Palo Alto's 2020 Greenhouse Gas Emissions Inventory[1]

1.a. Overview of Methodology for Quantifying Greenhouse Gas Emissions

Cities represent the single greatest opportunity for tackling climate change, as they are responsible for 75 percent of global energy-related carbon dioxide emissions, mostly from transportation and buildings. The first step for cities to realize their potential is to identify and measure where their emissions come from. There are two types of Greenhouse Gas (GHG) emissions inventories:

1. **Generation-based GHG inventory** – This measurement method helps a community understand its level of emissions based on community energy use. It includes 1) direct consumption of energy, 2) consumption of energy via the electrical grid, and 3) emissions from the treatment/decomposition of waste. This is the industry-accepted methodology for quantifying community GHG emissions, with emissions reported by emission source category[2].

2. **Consumption-based GHG inventory** – This measurement method helps a community understand its level of emissions based on consumption. It offers an alternative, more holistic, approach for quantifying emissions within a community, quantifying consumption of goods and services (including food, clothing, electronic equipment, etc.) by residents of a city, with emissions reported by consumption category.

Staff did not complete a consumption-based GHG inventory, though staff believes there would be value in completing one eventually. The California Air Resources Board (CARB) has been tasked with developing an implementation framework and accounting to track consumption-based emissions over time.[3] In particular, this framework needs to address how to account for the embodied emissions in the food, goods, and services the community purchases that are not covered by generation-based GHG inventories. While Palo Alto will await State guidance on how to account for these consumption-based emissions reductions, the community can work to reduce these emissions in the meantime.

In 2014, World Resources Institute, C40 Cities Climate Leadership Group (C40) and ICLEI – Local Governments for Sustainability (ICLEI)[4] partnered to create global standard protocol for GHG

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[1] This is a corrected version of the 2020 GHG inventory. The inventory in Staff Report 1474 incorrectly reported on Wastewater Biosolid Treatment: https://www.cityofpaloalto.org/files/assets/public/agendas-minutes-reports/reports/city-manager-reports-cmrs/2022/id.-14174-earth-day-report-2022-edr22.pdf

[2] There are two reporting frameworks commonly used by cities: the U.S. Community Protocol and the Global Protocol for Communities (GPC). Palo Alto uses the GPC framework.

[3] Executive Department State of California. (2019). Executive Order B-55-18 to Achieve Carbon Neutrality. https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf.

[4] Formerly the International Council for Local Environmental Initiatives, renamed in 2003 to ICLEI – Local Governments for Sustainability.

inventories. The official GHG Protocol standard for Cities,[5] also known as GPC, provides a robust framework for accounting and reporting city-wide GHG emissions. AECOM utilized this framework when developing our 2020 GHG inventory. It seeks to:

- Help cities develop a comprehensive and robust GHG inventory to support climate action planning
- Help cities establish a base year emissions inventory, set reduction targets, and track their performance
- Ensure consistent and transparent measurement and reporting of GHG emissions between cities, following internationally recognized GHG accounting and reporting principles
- Enable city inventories to be aggregated at subnational and national levels
- Demonstrate the important role that cities play in tackling climate change, and facilitate insight through benchmarking – and aggregation – of comparable data

Palo Alto's first generation-based inventory was completed for 2005 and then extrapolated for 1990 (the baseline year). Beginning in 2010, new community GHG inventories were completed annually, enabling Palo Alto to track progress over time.

The 2020 Palo Alto GHG inventory uses the approach and methods provided by the GPC and was completed by AECOM. Inventory calculations were performed using the ClearPath[6] tool. The City's GHG inventory conforms to the GPC Basic protocol.

The GPC Basic protocol describes three emissions scopes for community emissions:

- **Scope 1:** GHG emissions from sources located within the city boundary, such as stationary fuel consumption.
- **Scope 2:** GHG emissions occurring because of the use of grid-supplied electricity, heat, steam, and/or cooling within the city boundary
- **Scope 3:** All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary

This inventory follows the city-inducted framework in the GPC, which totals GHG emissions attributable to activities taking place within the geographic boundary of the city[7]. Under the BASIC reporting level as defined by GPC, the inventory requirements cover scope 1 and scope 2 emissions from stationary energy and transportation, as well as all emissions resulting from waste generating within the city boundary.

