ Planted$	188	trees	Cupertino Tree Operations Dashboard[1]
Trees removed	$Trees\ Removed$	197	trees	Cupertino Tree Operations Dashboard[1]
Annual carbon dioxide sequestration potential of tree seedling	EF_{Trees,CO_2}	0.0354	MT CO_2/tree	California Air Pollution Control Officers Association (CAPCOA)[2]

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent;

1. Provided by Cupertino Innovation Technology from Cupertino Tree Operations Dashboard via email on 1/22/24.

2. CAPCOA. Quantifying Greenhouse Gas Mitigation Measures. A Resource for Local Government to Assess Emission Reductions from Greenhouse Gas Mitigation Measures (2010). Available at: https://www.aqmd.gov/docs/default-source/ceqa/handbook/capcoa-quantifying-greenhouse-gas-mitigation-measures.pdf.

2.3 2021 Community GHG Emissions Inventory Results

The 2021 community inventory provides Cupertino with communitywide GHG emissions estimates that follow the Community Protocol and current best practices for GHG accounting. The results of the 2021 community GHG inventory are shown in Figure 1 and Figure 2 summarized in detail in Table 16. The figures exclude GHG emissions from carbon sequestration because those emissions are not included in the inventory's total GHG emissions and presented solely for informational purposes. This is consistent with the 2010 and 2018 inventories that did not account for carbon sequestration emissions or sinks.

Figure 1 2021 Community Inventory GHG Emissions by Sector

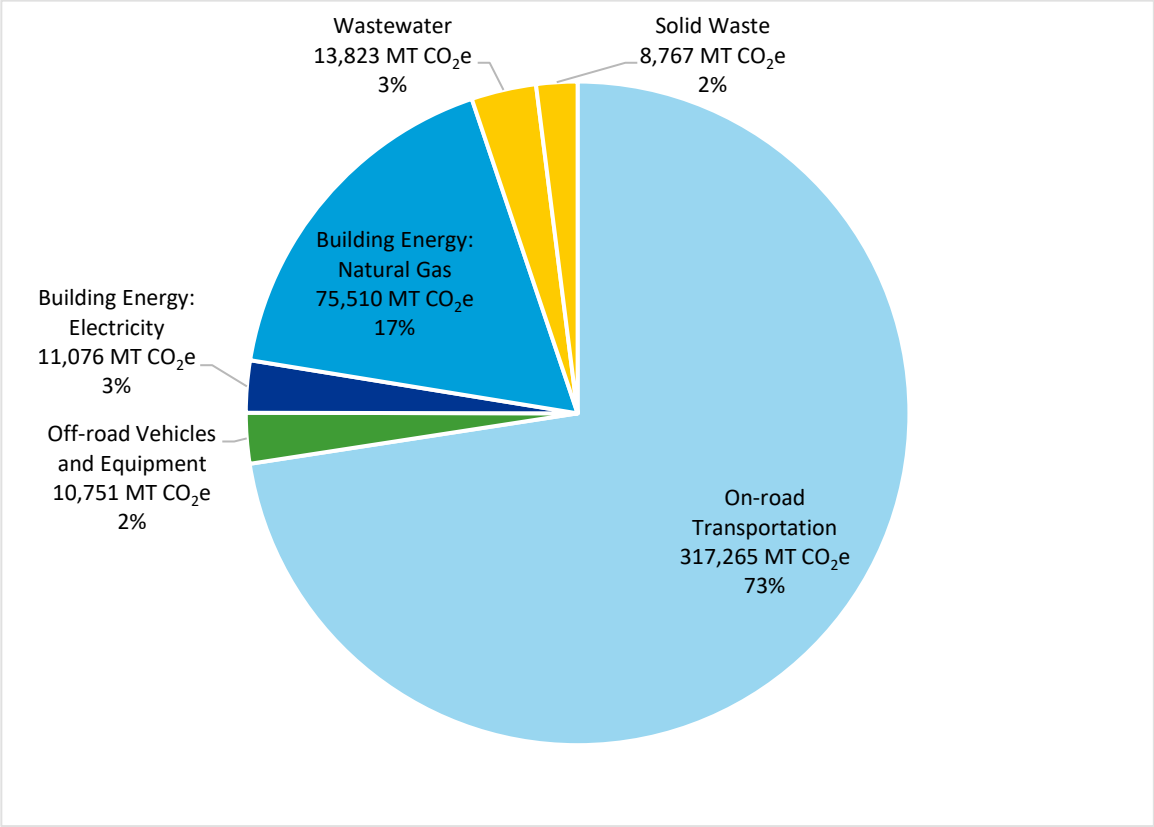


Figure 2 2021 Community Inventory GHG Emissions by Sub-Sector

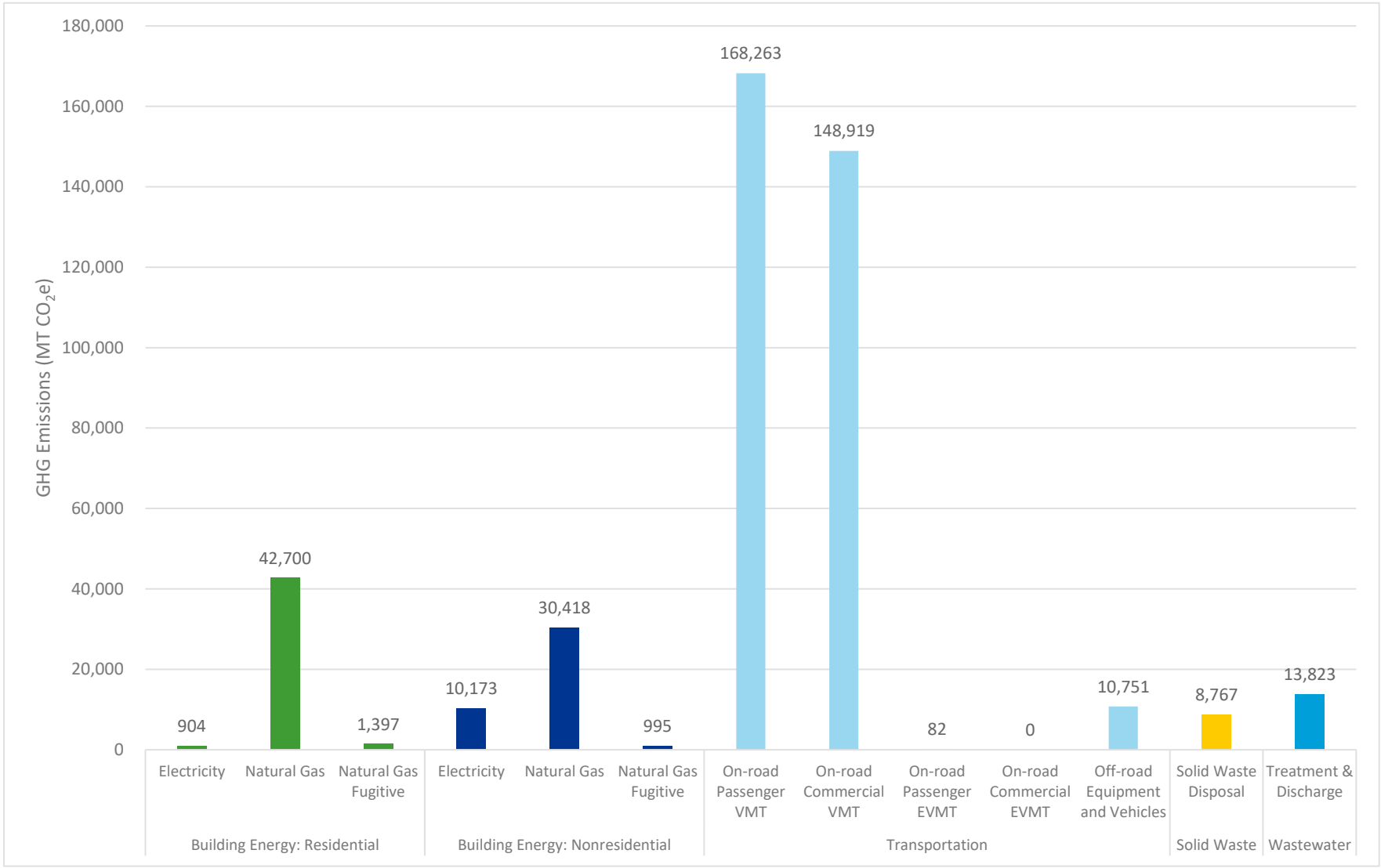


Table 16 2021 Community GHG Emissions Inventory

GHG Emissions Sector	GHG Emissions Subsector	Activity Data		CO_2 Emission Factor	CH_4 Emission Factor	N_2O Emission Factor	GHG Emissions (MT CO_2e)
Building Energy: Residential	Electricity: PG&E	2,710,220	kWh	0.0000447	0.0000000141	0.00000000181	123
	Electricity: SVCE	105,530,571	kWh	0.00000812	N/A	N/A	857
	Electricity: Direct Access	24,521	kWh	0.0002233	0.0000000301	0.00000000161	6
	EV Adjustment	(9,032,327)	kWh	0.00000909	0.000000000359	0.0000000000458	(82)
	Natural Gas	8,049,396	therms	0.00531	N/A	N/A	42,700
	Natural Gas Fugitive	N/A	N/A	0.0000000663	0.00000619	N/A	1,397
	Total Building Energy: Residential						45,000
Building Energy: Nonresidential	Electricity: PG&E	132,711,765	kWh	0.0000447	0.0000000141	0.00000000181	6,044
	Electricity: SVCE	95,193,048	kWh	0.00000776	N/A	N/A	738
	Electricity: Direct Access[1]	46,869,207	kWh	0.0000719	0.00000000968	0.000000000520	3,391
	EV Adjustment	(12,419)	kWh	0.0000365	0.00000000844	0.000000000965	0.46
	Natural Gas[2]	7,764,477	therms	0.00378	N/A	N/A	30,418
	Natural Gas Fugitive[2]	N/A	N/A	0.0000000490	0.00000457	N/A	995
	Total Building Energy: Nonresidential						41,586
Transportation	On-road Passenger VMT	464,734,941	VMT	0.000358	0.0000000182	0.0000000132	168,263
	On-road Commercial VMT	102,715,981	VMT	0.001400	0.0000000803	0.000000180	148,919
	On-road Passenger EVMT	9,032,327	kWh	0.000009087316	0.000000000359	0.0000000000458	82
	On-road Commercial EVMT	12,419	kWh	0.0000365	0.00000000844	0.000000000965	0.46
	Off-road Diesel	598,141	Gallons	0.01021	0.00000029	0.000000455	3,612
	Off-road Gasoline	614,838	Gallons	0.00878	0.00000877	0.000000138	4,186
	Off-road Natural Gas	507,876	Gallons	0.00568	0.000000897	0.000000410	2,953
	Total Transportation						328,016

