LEAD BY EXAMPLE

A Plan for Carbon Neutral Municipal Operations

DRAFT

Appendix A: Greenhouse Gas Emissions Inventory and Forecast

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1. INTRODUCTION

1.1 Municipal GHG Inventory Overview

In 2020, the City of San Luis Obispo (City) adopted the City of San Luis Obispo Climate Action Plan for Community Recovery (CAP). The CAP provides a pathway to achieve community carbon neutrality by 2035 while also advancing equity initiatives and accelerating the transition to a green local economy as the community recovers from the COVID-19 crisis. The CAP consists of six greenhouse gas (GHG) sector related pillars including Clean Energy, Green Buildings, Connected Community, Circular Economy, Natural Solutions, and Lead by Example.

The Lead by Example pillar's goals included achieving carbon neutral government operations by 2030 and adopting a carbon neutral municipal operations plan (now titled *Lead by Example: A Plan for Carbon Neutral Municipal Operations*) by July 2021. Although the City's operational emissions are only approximately 1.5% of community emissions, the Lead by Example pillar is important because it allows the City to illustrate the feasibility, challenges, and benefits of pursuing and achieving carbon neutral operations.

A GHG inventory and forecast is the technical foundation of any GHG emissions reduction plan. The City prepared an updated 2005 baseline municipal GHG emissions inventory and a 2019 "check-in" emissions inventory update compliant with relevant protocols and guidance documents including the Local Government Operations Protocol. The Local Government Operations Protocol is the national standard for identifying sectors, quantifying, and reporting emissions from operational activities and assets. Consistent with the Local Government Operations Protocol's Scope 1 and Scope 2[1] emissions sectors, this inventory includes emissions from the use of electricity, onsite fuel combustion (i.e., natural gas), energy used for water and wastewater conveyance and treatment, on-road vehicles, and generation of solid-waste.[2] This report presents a summary of the updated 2005 GHG emissions, details the 2019 municipal operations GHG inventory completed in 2021, and provides emissions forecasts for 2025 and 2030.[3]

Greenhouse gas emissions are not measured directly. They are modeled and estimated by multiplying data about some activity (e.g., the amount of electricity consumed, the number of miles travelled in fossil fuel powered vehicles, the tons of solid waste sent to the landfill, etc.) by the greenhouse gas emission content of a typical unit of that activity (e.g., the average greenhouse gas emissions content per therm of combusted natural gas). This inventory accounts for three common greenhouse gasses: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_20). Since methane and nitrous oxide are substantially more potent greenhouse gases than carbon

[1] Scope 1 covers all direct emissions from City-owned property and assets, with the exception of direct CO_2 from biogenic sources. Scope 2 covers indirect emissions associated with the consumption of purchased or acquired electricity, steam, heating, or cooling. More information can be found at https://ww3.arb.ca.gov/cc/protocols/localgov/pubs/lgo_protocol_v1_1_2010-05-03.pdf.
[2] The electricity and natural gas sectors of the City's GHG inventory include energy used to convey and treat water.
[3] Due to lagging data availability, 2019 is the most recent year for complete GHG inventory data. Annual inventory updates will occur beginning in 2021. Where more current information is available by sector, it is provided in this report.

dioxide (86 and 265 times more potent, respectively), the emissions modeled from their release into the atmosphere are multiplied by their respective potential to warm the atmosphere relative to CO_2. The common reporting unit for greenhouse gas emissions is "Metric Tons of Carbon Dioxide Equivalence", or $MTCO_2e$.

1.2 2005 Municipal GHG Inventory

In 2020-21, the City prepared a municipal operations inventory of GHG emissions for the 2005 calendar year. City municipal operations total 2005 baseline GHG emissions are estimated to be 6,730 metric tons of carbon dioxide equivalent ($MTCO_2e$). The inventory includes Building and Facility Energy, Fleet, Employee Commute and Solid Waste sectors[4]. Of the four sectors, Building & Facility Energy contributes the largest amount of GHG emissions with estimated emissions of 3,550 $MTCO_2e$ or 53 percent of the total municipal emissions. The second largest sector is Fleet with estimated emissions of 2,250 $MTCO_2e$ or 33 percent of the total City emissions. The third largest sector is Employee Commute with estimated emissions of 810 $MTCO_2e$ or 12 percent. The Solid Waste sector makes up the remaining two percent of the total city operations emissions. Table 1.1 presents the updated estimated 2005 GHG emissions by sector and their percent of total emissions.

Table 1.1. San Luis Obispo municipal GHG emissions (2005).