[5] The GPC is the official protocol specified by the Global Covenant of Mayors and defines what emissions must be reported and how.
[6] https://icleiusa.org/clearpath/
[7] https://ghgprotocol.org/sites/default/files/standards/GHGP_GPC_0.pdf

1.b. Palo Alto's 2020 GHG Emissions
We recognize that these are unprecedented times created by the coronavirus pandemic. COVID-19 has brought disruption to cities and communities across the globe. On March 16, 2020, six Bay Area Counties - including Santa Clara – issued coordinated shelter-in place orders that were not phased out until more than two months later. The shelter-in place order, as well as changes in how and where people worked, greatly impacted energy use, vehicle miles traveled, and carbon dioxide emissions. The 2020 inventory includes these pandemic impacts, resulting in emissions reductions that may be temporary.

In 2020, Palo Alto emitted an estimated 385,320 metric tons (MT) of carbon dioxide equivalent (CO_2e) from the residential, commercial, industrial, transportation, waste, water, and municipal sectors.[8] In comparison to the 1990 base year, that is a 50.6 percent decrease in total community emissions, despite a population increase of 21.8 percent during that same time period. This equates to 5.7 metric tons of carbon dioxide equivalent (MT CO2e) per Palo Alto resident in 2020 compared to 14 MT CO2e per Palo Alto resident in 1990. The California Air Resources Board's 2017 Scoping Plan Update recommends local government goals of 6 MT C02e per capita by 2030.

Of that 50.6 percent reduction to-date, 47.1 percent came from achieving carbon neutrality for the City's electricity portfolio, 23.6 percent from declines in transportation emissions, 15.1 percent from reduction in natural gas consumption, 12.3 percent from declines in solid waste emissions, and the remaining reductions from other sources. In comparison to 2019, that is a 20.1 percent decrease in total community emissions. Without the effects of the pandemic, emissions reductions would be closer to 41.9 percent and 6.7 MT CO2e per resident.

Of the remaining emissions sources as of 2020, roughly 56.4 percent are from on-road transportation, 34.9 percent are from natural gas use, and the remainder are from other sources. A comparison of 1990, 2019, and 2020 GHG emissions is shown in Figure 1 and Table 1. The full comparison between the inventories can be found in Attachment A: 1990 vs. 2020 Greenhouse Gas Emissions by Sector and Subsector. Additional existing emissions sources that were missing from the 1990 GHG inventory were included in the 2020 GHG inventory to comply with the GPC Basic protocol (Airport Emissions, Off-road Vehicles, Caltrain Commuter Rail, Composting, and Palo Alto Landfill Gas Flaring). As shown in Attachment A, a total of 23,183 MT CO_2e was added from GHG emissions sources that were not included previously, accounting for 6.5 percent of total emissions.

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[8] Carbon dioxide equivalent is a unit of measure that normalizes the varying climate warming potencies of all six GHG emissions, which are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). For example, one metric ton of nitrous oxide is 210 metric tons of CO_2e.