GHG Emissions Sector	GHG Emissions Subsector	Activity Data		CO_2 Emission Factor	CH_4 Emission Factor	N_2O Emission Factor	GHG Emissions (MT CO_2e)
Solid Waste	Landfill Methane	17,250	Wet short tons	N/A	See Table 9[3]	N/A	8,767
	Total Solid Waste						8,767
Wastewater	Stationary Combustion	60,183	people	N/A	See Table 10[3]	See Table 11[3]	77
	Lagoons	103,715	Kg BOD5/day	N/A	See Table 123	N/A	13,634
	Effluent Discharge	3,705	Kg N/day	N/A	N/A	See Table 13[3]	112
	Total Wastewater						13,823
Carbon Sequestration*	Compost Application	700	Short tons	See Table 14[3]	N/A	N/A	(278)
	Tree Planting	(9)	trees	0.0354	N/A	N/A	0.32
	Total Carbon Sequestration						(277)
Total							**437,192**

Notes: MT CO2e = Metric tons of carbon dioxide equivalent; VMT = vehicle miles traveled; EVMT = electric vehicle miles traveled; kWh = kilowatt hour; therms = thermal units; BOD_5 = five-day biochemical oxygen demand; kg = kilograms; N = nitrogen;

() denotes a negative value.

Values may not exactly add up to subtotals and totals due to rounding.

*Carbon Sequestration is included for informational purposes but is excluded from total inventory GHG emissions.

1. Nonresidential direct access electricity emission factors are presented as the weighted emission factors between PG&E direct access electricity and Apple's direct access electricity to maintain confidentiality for Apple's energy data.

2. Nonresidential natural gas and natural gas fugitive emission factors are presented as the weighted emission factors between PG&E's natural gas and Apple's biofuel to maintain confidentiality for Apple's energy data.

3. The GHG emissions of this subsector are determined by several variables and not a single emissions factor. To see the emission factors and variables, see referenced table.

3 Community GHG Inventories Comparison

The figure and table below present the comparative summary of GHG emissions results for the Cupertino 2010, 2018, and 2021 community GHG inventories. Total GHG emissions dropped noticeably between the years of 2010 and 2018 primarily due to the transition from PG&E electricity consumption (with high electricity emission factors) to SVCE electricity consumption (with near-zero electricity emission factors). This transition occurred in both residential and nonresidential electricity consumption.

While all other subsectors decreased between 2010 and 2021, on-road passenger and commercial emissions increased during the same period. In 2021, total community GHG emissions notably rose above 2010 levels. This notable increase can be traced to an increase in Cupertino's VMT and an increase in the County's VMT emission factors (representing vehicle's fuel makeup and fuel efficiencies). Specifically, between 2010 and 2021, VMT increased by about 42 percent and on-road GHG emissions increased by about 83 percent. This increase is partially attributable to a change in the MTC transportation demand model methodology and a methodology change in the CARB EMFAC model between version updates.

Figure 3 Cupertino Community Inventory GHG Emissions Comparison by Sector

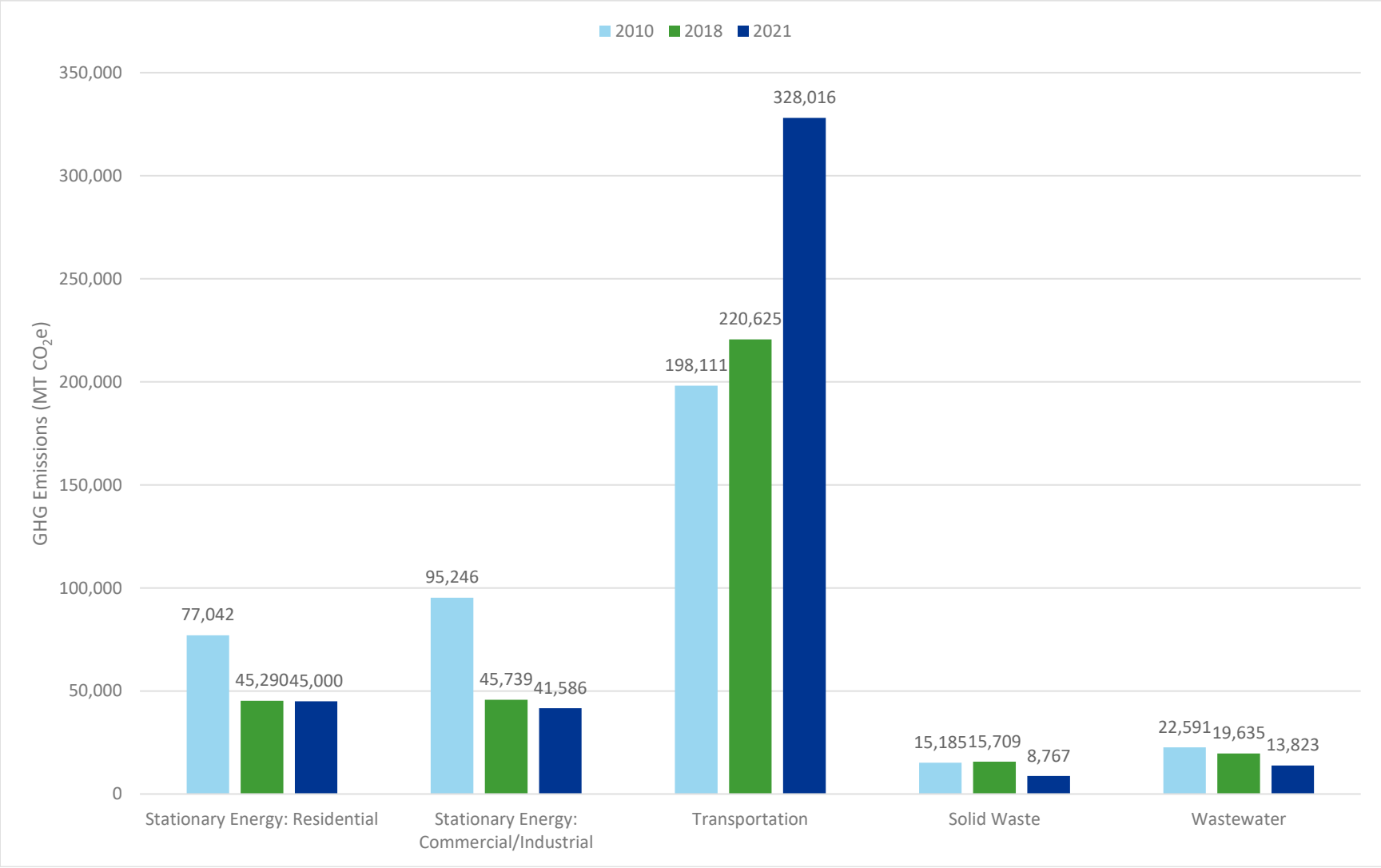


Table 17 Comparative Community GHG Emissions Inventories Summary (2010, 2018 & 2021)

GHG Emissions Sector	GHG Emissions Subsector	2010 GHG Emissions (MT CO_2e)	2018 GHG Emissions (MT CO_2e)	2021 GHG Emissions (MT CO_2e)
Building Energy: Residential	Electricity: PG&E	25,427	271	123
	Electricity: SVCE	0	197	857
	Electricity: Direct Access	0	6	6
	EV Adjustment	0	(27)	(82)
	Natural Gas	49,986	43,428	42,700
	Natural Gas Fugitive	1,630	1,420	1,397
	Total Building Energy: Residential	77,042	45,290	45,000
Building Energy: Nonresidential	Electricity: PG&E	55,859	287	6,044
	Electricity: SVCE	0	215	738
	Electricity: Direct Access[1]	4,166	3,564	3,391
	EV Adjustment	0	0	0.46
	Natural Gas[2]	34,109	39,957	30,418
	Natural Gas Fugitive[2]	1,112	1,710	995
	Total Building Energy: Nonresidential	95,246	45,739	41,586
Transportation	On-road Passenger VMT	152,411	132,635	168,263
	On-road Commercial VMT	21,204	73,972	148,919
	On-road Passenger EVMT	0	27	82
	On-road Commercial EVMT	0	0	0.46
	Off-road Diesel			3,612
	Off-road Gasoline	24,496	13,991	4,186
	Off-road Natural Gas			2,953
	Total Transportation	198,111	220,625	328,016
Solid Waste	Landfill Methane	15,185	15,709	8,767
	Total Solid Waste	15,185	15,709	8,767