Sector	Subsector	Subsector MTCO2e	Sector MTCO2e	Sector Percent of Total
Energy	Municipal electricity use	2,830	3,550	53%
	Municipal natural gas use	720		
Fleet	Fleet gasoline	730	2,250	33%
	Fleet diesel	1,520		
Employee Commute			810	12%
Solid Waste			120	2%
Total			6,730	100%

1.3 2019 Municipal GHG Inventory

Table 1.2 provides the 2019 GHG emissions inventory results. In 2019, total municipal GHG emissions are estimated to be 5,100 $MTCO_2e$. As in 2005, Building and Facility Energy is the largest contributor, with an estimated 2,130 $MTCO_2e$ or 42 percent of the total operational emissions. Fleet is the second largest sector with 2,090 $MTCO_2e$ or 41 percent of the total operational emissions. The third largest sector is Employee Commute with estimated emissions of 730 $MTCO_2e$ or 14 percent. The Solid Waste sector makes up the remaining two percent of the total city operations emissions.

[4] Staff also calculated direct process emissions from wastewater treatment, but they are not included in total estimated emissions for 2005 or 2019 due to indefensible methods. Estimated emissions for these processes are included in the Wastewater section as an informational item.

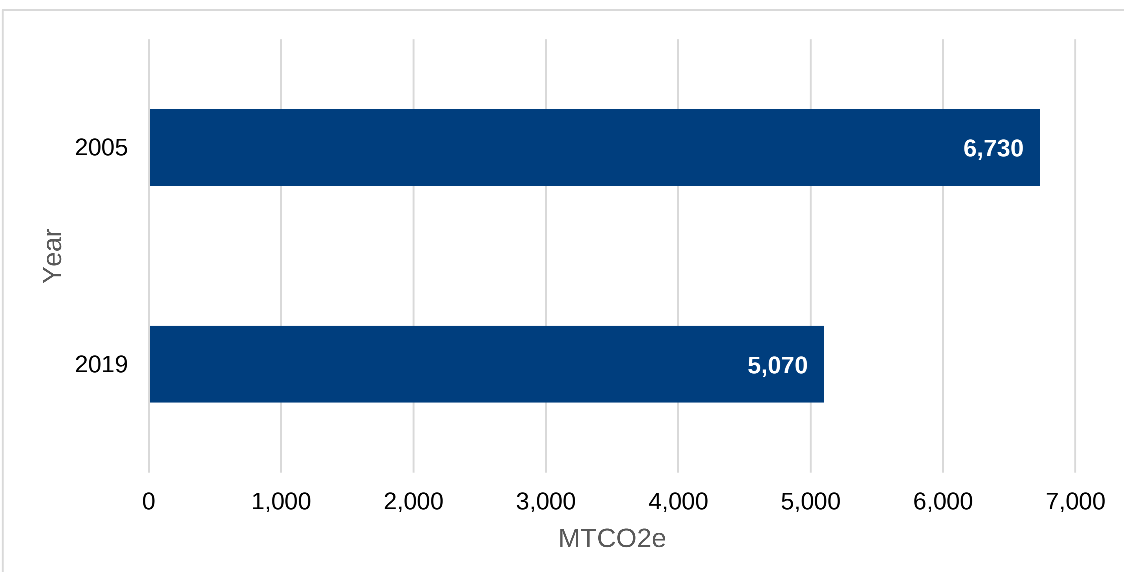
Table 1.2. San Luis Obispo municipal GHG emissions (2019).

Sector	Subsector	Subsector $MTCO_2e$	Sector $MTCO_2e$	Sector Percent of Total
Energy	Municipal electricity use	1,310	2,130	42%
	Municipal natural gas use	820		
Fleet	Fleet gasoline	660	2,090	41%
	Fleet diesel	1,430		
Employee Commute		--	730	14%
Solid Waste		--	120	3%
Total			5,070	100%

1.3 GHG Inventory Comparison

Between baseline year 2005 and inventory year 2019, municipal operations GHG emissions decreased by 1,660 $MTCO_2e$, or approximately 25 percent. This reduction in annual emissions can be attributed to a variety of energy efficiency projects that were implemented by the City, and the gradual reduction in greenhouse gas intensity of the electricity grid. Figure 1.1 shows the total inventoried greenhouse gas emissions for calendar years 2005 and 2019.

Figure 1.1 Total municipal GHG emissions, 2005 and 2019.



2. BUILDING & FACILITY ENERGY

2.1 Municipal Energy Sector Overview

This section presents the 2005 and 2019 GHG emissions for the Building & Facility Energy sector, which includes emissions generated from electricity and natural gas use that has occurred as a result of municipal operations.