Figure 1: 1990 vs 2020 GHG Emissions by Sector

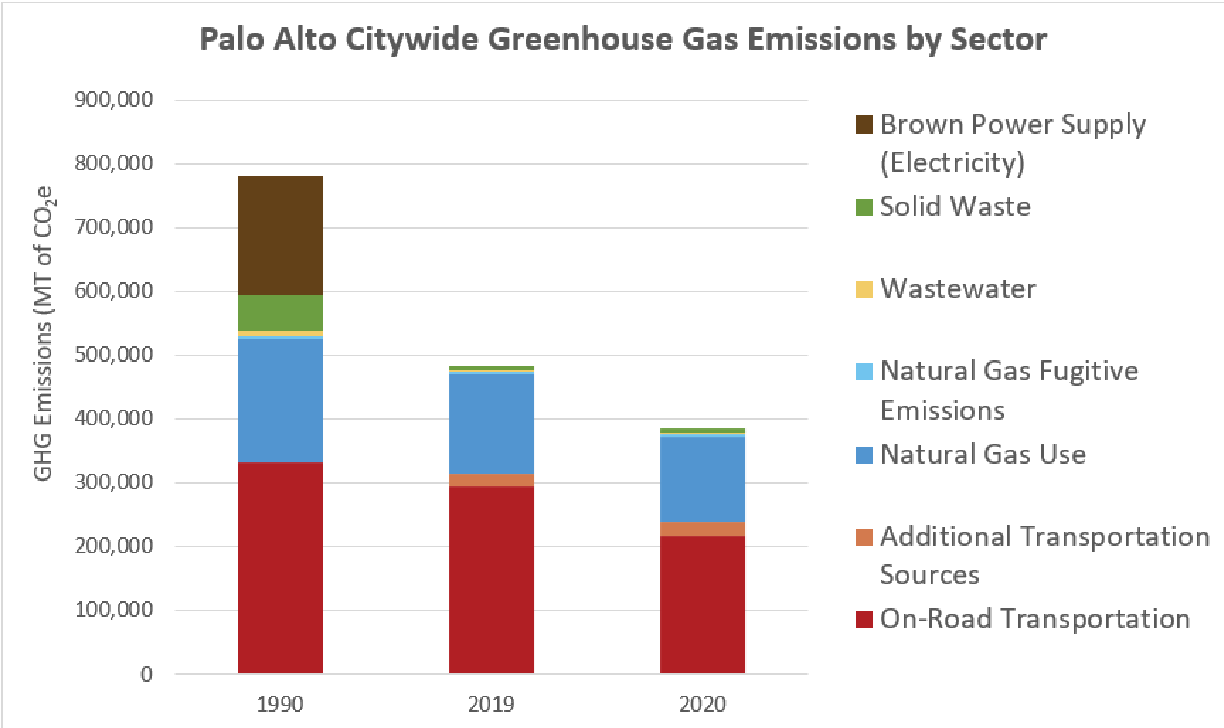
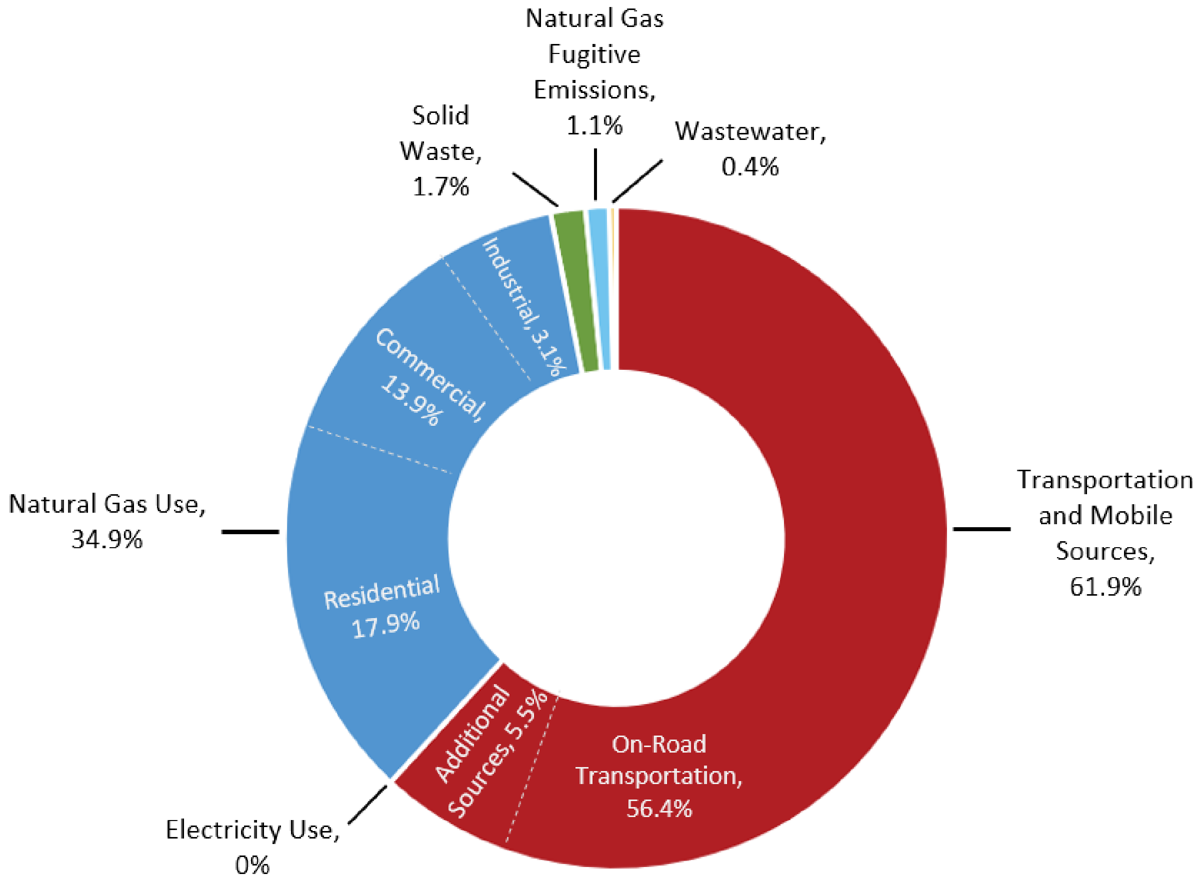