GHG Emissions Sector	GHG Emissions Subsector	2010 GHG Emissions (MT CO_2e)	2018 GHG Emissions (MT CO_2e)	2021 GHG Emissions (MT CO_2e)
Wastewater	Stationary Combustion			77
	Lagoons	22,591	19,635	13,634
	Effluent Discharge			112
	Total Wastewater	22,591	19,635	13,823
Carbon Sequestration*	Compost Application	N/A	N/A	(278)
	Tree Planting	N/A	N/A	0.32
	Total Carbon Sequestration	N/A	N/A	(277)
Total		**408,176**	**346,998**	**437,192**

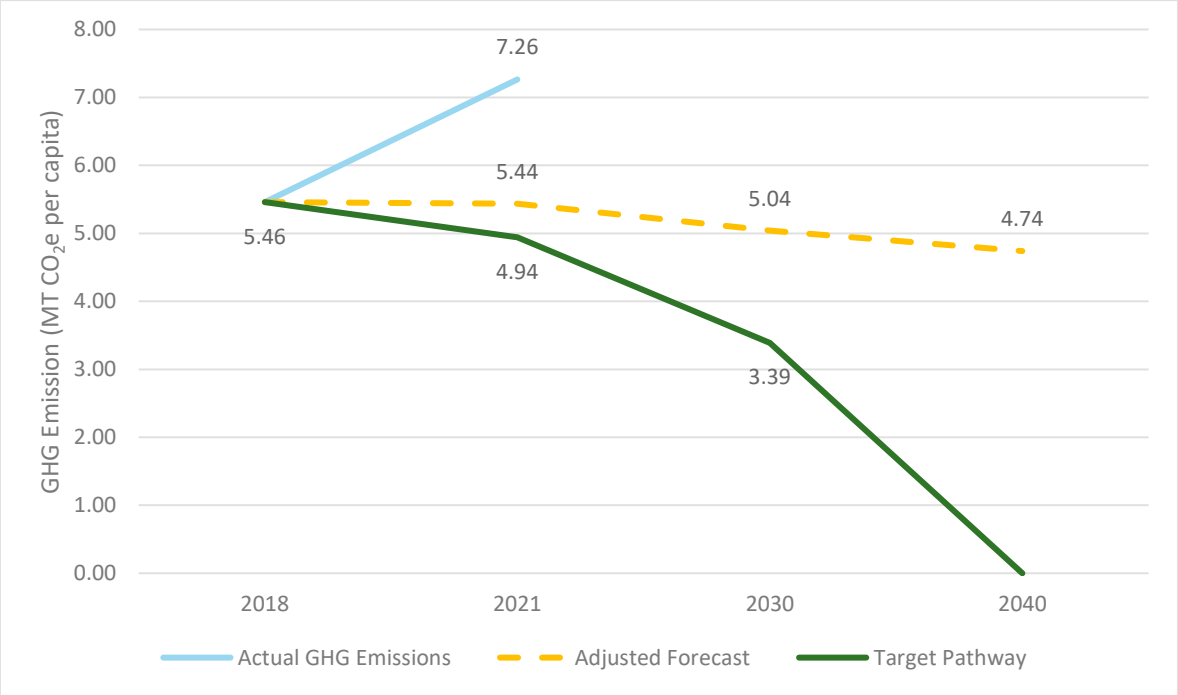
Notes: MT CO2e = Metric tons of carbon dioxide equivalent; VMT = vehicle miles traveled; EVMT = electric vehicle miles traveled.

() denotes a negative value.

*Carbon Sequestration is included for informational purposes in the 2021 GHG inventory but is excluded from total inventory GHG emissions.

Figure 4 below shows how the 2021 GHG emission inventory tracks against Cupertino's CAP 2.0 2030 and 2040 targets. The figure displays 2021 emissions and the 2030 and 2040 targets in emissions per capita (i.e., MT CO_2e/person). With a population of 60,183 people in 2021, Cupertino's 2021 community emissions equate to 7.26 MT CO_2e/person. These per capita emissions are not consistent with Cupertino's per capita emission reduction pathway and do not put Cupertino on track to meet the 2030 and 2040 targets. However, since population remained relatively consistent, the increase in 2021 per capita emissions can be attributed to the increase in on-road transportation emissions from the MTC and EMFAC model updates.

Figure 4 Comparison of 2021 Community GHG Inventory and CAP 2.0 2030 and 2040 Targets



4 2021 Municipal GHG Inventory

This 2021 municipal GHG emissions inventory includes direct (e.g., natural gas usage) and indirect (e.g., employee commute) GHG emissions resulting from City municipal operations during 2021.

A GHG emissions inventory provides a comprehensive understanding of a municipality's GHG emissions and is developed to serve the following purposes:

- Promote understanding of the role of local government operations in combating climate change;
- Provide an understanding of where the highest sources of GHG emissions in municipal operations originate and where the greatest opportunities for emissions reduction exist; and
- Help to create harmonization between GHG inventories developed and reported to multiple programs.

4.1 Municipal GHG Inventory Approach

GHG Emissions Accounting Protocol

The Cupertino 2021 municipal GHG inventory was developed in alignment with the ICLEI LGOP and the Global Covenant of Mayors (GCoM) Common Reporting Framework (CRF).[17]

GHG emissions were calculated by multiplying the activity data in each included GHG emissions sector by an associated emission factor. Activity data refer to the relevant measured or estimated level of GHG-generating activity (e.g., energy consumption, fuel usage). Emission factors are observation-based conversion factors used to equate activity data to generated GHG emissions. The 2021 municipal GHG inventory provides a comprehensive understanding of municipal-related GHG emissions. The following sections contain further information on the scope of the inventory, calculation methodologies, data used, and results.

Emissions Geographic Boundary

Cupertino's municipal inventory covers the relevant emissions sources within the operational boundary of Cupertino's municipality (e.g. city buildings, parks, and vehicles). The inventory, thereby, reflects emissions sectors over which the City of Cupertino has full operational control. Sectors where the jurisdiction has limited influence (e.g., upstream production of purchased goods) are generally excluded from the 2021 municipal GHG inventory, as the City of Cupertino does not have the power to develop measures to affect associated emissions.

Emissions Inventory Scope

Cupertino's municipal inventory includes scope 1, 2, and 3 emissions. The LGOP recommends reporting GHG emissions from two operational boundaries in a municipal inventory that include:

- Scope 1: direct GHG emissions from sources within a local government's operations that it owns and/or controls (e.g., stationary combustion of natural gas)

[17] GCoM CRF. Available at: https://www.globalcovenantofmayors.org/faq/hat-is-the-gcom-common-reporting-framework-crf/

- Scope 2: indirect GHG emissions associated with the consumption of energy that is purchased from an outside entity (e.g., purchased electricity)

The LGOP also provides recommendations for additional GHG emissions source reporting for emission sources of potential operational policy relevance. These include Scope 3 indirect emissions which cover all indirect emission not covered in Scope 2.

- Scope 3: emissions include those from vehicles not owned or controlled by the City (e.g., employee commute) and solid waste disposal.[18]

To maintain consistency and comparability with Cupertino's community GHG inventories, emissions from each scope are organized into the same sectors used for the community GHG inventories. GHG emission sources in the municipal GHG inventory are thus categorized more generally into the following five activity sectors:

- Building Energy
- Transportation
- Solid Waste
- Wastewater[19]
- Carbon Sequestration

Global Warming Potential

The LGOP assesses GHG emissions associated with the six internationally recognized GHGs. These GHGs are consistent with those assessed in the Community Protocol and are outlined in Table 1 in Section 2.1's subsection *Global Warming Potential*. The 2021 municipal inventory focuses on the three GHGs most relevant to the municipality's operations: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The other gases (i.e., hydrofluorocarbons, perfluorocarbons, and sulfur hexafluorides) are emitted primarily in private sector manufacturing and electricity transmission and are therefore omitted from the inventory. This approach is consistent with typical municipal inventory approaches, as such industrial emissions are typically outside of the City's operational control. Table 1 also includes the global warming potentials (GWP) for each gas. The 2021 inventory used 100-year global warming potentials (GWP) for each gas that are consistent with the IPCC AR5, which are the latest GWPs. This method allows for consistency with the LGOP as well as comparability with Cupertino's community GHG inventories.

4.2 2021 Municipal GHG Emissions Inventory Activity Data and Emissions Factors

4.2.1 Building Energy

Building Energy: Infrastructure Electricity

[18] Although carbon sequestration was included in Cupertino's 2021 community GHG inventory, it is not included in the 2021 municipal inventory for consistency with the LGOP (i.e., the protocol does not recommend inclusion of GHG emissions from carbon sequestration). Additionally, it is expected that carbon sequestration associated with municipal operations will be relatively unnoticeable.

[19] In alignment with the community inventory, it is assumed that electricity GHG emissions associated with potable water delivery are covered under the building energy sector.

The City relies almost exclusively on electricity from SVCE, with only a small portion (i.e., less than 0.1 percent) purchased from PG&E. Activity data for all municipal electricity consumption was provided by SVCE and broken out by business activity (e.g., buildings & facilities, traffic control, irrigation, etc.) and rate type (i.e., SVCE GreenPrime, SVCE GreenStart, and PG&E). Electricity emission factors for SVCE and PG&E were calculated from California Energy Commission (CEC) Power Content Labels and The Climate Registry, respectively. While CEC Power Content Labels provide SVCE's emission factors in carbon dioxide equivalents, the Climate Registry only provides PG&E's carbon dioxide emission factor. Therefore, PG&E's electricity emission factor was supplemented with methane and nitrous oxide emission factors from EPA's eGRID.[20] SVCE's emission factor was calculated as the weighted average between SVCE's GreenPrime and GreenStart options based on the share of municipal electricity usage.