Table 1: 1990 vs 2020 GHG Emissions by Sector

Sector	1990 GHG emissions (MT CO_2e)	2019 GHG emissions (MT CO_2e)	2020 GHG emissions (MT CO_2e)	Percent Change in 2020 from 1990
On-Road Transportation	331,840	293,413	217,279	-34.5%
Additional Transportation Sources		21,668	21,244	n/a
Natural Gas Use	194,000	153,509	134,365	- 30.7%
Natural Gas Fugitive Emissions	4,718	5,009	4,384	- 7.1%
Wastewater	8,504	2,197	3,355	- 83.7%
Solid Waste	55,057	6,531	6,660	- 87.9%
Brown Power Supply (Electricity)	186,000			- 100%
Total GHG Emissions (MT CO_2e)	**780,119**	**482,237**	**387,287**	**- 50.6%**

As shown in Figure 2, the two largest categories of emissions are transportation and mobile sources (including on-road transportation, airport emissions, off-road vehicles, and Caltrain commuter rail) and natural gas use (including residential, commercial, and industrial).

Figure 2: 2020 GHG Emissions by Sector



Transportation and mobile sources include emissions from private, commercial, and fleet vehicles driven within the City's geographical boundaries, as well as the emissions from public transit vehicles and the City-owned fleet. Off-road vehicles include airport ground support, construction and mining, industrial, light commercial, portable equipment, and transportation refrigeration.

Natural gas use includes emissions that result from natural gas consumption in both private and public sector buildings and facilities, and residential, commercial, and industrial sources. Fugitive Emissions related to natural gas consumption are calculated separately and are discussed in Section 1.d. The City's electricity supply has been carbon neutral since 2013, when Council approved a Carbon Neutral Electric Resource Plan, committing Palo Alto to pursuing only carbon-neutral electric resources and effectively eliminating all GHG emissions from the City's electric portfolio.

1.c. Transportation and Mobile Sources

In 2020, transportation and mobile sources accounted for roughly 61.9 percent of total 2020 GHG emissions in Palo Alto. As shown in Table 2, transportation and mobile sources consist of:

- On-Road Transportation – This includes all daily vehicular trips made entirely within the Palo Alto city limits, one-half of daily vehicular trips with an origin within Palo Alto city limits and a destination outside of Palo Alto city limits (this assumes that Palo Alto shares half the responsibility for trips traveling from other jurisdictions), and one-half of daily vehicular trips with an origin outside Palo Alto city limits and a destination within Palo Alto city limits (this assumes that Palo Alto shares the responsibility of trips traveling to other jurisdictions). Vehicular trips through Palo Alto are not included because Palo Alto cannot solely implement policies that influence the trip-making behavior. Rather, through trips are assigned to other jurisdictions that can influence either the origin or destination side of the trip-making behavior.
- Airport Emissions – This includes emissions from take-offs and landings from trips that start and end at Palo Alto Airport. This includes emergency services helicopters, sightseeing helicopters, and training flights. Flights that take-off from Palo Alto Airport but land elsewhere, and flights that land in Palo Alto Airport but take-off from elsewhere are not included per GPC Basic.
- Off-road Vehicles - This includes airport ground support (based on take-offs and landings), construction and mining, industrial (based on employment data), light commercial (based on employment data), portable equipment (e.g. back-pack leaf blower, based on service population), and transportation refrigeration units (based on service population).
- Caltrain Commuter Rail – This includes emissions from Caltrain travel within Palo Alto.

Table 2: 2020 Transportation and Mobile Sources

Subsector	2019 GHG emissions (MT CO_2e)	2020 GHG emissions (MT CO_2e)	Percent of Total 2020 Emissions (%)
On-Road Transportation	293,413	217,279	56.4%
Airport Emissions	2,192	1,664	0.4%
Off-road Vehicles	14,634	15,029	3.9%
Caltrain Commuter Rail	4,842	4,552	1.2%
Total Transportation & Mobile Sources	**315,081**	**238,523**	**61.9%**

Estimating vehicles miles traveled (VMT) is a complicated process and is one of the few emissions sources that the City does not estimate annually. Forecasts of on-road transportation emissions are typically based on outputs from a travel forecasting model, other accounting-type method (sketch models), or Big Data (vehicle navigation data from built-in GPS and location-based services data from cell-phones). Previously, Fehr & Peers provided VMT estimates for 2019, 2030, and 2040. Per the current Santa Clara Valley Transportation Authority (VTA) transportation model, in 2019 Palo Alto's annual VMT was roughly 952,584,400. However, the model that Fehr & Peers used to provide VMT estimates was based on pre-pandemic travel patterns. The temporary Shelter-in Place order, combined with more people working from home, resulted in a decrease in VMT throughout the Bay Area. Comparing California

Department of Transportation traffic count data[9] during the same two-week period starting the Tuesday after Thanksgiving, the data shows that in Santa Clara County, VMT dropped 23.4 percent in 2020 compared to 2019. While the traffic count data is for all of Santa Clara County and not exclusive to Palo Alto, the 23.4 percent reduction in VMT was used to estimate Palo Alto's 2020 annual VMT. The VTA model used to calculate Palo Alto's 2019 annual VMT is only updated every few years, so until the model is updated to better reflect changes in VMT due to the pandemic, we are limited in our options for modeling our VMT annually.

If we include the effects of the pandemic on VMT, on-road transportation accounts for approximately 56.4 percent of Palo Alto's total emissions, with a 25.9 percent decrease from 2019 and a 34.5 percent decrease from 1990. However, these reductions are largely because of the pandemic and may be temporary. If we don't adjust Palo Alto's annual VMT to better reflect the effects of the pandemic on transportation, then on-road transportation would account for approximately 62.9 percent of Palo Alto's total emissions, with a 2.9 percent decrease from 2019 and a 14.1 percent decrease from 1990.

Off-road transportation accounts for approximately 3.9 percent of Palo Alto's total emissions, with a 2.7 percent increase from 2019. Off-road transportation emissions were not calculated in 1990. It is important to note that most of the off-road transportation emissions are based on models at the County level that were not adjusted to reflect any pandemic-induced activity changes.

Caltrain electrification is a key component of the Caltrain Modernization program[10], with Caltrain scheduled to be electrified in 2023. Once the Caltrain Modernization program is complete, most of the Caltrain commuter rail emissions will be eliminated.

1.d Natural Gas Use

In 2020, natural gas emissions accounted for 34.9 percent of total 2020 GHG emissions in Palo Alto, with a 12.5 percent decrease from 2019 and a 30.7 percent decrease from 1990. As shown in Table 3, Palo Alto's total natural consumption in 2020 was 25,267,739 therms. Residential energy accounts for 17.9 percent of total emissions, commercial energy accounts for 13.9 percent of total emissions, and industrial energy accounts for 3.1 percent of total emissions. The pandemic drastically affected natural gas consumption. The temporary shelter-in place order, as well as changes in how and where people worked, resulted in major changes in the commercial and industrial sectors, with fewer people staying in hotels, going to restaurants, and going to retail establishments. Natural gas emissions decreased by 19,763 MT CO_2e between 2019 to 2020, representing 15.1 percent of total emissions reductions.

City Council unanimously approved Palo Alto's Carbon Neutral Natural Gas Plan on December 5, 2016. The Natural Gas Plan, implemented on July 1, 2017, achieves carbon neutrality for the gas supply portfolio by 1) purchasing high-quality carbon offsets equivalent to our City and

[9] https://dot.ca.gov/programs/traffic-operations/census
[10] https://calmod.org/

community natural gas emissions; 2) pursuing efficiency strategies to reduce natural gas use, and 3) seeking opportunities to fund local offsets that finance actual emissions reductions in Palo Alto and the surrounding region. As a bridging strategy, carbon offsets are being purchased in an amount equal to the GHG emissions caused by natural gas use within the City. However, offsets are not included in this GHG inventory.

Table 3: 2020 Natural Gas Use

Subsector	2019 Consumption (Therms)	2019 GHG emissions (MT CO_2e)	2020 Consumption (Therms)	2020 GHG emissions (MT CO_2e)	Percent of Total 2020 Emissions (%)
Residential Energy	13,565,360	72,149	12,952,262	68,889	17.9%
Industrial Energy	2,707,034	14,373	2,253,635	11,961	3.1%
Commercial Energy	12,954,768	66,987	10,061,842	53,515	13.9%
Total Natural Gas Use	**28,867,162**	**153,509**	**25,267,739**	**134,365**	**34.9%**

Natural Gas Fugitive Emissions
Natural gas is mainly methane (CH_4), some of which escapes during the drilling, extraction, and transportation processes. Such releases are known as fugitive emissions. The primary sources of these emissions may include equipment leaks, evaporation losses, venting, flaring and accidental releases. Methane is a potent greenhouse gas – approximately 25 times more powerful than carbon dioxide over a 100-year timescale.

In 2020, natural gas fugitive emissions accounted for 1.1 percent of total 2020 GHG emissions in Palo Alto, which is decrease of 12.5 percent from 2019 and a decrease of 7.1 percent from 1990. Per the GPC, fugitive emissions from natural gas are based on overall community consumption and a leakage rate of 0.03 percent.