The equation and data sources used to quantify GHG emissions from municipal infrastructure electricity are consistent with Equation 2.1 with only slight deviations in methodology.[21] The equation used for infrastructure electricity follows guidelines under the Local Government Operations Protocol (LGOP) Section 6.2 Electricity Use. Building Energy: Infrastructure Electricity is considered Scope 2 emissions. Activity data, emission factors, and GHG emissions for municipal infrastructure electricity can be found in Table 22[22] in Section 2.2.1, *Building Energy.*

Building Energy: Infrastructure Natural Gas

GHG emissions from natural gas result from the stationary combustion of natural gas in City-owned buildings and facilities. Natural gas is purchased from Association of Bay Area Governments (ABAG) Power delivered by PG&E. Activity data for all municipal natural gas consumption was provided by SVCE. To remain consistent with the community GHG inventories and The Climate Registry, methane and nitrous oxide emissions are considered de minimis in the municipal GHG inventory.

The equation and data sources used to quantify GHG emissions from municipal infrastructure electricity match Equation 2.2 and follow guidelines under LGOP Section 6.1 Stationary Combustion. Building Energy: Infrastructure Natural Gas is considered Scope 1 emissions. Activity data, emission factors, and GHG emissions for infrastructure natural gas can be found in Table 22 in Section 2.2.1, *Building Energy* [23]

Building Energy: Emergency Generators

GHG emissions from emergency generators result from the stationary combustion of gasoline and renewable diesel in emergency generators located in City-owned buildings and facilities. Activity data for all emergency generator fuel consumption was provided by the City. To remain consistent with the community GHG inventories and The Climate Registry, methane and nitrous oxide emissions are considered de minimis in the municipal GHG inventory. The methodology leverages

[20] EPA Emissions & Generation Resource Integrated Database (eGRID). Available at: https://www.epa.gov/egrid

[21] Unlike the community electricity sector, the municipal infrastructure electricity sector does not remove electricity consumption attributable to EV charging and therefore captures potential EV charging electricity from the vehicle fleet and employee vehicles. In 2021, municipal EV charging was negligible.

[22] The table indicates the community GHG inventory included electricity from direct access. There was no direct access electricity usage or providers for the municipality.

[23] The table indicates the community GHG inventory included biofuel usage from Apple. The municipality did not use biofuel and the municipal GHG inventory did not make adjustments for biofuel usage.

stationary combustion emission factors from the U.S. EPA's Emission Factors Hub.[24] It is assumed that the renewable diesel emission factor is 65 percent lower than conventional diesel, according to CARB's Low Carbon Fuel Standard.[25] Building Energy: Emergency Generators is considered Scope 1 emissions.

Equation 4.1 and Table 18 define the equation, parameters, and data sources used to estimate GHG emissions from emergency generator fuel combustion.

EQUATION 4.1

EMERGENCY GENERATOR FUEL COMBUSTION EMISSIONS

$$CO_{2_{EmGen,i}} = (Fuel_i \times EF_{i,CO_2}) \quad 4.1$$

Table 18 Emissions Parameters and Data Sources – Emergency Generators

Definition	Parameter	Value	Unit	Data Source
Total annual emergency generator GHG emissions per fuel type	$CO_{2_{EmGen,i}}$	See Table 22	MT CO_2/year	Calculated
Annual Fuel Consumption	$Fuel_i$	See Table 22	Gallons	City of Cupertino
Carbon dioxide emission factor for gasoline combustion	EF_{i,CO_2}	0.00878	MT CO_2/gallon	EPA Emission Factors Hub[1]
Carbon dioxide emission factor for renewable diesel combustion	EF_{i,CO_2}	0.00357	MT CO_2/gallon	Calculated[2]
Fuel type	i	Gasoline Renewable Diesel	Categorical	N/A

Notes: MT CO_2 = Metric tons of carbon dioxide

1. EPA. 2021 GHG Emission Factors Hub. Available at: https://www.epa.gov/climateleadership/ghg-emission-factors-hub.

2. Calculated by multiplying conventional diesel emission factor from EPA Emission Factors Hub by (1-0.65) since renewable diesel is assumed to have a 65% lower carbon intensity than convention diesel, as explained above.

Building Energy: Fugitive Infrastructure Natural Gas

Fugitive emissions from natural gas include GHG emissions that are not physically controlled by the City but result from intentional or unintentional releases, commonly arising from the production, processing, transmission, storage, and use of natural gas. While natural gas leakage is technically outside of the City's operational control, the leakage is directly affected by natural gas consumption from the municipality and should be included as an emissions sector in municipal GHG inventories. Further, while not a part of LGOP's guidelines for stationary combustion, the municipal inventory

[24] EPA. 2021 GHG Emission Factors Hub. Available at: https://www.epa.gov/climateleadership/ghg-emission-factors-hub.

[25] US Department of Energy. Alternative Fuels Data Center. More information available at: https://afdc.energy.gov/fuels/renewable-diesel

includes fugitive natural gas emissions to be consistent with Cupertino's community GHG inventories.

The equation and data sources used to quantify GHG emissions from fugitive infrastructure natural gas match Equation 2.3. Building Energy: Fugitive Infrastructure Natural Gas is considered Scope 1 emissions. Activity data, emission factors, and GHG emissions for fugitive infrastructure natural gas can be found in Table 22 in Section 2.2.1, *Building Energy.*

4.2.2 Transportation

Transportation: On-road Vehicle Fleet Combustion

The City's on-road vehicle fleet produces GHG emissions from the mobile combustion of fossil fuels (i.e., internal combustion engines). GHG emissions from the on-road transportation sector were calculated in accordance with guidelines under LGOP Section 7.1 Mobile Combustion. The City provided annual mileage and the year, make, model, and fuel type for each vehicle in their on-road fleet. To estimate fuel consumption, annual mileages were converted to gallons of each fuel type (i.e., gasoline or diesel)[26] using vehicle-specific fuel economy data sourced from the U.S. EPA's and DOE's Fuel Economy database and supplementary data from Fuelly, a crowd-sourced fuel economy database. [27,28] The methodology leverages on-road transportation emission factors from the U.S. EPA's Emission Factors Hub.[29] Transportation: On-road Vehicle Fleet is considered Scope 1 emissions.

Equation 4.2 and Table 19 define the equation, parameters, and data sources used to estimate GHG emissions from on-road vehicle fleet fuel combustion.

EQUATION 4.2

ON-ROAD VEHICLE FLEET COMBUSTION EMISSIONS

$$CO_2e_{fleet,i} = (Fuel_i \times EF_{i,CO_2}) + (Miles_i \times EF_{i,CH_4} \times GWP_{CH_4}) + (Miles_i \times EF_{i,N_2O} \times GWP_{N_2O}) \quad 4.2$$

Table 19 Emissions Parameters and Data Sources – Municipal Vehicle Fleet (On-road)

Definition	Parameter	Value	Unit	Data Source
Total annual on-road vehicle fleet GHG emissions per fuel type	$CO_2e_{fleet,i}$	See Table 22	MT CO_2e/year	Calculated
Annual Fuel Consumption	$Fuel_i$	See Table 22	Gallons	Calculated using annual mileage and fuel economy per vehicle

[26] Because EV usage was negligible (the City owns two EVs that drove a combined 30,213 miles in 2021), EV emissions are not quantified in the transportation sector and instead captured under the building energy: infrastructure electricity sector

[27] US EPA and DOE. U.S. Government Source for Fuel Economy Information. Available at: https://www.fueleconomy.gov/feg/download.shtml.

[28] Fuelly. Available at: https://www.fuelly.com/about

[29] EPA. 2021 GHG Emission Factors Hub. Available at: https://www.epa.gov/climateleadership/ghg-emission-factors-hub.

Definition	Parameter	Value	Unit	Data Source
Annual Mileage	$Miles_i$	See Footnote	Miles[1]	City of Cupertino Vehicle Fleet Report
Carbon dioxide emission factor for motor gasoline combustion	EF_{i,CO_2}	See Footnote	MT CO_2/gallon[2]	EPA Emission Factors Hub[4]
Methane emission factor for on-road vehicles per fuel type	EF_{i,CH_4}	See Footnote	MT CH_4/mile[3]	EPA Emission Factors Hub[4]
Nitrous oxide emission factor for on-road vehicles per fuel type	EF_{i,N_2O}	See Footnote	MT N_2O/mile[3]	EPA Emission Factors Hub[4]
Global warming potential of carbon dioxide	GWP_{CO_2}	1	N/A	IPCC AR5
Global warming potential of methane	GWP_{CH_4}	28	N/A	IPCC AR5
Global warming potential of nitrous oxide	GWP_{N_2O}	265	N/A	IPCC AR5
Fuel type	i	Gasoline Diesel	Categorical	

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent

1. Diesel: 181,744 miles; gasoline: 1,753,244 miles
2. Diesel: 1 x 10^{-2} MT CO_2/gal; gasoline: 8.8 x 10^{-3} MT CO_2/gal
3. Diesel: 9.5 x 10^{-9} MT CH_4/mile, 4.3 x 10^{-8} MT N_2O/mile; gasoline: 7.5 x 10^{-9} MT CH_4/mile, 2.9 x 10^{-9} MT N_2O/mile
4. EPA. 2021 GHG Emission Factors Hub. Available at: https://www.epa.gov/climateleadership/ghg-emission-factors-hub.

Transportation: Off-road Vehicle and Equipment Combustion

The City's off-road vehicle fleet produces GHG emissions from the mobile combustion of fossil fuels (i.e., internal combustion engines). GHG emissions from the off-road transportation sector were calculated in accordance with guidelines under LGOP Section 7.1 Mobile Combustion. The City provided annual fuel consumption (gallons of gasoline) for City-owned off-road vehicles and equipment. The methodology leverages off-road transportation and equipment emission factors from the U.S. EPA's Emission Factors Hub.[30] Transportation: Off-road Vehicle Fleet and Equipment is considered Scope 1 emissions.

Equation 4.3 and Table 20 define the equation, parameters, and data sources used to estimate GHG emissions from on-road vehicle fleet fuel combustion.

EQUATION 4.3

OFF-ROAD VEHICLE AND EQUIPMENT COMBUSTION EMISSIONS

$$CO_2e_{offroad} = (Fuel \times EF_{CO_2}) + (Fuel \times EF_{CH_4} \times GWP_{CH_4}) + (Fuel \times EF_{N_2O} \times GWP_{N_2O}) \quad 4.3$$

[30] EPA. 2021 GHG Emission Factors Hub. Available at: https://www.epa.gov/climateleadership/ghg-emission-factors-hub. Available Note: Rincon assumed lawn/garden and commercial equipment for gasoline methane and nitrous oxide emission factors as these are the most commonly used equipment by municipalities.

Table 20 Emissions Parameters and Data Sources – Municipal Vehicle Fleet (Off-road)

Definition	Parameter	Value	Unit	Data Source
Total annual on-road vehicle fleet GHG emissions	$CO_2e_{offroad}$	See Table 22	MT CO_2e/year	Calculated
Annual Fuel Consumption	$Fuel$	See Table 22	Gallons of gasoline	City of Cupertino Off-Road Gasoline Invoices
Carbon dioxide emission factor for motor gasoline combustion	EF_{CO_2}	See Table 22	MT CO_2/gallon	EPA Emission Factors Hub[1]
Methane emission factor for off-road vehicles/equipment	EF_{CH_4}	See Table 22	MT CH_4/gallon	EPA Emission Factors Hub[1]
Nitrous oxide emission factor for off-road vehicles/equipment	EF_{N_2O}	See Table 22	MT N_2O/gallon	EPA Emission Factors Hub[1]
Global warming potential of carbon dioxide	GWP_{CO_2}	1	N/A	IPCC AR5
Global warming potential of methane	GWP_{CH_4}	28	N/A	IPCC AR5
Global warming potential of nitrous oxide	GWP_{N_2O}	265	N/A	IPCC AR5

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent

1. EPA. 2021 GHG Emission Factors Hub. Available at: https://www.epa.gov/climateleadership/ghg-emission-factors-hub.

Transportation: Employee Commute

Employee commute emissions are GHG emissions associated with the travel of employees to and from work in personal vehicles not owned and operated by the City. While reporting of these types of emissions (Scope 3) is considered optional under the LGOP reporting framework, doing so provides an opportunity for innovation in GHG management and is, therefore, reported in Cupertino's municipal GHG inventory. Additionally, employee commute emissions tend to represent a noticeable portion of local government emissions. GHG emissions from employee commute were calculated by taking employee commute data provided by the City (annual, mixed-mode mileage and average fuel economy) and applying on-road transportation emission factors sourced from the U.S. EPA's Emission Factors Hub to estimated annual fuel consumption (gallons of gasoline). [31] Transportation: Employee Commute is considered Scope 3 emissions.

Equation 4.4 and Table 21 define the equation, parameters, and data sources used to estimate GHG emissions from on-road vehicle fleet fuel combustion.

EQUATION 4.4

EMPLOYEE COMMUTE EMISSIONS

$$CO_2e_{Commute} = (Fuel \times EF_{CO_2}) + (Miles \times EF_{CH_4} \times GWP_{CH_4}) + (Miles \times EF_{N_2O} \times GWP_{N_2O}) \quad 4.4$$

31 EPA. 2021 GHG Emission Factors Hub. Available at: https://www.epa.gov/climateleadership/ghg-emission-factors-hub.

Table 21 Emissions Parameters and Data Sources – Employee Commute

Definition	Parameter	Value	Unit	Data Source
Total annual employee commute GHG emissions	$CO_2e_{offroad}$	See Table 22	MT CO_2e/year	Calculated
Annual Fuel Consumption	$Fuel$	See Table 22	Gallons of gasoline	Calculated using annual mileage and City-provided average fuel economy for employee commute
Carbon dioxide emission factor for motor gasoline combustion	EF_{CO_2}	See Table 22	MT CO_2/gallon	EPA Emission Factors Hub[1]
Annual Mileage	$Miles$	See Table 22	Miles	City of Cupertino Employee Commute Report
Methane emission factor for off-road vehicles/equipment	EF_{CH_4}	See Table 22	MT CH_4/mile	EPA Emission Factors Hub[1]
Nitrous oxide emission factor for off-road vehicles/equipment	EF_{N_2O}	See Table 22	MT N_2O/mile	EPA Emission Factors Hub[1]
Global warming potential of carbon dioxide	GWP_{CO_2}	1	N/A	IPCC AR5
Global warming potential of methane	GWP_{CH_4}	28	N/A	IPCC AR5
Global warming potential of nitrous oxide	GWP_{N_2O}	265	N/A	IPCC AR5

Notes: MT CO_2e = Metric tons of carbon dioxide equivalent

1. EPA. 2021 GHG Emission Factors Hub. Available at: https://www.epa.gov/climateleadership/ghg-emission-factors-hub.

4.2.3 Solid Waste

GHG emissions associated with the municipal solid waste sector result from the decomposition of waste at a landfill. While reporting of indirect solid waste emissions (Scope 3) under the LGOP framework is considered optional, they were quantified as part of the Cupertino municipal inventory to be consistent with the community inventory and to provide an opportunity for innovation in GHG management. Activity data (short tons of waste entering the landfill) was estimated using waste container size and pickup frequency provided by the City. Per discussions with City staff, it was assumed that each container was 75 percent full upon pickup. A weighted emission factor of 0.0441 MT CH_4/short ton of municipal landfilled waste was derived by applying the City of Cupertino 2019 Municipal Waste Characterization Study to landfilled waste activity data, and multiplying each material category (e.g., paper, plastic, etc.) by its respective emission factor sourced from the Community Protocol, as referenced by the LGOP.

The equation and data sources used to quantify GHG emissions from solid waste match Equation 2.7, except for the activity data and emission factor.[32] Solid Waste is considered Scope 3 emissions. Activity data, emission factors, and GHG emissions can be found in Table 22 in Section 2.2.3, Solid Waste.

[32] The emission factor for landfilled solid waste as part of the municipal inventory is 0.0441 MT CH4/short ton waste, derived from the 2019 waste characterization study and Community Protocol discussed above.

4.2.4 Wastewater

While the City of Cupertino does not own or operate wastewater treatment facilities, GHG emissions result from the management of wastewater produced by City personnel. Similar to previous sections, the reporting of indirect wastewater emissions (Scope 3) under the LGOP framework is considered optional, however were quantified as part of the Cupertino municipal inventory to be consistent with the community inventories and to provide an opportunity for innovation in GHG management.

The equations and data sources used to quantify GHG emissions from wastewater match Equations 2.8-2.11, except for the number of full time City of Cupertino employees[33] (i.e., 182 full time employees) being used to attribute emissions from the various wastewater processes to the City instead of the City's population. Wastewater is considered Scope 3 emissions. Activity data, emission factors, and GHG emissions can be found in Table 22 in Section 2.2.4, Wastewater.

4.2.5 Carbon Sequestration

Compost Application

The municipal GHG inventory includes carbon sequestration associated with compost application on City-owned land. Because previous municipal GHG inventories and the ICLEI LGOP do not include carbon sequestration, the carbon sequestration from compost application is not aggregated into the 2021 municipal GHG inventory. This methodology is consistent with the 2021 community GHG inventory. Instead, the carbon sequestration associated with compost application is provided for information purposes only.

The equations and data sources used to quantify carbon sequestration associated with compost application match Equation 2.12, except for tons of compost applied (i.e., 48 tons).[34] The calculation method, associated parameters, and data sources can be found in Table 14 in Section 2.2.5, Carbon Sequestration.

4.3 2021 Municipal GHG Emissions Inventory Results

The 2021 municipal GHG inventory provides Cupertino with current municipal operations GHG emissions estimates that follow the LGOP and current best practices for GHG accounting. The results of the 2021 municipal GHG inventory are shown in Figure 5 and Figure 6 summarized in detail in Table 22.

[33] While some employees worked remote in 2021, the full FTE number was used to remain conservative.

[34] The City of Cupertino provided cubic yards (CY) of compost applied, which was converted to tons using a CY to tons of compost conversion factor (2.5 CY/ton of compost) also provided by the City. This conversion factor is sourced from CalRecycle.