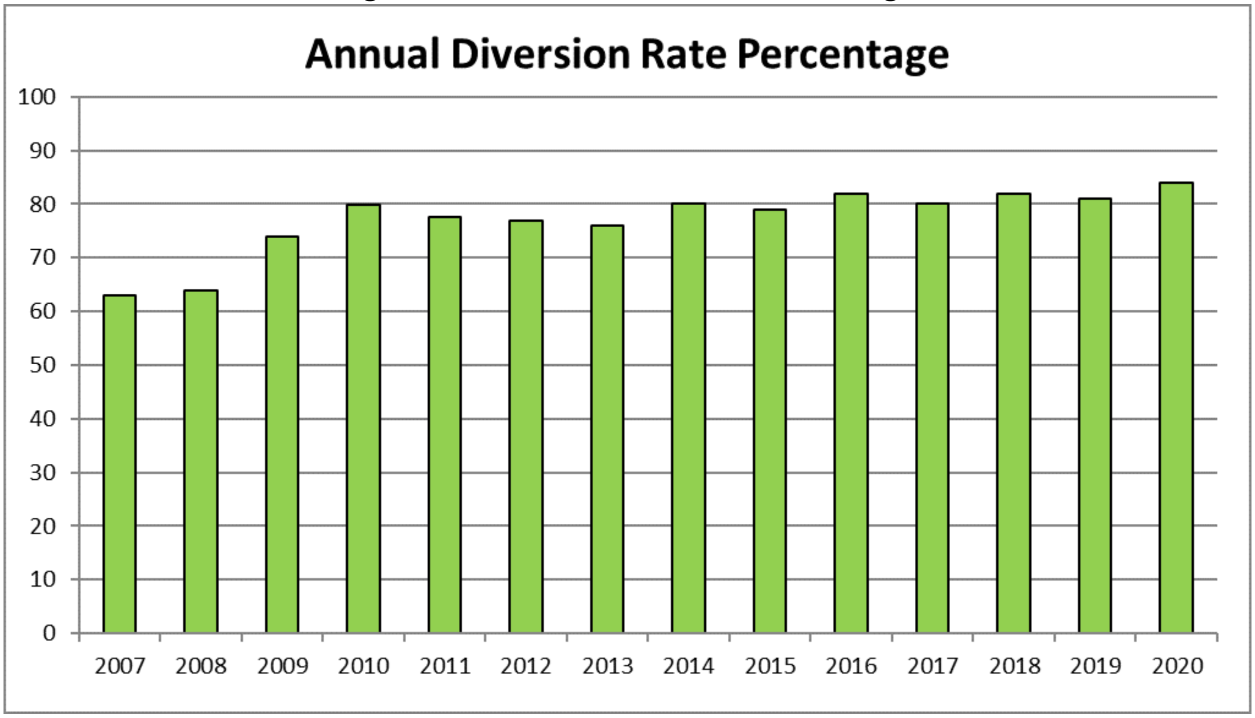
As mentioned in Section 1.a., the GPC Basic methodology includes GHG emissions attributable to activities taking place within the geographic boundary of the city. As such, the 2020 GHG inventory does not include a category of emissions that are called "upstream emissions".

1.e. Solid Waste
In 2020, Palo Alto's solid waste diversion rate was 84 percent. "Diversion" includes all waste prevention, reuse, recycling, and composting activities that "divert" materials from landfills. In 2015, the national average of landfill diversion was 34.7 percent. In 2017, California's statewide diversion rate was 58 percent, which continues to outpace the 50 percent diversion mandate set for local jurisdictions.[11] The City uses the diversion rate to measure progress on waste reduction and resource conservation goals. As shown in Figure 3, the diversion rate of 84 percent is an improvement from the rate of 62 percent in 2007 but has remained relatively flat

[11] https://www.calrecycle.ca.gov/lgcentral/goalmeasure/disposalrate/graphs/estdiversion

the last few years. As part of the 2016 S/CAP Framework, Council adopted a goal of 95 percent diversion of materials from landfills by 2030[12].

Figure 3: Annual Diversion Rate Percentage



Solid waste emissions accounted for 1.7 percent of total 2020 GHG emissions in Palo Alto, which is an increase of 2 percent from 2019 and a decrease of 87.9 percent from 1990. It must be noted that solid waste emissions were calculated using a different methodology than 1990 for the 2020 GHG inventory.[13] In addition, as shown in Table 4, the 1990 inventory included Palo Alto Landfill Gas Fugitive emissions, whereas the 2020 inventory did not, and the 2020 inventory included composting emissions at the ZeroWaste Energy Development Company's (ZWED) Dry Fermentation Anaerobic Digestion (AD) Facility in San Jose, CA, composting emissions at the Synagro El Nido Central Valley Composting (CVC) facility in Dos Palos, as well as Palo Alto Landfill Gas Flaring Emissions while the 1990 inventory did not. The increase in solid waste emissions from 2019 is due largely to the increase in composting emissions. The 2019 data source for ZWED compost feedstock is no longer available. The new data source shows an undercount of 2019 ZWED compost by more than double what was previously reported. In addition, compost emissions from wastewater sludge at Synargo was not included in previous GHG emissions inventories, since the wastewater sludge is a new source of emissions related to the decommissioning of the sewage sludge incinerators, as described in further detail in section