Figure 5 2021 Municipal Inventory GHG Emissions by Sector

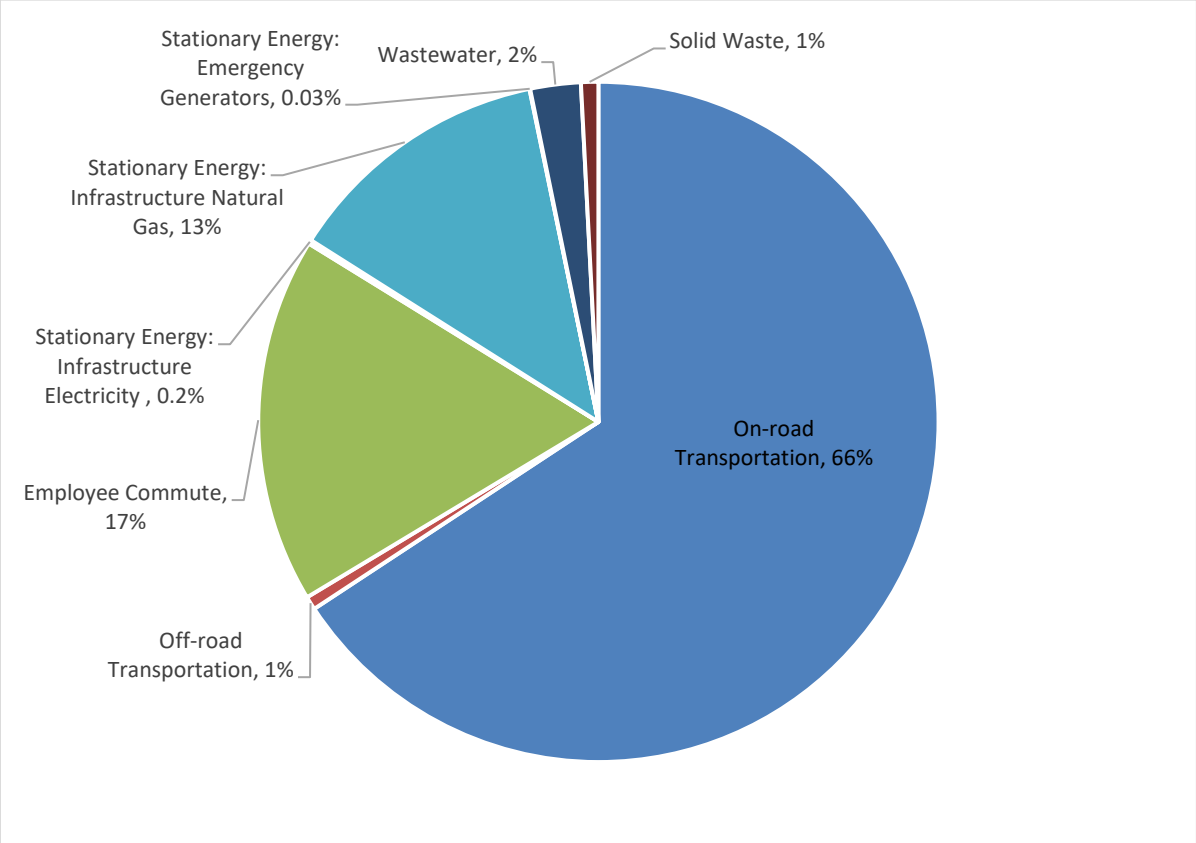


Figure 6 2021 Municipal Inventory GHG Emissions by Sub-Sector

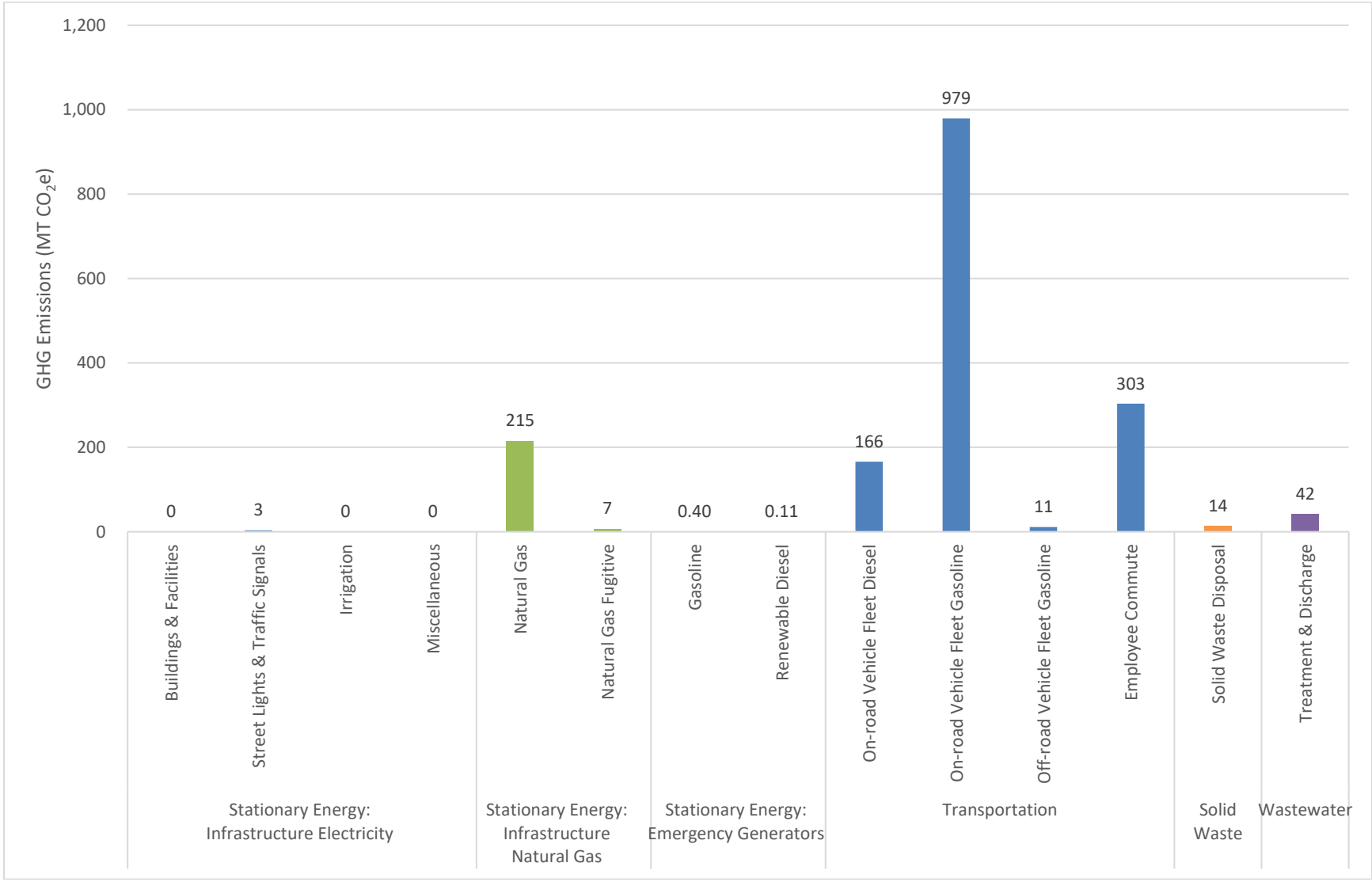


Table 22 2021 Municipal GHG Emissions Inventory

GHG Emissions Sector	GHG Emissions Subsector	Activity Data		CO_2e Emission Factor	GHG Emissions (MT CO_2e)
Building Energy: Infrastructure Electricity	Buildings & Facilities: SVCE – Green Prime	1,291,098	kWh	0.000000	0.00
	Streetlights & Traffic Signals: SVCE – Green Prime	680,757	kWh	0.000000	0.00
	Streetlights & Traffic Signals: SVCE – Green Start	352,767	kWh	0.000009	3.17
	Streetlights & Traffic Signals: PG&E	1,466	kWh	0.000046	0.07
	Irrigation: SVCE – Green Prime	16,664	kWh	0.000000	0.00
	Miscellaneous: SVCE – Green Prime	300,875	kWh	0.000000	0.00
	Total Building Energy: Infrastructure Electricity	3.24			
Building Energy: Infrastructure Natural Gas	Buildings & Facilities	40,621	therms	0.005305	215.48
	Buildings & Facilities Fugitive	N/A	N/A	0.000173	7.05
	Total Building Energy: Infrastructure Natural Gas	222.53			
Building Energy: Emergency Generators	Gasoline	45	gallons	0.008780	0.4
	Renewable Diesel	31	gallons	0.003574	0.11
	Total Building Energy: Emergency Generators	0.51			
Transportation	On-road Vehicle Fleet Diesel	16,027	gallons	See Table 19	165.76
	On-road Vehicle Fleet Gasoline	111,340	gallons	See Table 19	979.26
	Off-road Vehicle Fleet Gasoline	1,196	gallons	0.009290	11.11
	Employee Commute	34,411	gallons	See Table 19	303.25
	Total Transportation	1,459.38			

GHG Emissions Sector	GHG Emissions Subsector	Activity Data					CO_2e Emission Factor	GHG Emissions (MT CO_2e)
Solid Waste	Landfill Methane				52	short tons	See Table 9[1]	14.33
	Total Solid Waste				14.33			
Wastewater	Stationary Combustion				182	FTE	See Table 10 and Table 11[2]	0.23
	Lagoons				103,715	kg BOD5/day	See Table 12[3]	41.20
	Effluent Discharge				3,705	kg N/day	See Table 13[4]	0.34
	Total Wastewater				41.77			
Carbon Sequestration	Compost Application	48	short tons	N/A	(19.03)			
	Total Carbon Sequestration				(19.03)			
Total								**1,741.76**

Notes: MT CO2e = Metric tons of carbon dioxide equivalent; kWh = kilowatt hour; therms = thermal units; BOD_5 = five-day biochemical oxygen demand; FTE = full-time employee; kg = kilograms; N = nitrogen;

Values may not add up to subtotals and totals due to rounding.

1. The GHG emissions of this subsector are determined by several variables and not a single emissions factor. See Table 9 for variables used in equation (LFG capture rate and oxidation rate), and Section 4.2.3 for information specific to the municipal solid waste equation.

2, 3, 4. The GHG emissions of this subsector are determined by several variables and an attribution factor based on number of FTEs. See referenced tables for variables used in equations.

5 Municipal GHG Inventories Comparison

Figure 7 and Table 23, below, present the comparative summary of GHG emissions results for the Cupertino 2010, 2015, and 2021 municipal GHG inventories. Total GHG emissions dropped noticeably between the years of 2010 and 2021 primarily due to the transition from PG&E electricity consumption (with high electricity emission factors) to SVCE electricity consumption (with near-zero electricity emission factors). Reductions in natural gas usage since 2010 also decreased total GHG emissions for the City. However, on-road transportation GHG emissions increased noticeably in 2021, attributed to an increase in activity data (i.e., VMT) of the City's vehicle fleet (i.e., primarily the gasoline vehicle fleet).

While solid waste GHG emissions appear to have decreased noticeably since 2010, this change could potentially be artificial given the unknown activity data and methodologies used to quantify solid waste emissions in the 2010 and 2015 municipal GHG inventories. Similarly, wastewater GHG emissions appear to have not been quantified in previous inventories, as reported by ClearPath, and, therefore, the 2021 wastewater GHG emissions cannot be compared to previous years.

Figure 7 Cupertino Municipal Inventory GHG Emissions Comparison by Sector

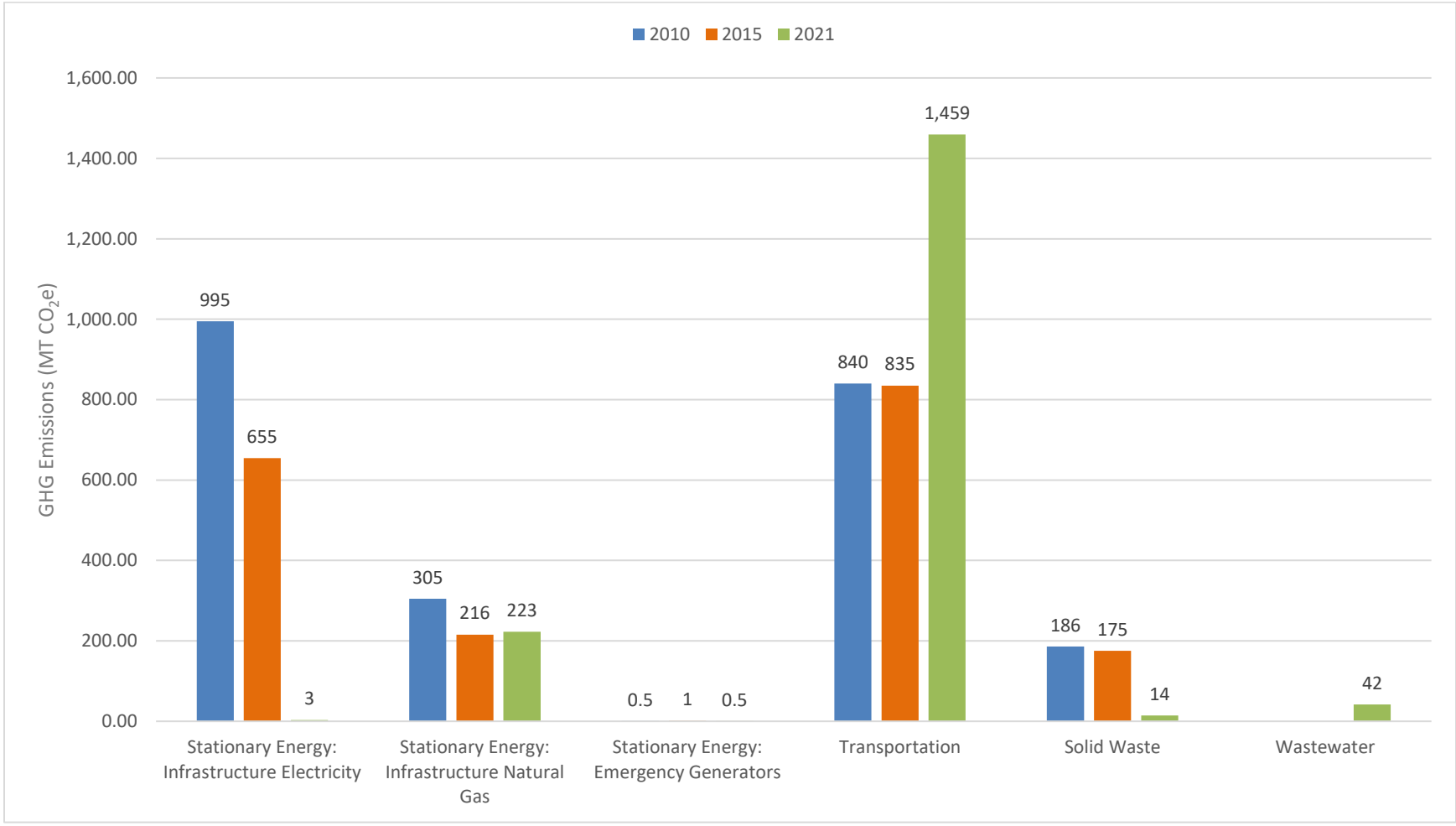


Table 23 Comparative Municipal GHG Emissions Inventories Summary (2010, 2015 & 2021)

GHG Emissions Sector	GHG Emissions Subsector	2010 GHG Emissions (MT CO_2e)	2015 GHG Emissions (MT CO_2e)	2021 GHG Emissions (MT CO_2e)
Building Energy: Infrastructure Electricity	Buildings & Facilities	576.65	417.10	0.00
	Street Lights & Traffic Signals	411.76	230.80	3.24
	Irrigation	6.59	6.90	0.00
	Miscellaneous	N/A	N/A	0.00
	Total Building Energy: Infrastructure Electricity	994.99	654.80	3.24
Building Energy: Infrastructure Natural Gas	Buildings & Facilities	256.53	178.60	215.48
	Buildings & Facilities Fugitive	48.00	37.00	7.05
	Total Building Energy: Infrastructure Natural Gas	304.53	215.60	222.53
Building Energy: Emergency Generators	Emergency Generators	0.46	1.12	0.51
	Total Building Energy: Emergency Generators	0.46	1.12	0.51
Transportation	On-road Vehicle Fleet Diesel	96.67	140.70	165.76
	On-road Vehicle Fleet Gasoline	282.43	252.20	979.26
	Off-road Vehicle Fleet Gasoline	N/A	N/A	11.11
	Employee Commute	461.00	442.00	303.25
	Total Transportation	840.10	834.90	1,459.38
Solid Waste	Landfill Waste	186.00	175.00	14.33
	Total Solid Waste	186.00	175.00	14.33
Wastewater	Stationary Combustion CH4	N/A	N/A	0.23
	Stationary Combustion N2O	N/A	N/A	0.01
	Lagoon Fugitive CH4	N/A	N/A	41.20
	Effluent Discharge Fugitive N2O	N/A	N/A	0.34
	Total Wastewater	N/A	N/A	41.77
Carbon Sequestration*	Compost Application	N/A	N/A	(19.03)
	Total Carbon Sequestration	N/A	N/A	(19.03)

GHG Emissions Sector	GHG Emissions Subsector	2010 GHG Emissions (MT CO_2e)	2015 GHG Emissions (MT CO_2e)	2021 GHG Emissions (MT CO_2e)
Total		**2,326.08**	**1,881.42**	**1,741.76**

Notes: MT CO2e = Metric tons of carbon dioxide equivalent; () denotes a negative value.

*Carbon Sequestration is included for informational purposes in the 2021 GHG inventory but is excluded from total inventory GHG emissions.

Appendix 1: Future Community GHG Inventory Guidance

Future Community GHG Inventory Guidance

GHG Emissions Accounting Protocol

Cupertino's 2010, updated 2018, and 2021 community GHG inventories were developed in alignment with accounting protocols provided by the Local Governments for Sustainability International Council for Local Environmental Initiatives (ICLEI)—as recommended by the Association of Environmental Professionals (AEP) and the California Office of Planning and Research (OPR).[1] ICLEI protocols are designed for local-scale accounting of GHG emissions that contribute to climate change and provide authoritative guidance to account for GHG emissions accurately and consistently. The ICLEI U.S. Community Protocol for Accounting and Reporting Greenhouse Gas Emissions Version 1.2 (Community Protocol)[2] serves to guide the measurement and reporting of GHG emissions in a standardized way and is used by other jurisdictions to support their own inventory, forecast, and climate action planning efforts. Use of Community Protocol methodology for GHG accounting aligns with statewide GHG inventory methods and focuses on analyzing sectors within jurisdictional control of cities or counties. The Community Protocol also includes steps to evaluate the relevance, completeness, consistency, transparency, and accuracy of data used in the GHG inventory. The Community Protocol shall be used for Cupertino's future community GHG inventories to maintain consistency with the 2010, updated 2018, and 2021 community GHG inventories.

Emissions Inventory Sectors

Cupertino's 2010, updated 2018, and 2021 community GHG inventories reported GHG emissions from the following five activity sectors:

- Building Energy (i.e., electricity and natural gas)
- Transportation (i.e., on-road vehicles and off-road equipment and vehicles)
- Solid Waste
- Wastewater
- Carbon Sequestration

To maintain consistency with the 2010, updated 2018, and 2021 community GHG inventories, Cupertino's future community GHG inventories should include these five sectors as well.