[12] https://www.cityofpaloalto.org/civicax/filebank/documents/64814

[13] The 1990 Solid Waste emissions were calculated using the EPA WARM methodology, which includes lifecycle emissions and emissions from landfilling recyclable material; waste was landfilled inside and outside Palo Alto. The 2020 Solid Waste emissions were calculated using the ICLEI (Local Governments for Sustainability) ClearPath tool, which includes composting and Palo Alto landfill gas flaring emissions; waste is landfilled and composted outside of Palo Alto and methane flared in closed landfill.

1.f. We are not updating the 2019 GHG inventory but recognize that the new data source and new source of emissions for composting related emission results in an overly inflated increase in composting emissions relative to 2019.

In 2020, emissions from landfills located within the community accounted for 1.2 percent of total waste emissions.

Table 4: 1990 vs 2020 Solid Waste Emissions by Subsector

Subsector	1990 GHG emissions (MT CO_2e)	2019 GHG emissions (MT CO_2e)	2020 GHG emissions (MT CO_2e)	Percent of Total 2020 Emissions (%)
Composting	Not included	731	1,623	0.4%
Palo Alto Landfill Gas Flaring	Not included	281	316	0.1%
Palo Alto Landfill Gas Fugitive	24,325	n/a[14]	n/a	n/a
Landfill Waste	30,732	5,519	4,721	1.2%
Total	**55,057**	**6,531**	**6,660**	**1.7%**

Waste emissions result from organic material decomposing in the anaerobic conditions present in a landfill and releasing methane (CH_4) – a greenhouse gas much more potent than CO_2. Organic materials (e.g., paper, plant debris, food waste, etc.) generate methane within the anaerobic environment of a landfill while non-organic materials (e.g., metal, glass, etc.) do not.

1.f. Wastewater

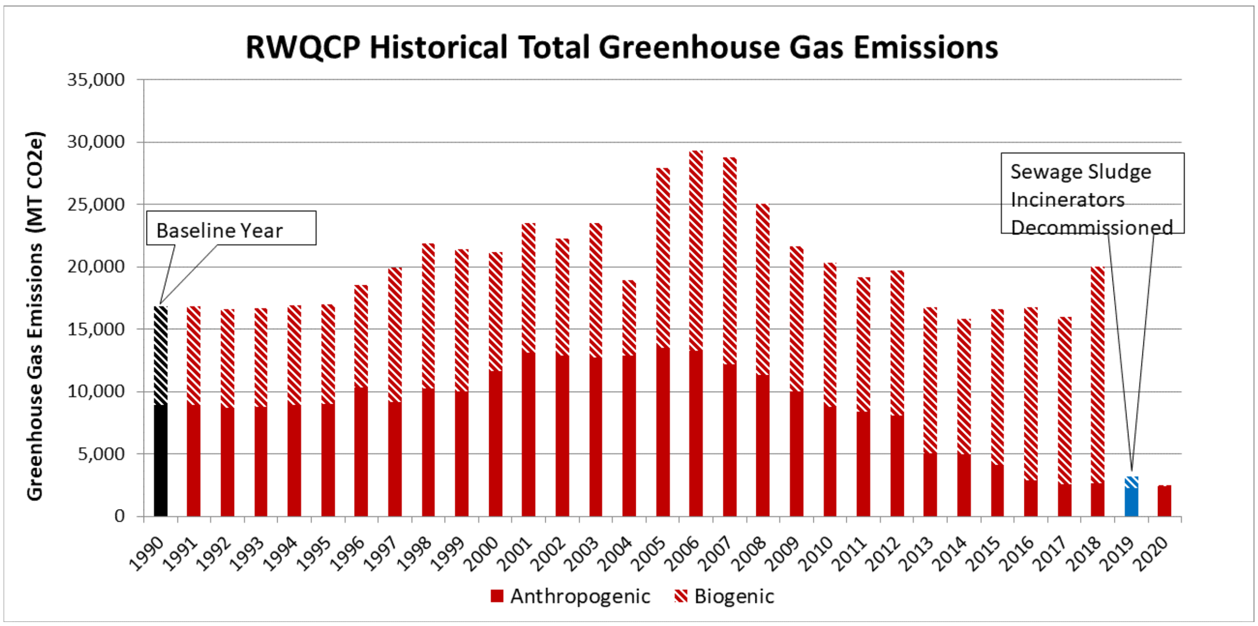
As shown in Table 5, in 2020, wastewater emissions accounted for 0.4 percent of total 2020 GHG emissions in Palo Alto, which is a decrease of 36.8 percent from 2019 and a decrease of 83.7 percent from 1990. These emissions include wastewater biosolid treatment (which were eliminated with the decommissioning of the sewage sludge incinerators) and wastewater treatment and effluent. In March 2019, the City of Palo Alto's Regional Water Quality Control Plant (RWQCP) replaced the City facility with the largest energy use - the sewage sludge incinerators - with a more environmentally friendly Sludge Dewatering and Truck Loadout Facility. The updated treatment process will reduce climate-warming GHG emissions by approximately 15,000 MT of CO_2e per year – this approximates the carbon dioxide emissions of 3,000 passenger cars. The replacement technologies dewater the sludge and send it to farm areas to produce agricultural soil supplements.