Data Collection and Calculations for Future Community GHG Inventories

To conduct future community GHG inventories, the equations presented in Section 2 of the *Final Community and Municipal Greenhouse Gas Emissions Inventories Report* should be followed and updated with current activity data and emissions factors. Table 1 through Table 8 summarize the activity data that will need to be updated in future GHG inventories, along with their associated emission factors, for each sector included in Cupertino's community GHG inventories. Variables

[1] Association of Environmental Professionals (AEP). 2013. AEP Climate Change Committee's "The California Supplement to the United States Community-Wide Greenhouse Gas (GHG) Emissions Protocol". Available at: https://califaep.org/docs/California_Supplement_to_the_National_Protocol.pdf

[2] The Community Protocol can be downloaded from the following link: https://icleiusa.org/us-community-protocol/.

(including emission factors) excluded from the below tables are considered defaults from the Community Protocol and do not need to be updated for each future inventory.

The Excel workbook, titled "2021 Cupertino Community GHG Inventory_Final," contains each of the equations listed in Section 2 of the report. The updated activity data and emissions factors that are identified in Table 1 through Table 8 can be entered into the workbook cells and fed through the existing formulas to follow the equations.

Building Energy Data

Table 1 Building Energy Activity Data

Variable	Definition	Unit	Data Source
Equation 2.1			
$Elec_{i,j}$	Electricity consumption per building type per energy provider	kWh/year	▪ SVCE Electricity Report ▪ Annual Renewable Electricity Use Report from Apple
$EV_{i,j}$	Attributed electric vehicle electricity consumption (i.e., EV adjustment)	kWh/year	CARB's EMFAC2021 v1.0.2 (https://arb.ca.gov/emfac/emissions-inventory/) and MTC (http://capvmt.mtcanalytics.org/)
Equation 2.2			
$Fuel_{NG,i}$	Natural gas consumed per building type	therms/year	▪ SVCE Electricity Report ▪ Environmental Progress Reports from Apple
Equation 2.3			
$Fuel_{NG,i}$	Natural gas consumed per building type	therms/year	▪ SVCE Electricity Report ▪ Environmental Progress Reports from Apple

SVCE = Silicon Valley Clean Energy, CARB = California Air Resources Board.

Table 2 Building Energy Emission Factors

Emission Factor	Definition	Unit	Data Source
Equation 2.1			
EF_{elec,i,j,CO_2}	Electricity carbon dioxide emission factor based on energy provider	MT CO_2/kWh	▪ PG&E emission factor sourced from The Climate Registry ▪ SVCE emission factors calculated from California Energy Commission Power Content Label ▪ Direct access emission factor calculated using state level data from CARB ▪ Apple direct access emission factor sourced from Apple
EF_{elec,i,j,CH_4}	Electricity methane emission factor based on energy provider	MT CH_4/kWh	▪ PG&E emission factor sourced from EPA's Emissions & Generation Resource Integrated Database (eGRID) ▪ SVCE emission factors included in carbon dioxide emission factor

			▪ Direct access emission factor calculated using state level data from CARB ▪ Apple direct access emission factor sourced from Apple
EF_{elec,i,j,N_2O}	Electricity nitrous oxide emission factor based on energy provider	MT CH_4/kWh	▪ PG&E emission factor sourced from EPA's eGRID ▪ SVCE emission factors included in carbon dioxide emission factor ▪ Direct access emission factor calculated using state level data from CARB ▪ Apple direct access emission factor sourced from Apple
Equation 2.2			
EF_{NG,CO_2}	Carbon dioxide emission factor for natural gas combustion	kg CO_2/MMBtu natural gas	▪ EPA Emission Factora Hub (https://www.epa.gov/climateleadership/ghg-emission-factors-hub) ▪ Apple (emission factor for Apple's biofuel is considered 0)
Equation 2.3			
$EF_{NG\ fugitive,CO2}$	Carbon dioxide emission factor for fugitive natural gas leakage	MT CO_2/therm	ICLEI ClearPath
$EF_{NG\ fugitive,CH4}$	Methane emission factor for fugitive natural gas leakage	MT CH_4/therm	ICLEI ClearPath

PG&E = Pacific Gas and Electric, SVCE = Silicon Valley Clean Energy, CARB = California Air Resources Board.

Transportation Data

Table 3 Transportation Activity Data

Variable	Definition	Unit	Data Source
Equation 2.4			
VMT_i	Annual VMT	miles	MTC (http://capvmt.mtcanalytics.org/)
Equation 2.5			
VMT_i	Annual VMT	miles	MTC (http://capvmt.mtcanalytics.org/)
$EV_{share,i}$	Percent share of VMT attributable to EVs	%	CARB's EMFAC2021 v1.0.2 (https://arb.ca.gov/emfac/emissions-inventory/)
EPM_i	Average rate of electricity consumption per EV-mile per vehicle class	kWh/mile	CARB's EMFAC2021 v1.0.2 (https://arb.ca.gov/emfac/emissions-inventory/)
Equation 2.6			
$Fuel_{offroad,i,j}$	Annual fuel consumption in the County per sector per fuel type	Gallons/year	CARB's OFFROAD2021 (https://arb.ca.gov/emfac/offroad/emissions-inventory/)

AF_i	Fuel attribution factor per equipment type	Percent	▪ California Department of Finance (E-5 Population and Housing Estimates) ▪ California Employment Development Department (Unemployment Rates)

MTC = Metropolitan Transportation Commission, CARB = California Air Resources Board.

Table 4 Transportation Emission Factors

Emission Factor	Definition	Unit	Data Source
Equation 2.4			
EF_{auto,i,CO_2}	Carbon dioxide emission factor for on-road vehicles per vehicle class	MT CO_2/mile	CARB's EMFAC2021 v1.0.2 (https://arb.ca.gov/emfac/emissions-inventory/)
EF_{auto,i,CH_4}	Methane emission factor for on-road vehicles per vehicle class	MT CH_4/mile	CARB's EMFAC2021 v1.0.2 (https://arb.ca.gov/emfac/emissions-inventory/)
EF_{auto,i,N_2O}	Nitrous oxide emission factor for on-road vehicles per vehicle class	MT N_2O/mile	CARB's EMFAC2021 v1.0.2 (https://arb.ca.gov/emfac/emissions-inventory/)
Equation 2.5			
$EF_{weighted\ elec,j,CO_2}$	Weighted average carbon dioxide electricity emissions factor per building type	MT CO_2/kWh	Calculated Table 2
$EF_{weighted\ elec,j,CH_4}$	Weighted average methane electricity emissions factor per building type	MT CH_4/kWh	Calculated from Table 2
$EF_{weighted\ elec,j,N_2O}$	Weighted average nitrous oxide electricity emissions factor per building type	MT N_2O/kWh	Calculated from Table 2
Equation 2.6			
EF_{j,CO_2}	Carbon dioxide emission factor per fuel type	MT CO_2/gallon	EPA Emission Factors Hub (https://www.epa.gov/climateleadership/ghg-emission-factors-hub)
EF_{j,CH_4}	Methane emission factor per fuel type	MT CH_4/gallon	EPA Emission Factors Hub (https://www.epa.gov/climateleadership/ghg-emission-factors-hub)
EF_{j,N_2O}	Nitrous oxide emission factor per fuel type	MT N_2O/gallon	EPA Emission Factors Hub (https://www.epa.gov/climateleadership/ghg-emission-factors-hub)

CARB = California Air Resources Board.

Solid Waste Data

Table 5 Solid Waste Activity Data

Variable	Definition	Unit	Data Source

Equation 2.7			
M	Total mass of waste entering landfill	MT	Recology

Table 6 Solid Waste Emission Factors

Emission Factor	Definition	Unit	Data Source
Equation 2.7			
EF	Emission factor	MT CH_4/MT waste	Calculated from Cupertino's Residential Waste Pilot Study and CalRecycle's 2014 Disposal Facility-Based Characterization of Solid Waste in California

Wastewater Data

Table 7 Wastewater Activity Data

Variable	Definition	Unit	Data Source
Equation 2.8			
SP	Service population	People served	SJ-SC RWF
P	Population	People	California Department of Finance (E-5 Population and Housing Estimates)
Equation 2.9			
SP	Service population	People served	SJ-SC RWF
P	Population	People	California Department of Finance (E-5 Population and Housing Estimates)
Equation 2.10			
BOD_5	Amount of BOD_5 treated per day	kg BOD_5/day	SJ-SC RWF
F_{BOD5}	Fraction of BOD_5 removed in primary treatment	Fraction	San Jose 2014 GHG inventory or new data source
P	Population	People	California Department of Finance (E-5 Population and Housing Estimates)
Equation 2.11			
$N - Load$	Average total nitrogen per day	kg N/day	Calculated from SJ-SC RWF
P	Population	People	California Department of Finance (E-5 Population and Housing Estimates)
SP	Service population	People served	SJ-SC RWF

SJ-SC RWF = San Jose-Santa Clara Regional Wastewater Facility.

Carbon Sequestration Data

Table 8 Carbon Sequestration Activity Data

Variable	Definition	Unit	Data Source
Equation 2.12			
$Compost$	Compost applied	Short tons	Cupertino Public Works
Equation 2.13			
$Trees\ Planted$	Trees planted	trees	Cupertino Tree Operations Dashboard
$Trees\ Removed$	Trees removed	trees	Cupertino Tree Operations Dashboard