[14] Not included because the landfill was closed

Table 5: 1990 vs 2020 Wastewater Emissions by Subsector

Subsector	1990 GHG emissions (MT CO_2e)	2019 GHG emissions (MT CO_2e)	2020 GHG emissions (MT CO_2e)	Percent of Total 2020 Emissions (%)
Wastewater Biosolid Treatment[15]	n/a	812 (new)	0[16]	0%
Wastewater Treatment and Effluent	8,504	1,385	1,388	0.4%
Total	**8,504**	**2,197**	**1,388**	**0.4%**

Figure 4: RWQCP Historical Total Greenhouse Gas Emissions



[15] Includes biosolid composting, anaerobic digestion, and incineration

[16] This was incorrectly reported as 1,967 MT CO_2e in Staff Report 1474: https://www.cityofpaloalto.org/files/assets/public/agendas-minutes-reports/reports/city-manager-reports-cmrs/2022/id.-14174-earth-day-report-2022-edr22.pdf

Attachment A: 1990 vs. 2020 Greenhouse Gas Emissions by Sector and Subsector

Sector and Subsector	1990 GHG emissions (MT CO_2e)[1]	2019 GHG emissions (MT CO_2e)	2020 GHG emissions (MT CO_2e)	Percent Change in 2020 from 1990 (%)	Percent of Total 2020 Emissions (%)
Total Transportation and Mobile Sources	**331,840**	**315,081**	**238,523**	**-28.1%**	**61.9%**
- On-Road Transportation	331,840	293,413	217,279	-34.5%	56.4%
- Airport Emissions	Not Included	2,192	1,664	n/a	0.4%
- Off-road Vehicles	Not Included	14,634	15,029	n/a	3.9%
- Caltrain Commuter Rail	Not Included	4,842	4,552	n/a	1.2%
Total Natural Gas Use	**194,000**	**153,509**	**134,365**	**-30.7%**	**34.9%**
- Commercial Energy	Not calculated	66,987	53,515	n/a	13.9%
- Industrial Energy	Not calculated	14,373	11,961	n/a	3.1%
- Residential Energy	Not calculated	72,149	68,889	n/a	17.9%
Natural Gas Fugitive Emissions	**4,718**	**5,009**	**4,384**	**-7.1%**	**1.1%**
Total Wastewater	**8,504**	**2,197**	**3,355**	**-83.7%**	**0.4%**
- Wastewater Biosolid Treatment[2]	n/a	812 (new)	0	n/a	0%
- Wastewater Treatment and Effluent	8,504	1,385	1,388	-83.7%	0.4%
Total Solid Waste	**55,057**	**6,531**	**6,660**	**-87.9%**	**1.7%**
- Composting	Not Included	731	1,623	n/a	0.4%
- Palo Alto Landfill Gas Flaring[3]	Not Included	281	316	n/a	0.1%
- Palo Alto Landfill Gas Fugitive	24,325	n/a[4]	n/a	n/a	n/a
- Landfill Waste	30,732	5,519	4,721	-84.6%	1.2%
Brown Power Supply (Electricity)	186,000	n/a	n/a	**-100.0%**	n/a
Total GHG Emissions (MT CO_2e)	**780,119**	**482,237**	**385,320**	**-50.6%**	100%
- Total Additional Emissions Sources		23,493	23,183		6.0%

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[1] Source: 2016 S/CAP Framework and 2016 Earth Day Report
[2] Includes biosolid composting, anaerobic digestion, and incineration
[3] 2016 Earth Day Report labeled these emissions as biogenic
[4] Not included because the landfill was closed