2.2 Inventory Data and Methods

This section provides municipal electricity and natural gas activity data and emissions estimates for the baseline years of 2005 and 2019. Emissions estimates are calculated by multiplying the activity data (kWh for electricity and therms for natural gas) by an emissions coefficient provided by the utility or from the Local Government Operations Protocol.

2.2.1 Electricity

Pacific Gas & Electric (PG&E) Company provides municipal operations electricity data upon request from City staff. Between 2005 and 2019, annual electricity activity decreased by 2,839,970 kWh, or 23 percent. Between 2013 and 2019, the City implemented a number of energy efficiency projects across municipal buildings and facilities, including key street lighting retrofits, which is reflected in decreases in activity data. Activity data for calendar year 2017 was not provided in its entirety by PG&E and is not included in this data set.

To calculate GHG emissions, an emissions factor is applied to the activity data. PG&E staff provided CO_2 emissions factors via a City staff request. Due to changes in PG&E's energy portfolio (and particularly an increase in renewable energy supplies), the 2019 emissions factor is approximately 40 percent lower than the 2005 factor.

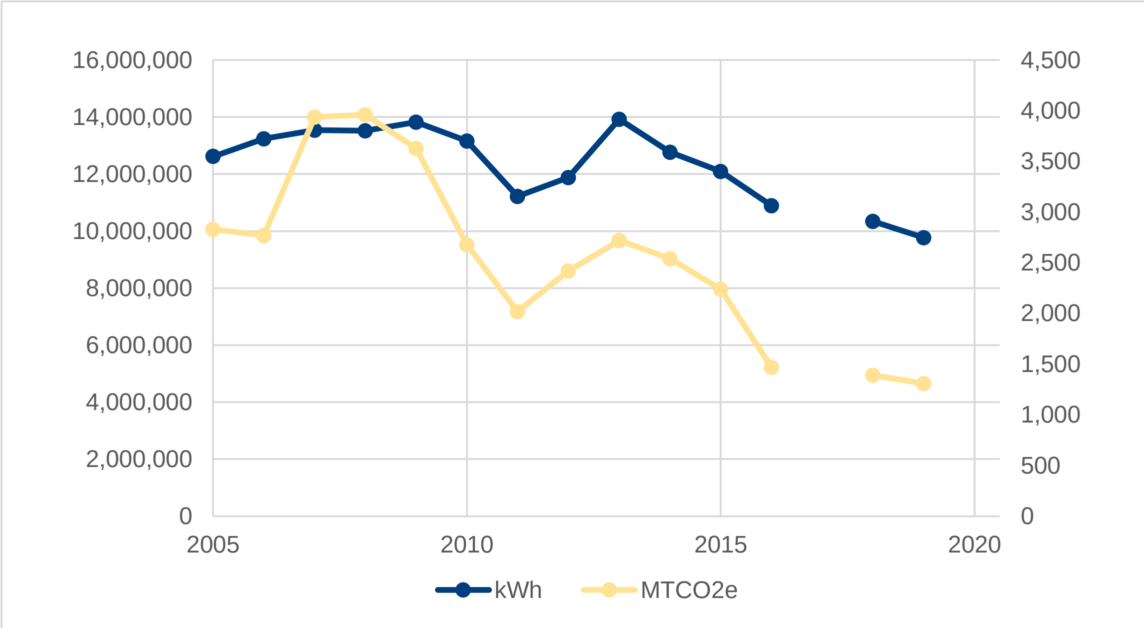
Table 2.1 provides the activity data, emissions factor, and GHG emissions from municipal electricity use from 2005 to 2019. During this time, electricity related GHG emissions decreased by 1,520 $MTCO_2e$, or approximately 54 percent. Staff attribute this decrease in energy use activity data and GHG emissions to widespread facility efficiency projects beginning in 2013, including streetlight LED retrofits and the integration of an onsite co-generation system at the Water Resource Recovery Facility (WRRF). Coupled with the observed decrease in electricity activity data as explained above, decreasing emissions intensity for electricity (activity data for calendar year 2017 was not provided in its entirety by PG&E, so annual $MTCO_2e$ was not calculated for that year).

Table 2.1. Municipal electricity activity data, 2005-2019 (kWh).

Year	Annual Activity Data (kWh)	$MTCO_2e/kWh$	Total ($MTCO_2e$)
2005	12,615,160	0.000224	2,830
2006	13,235,010	0.000208	2,770
2007	13,547,430	0.000290	3,940
2008	13,524,290	0.000292	3,960
2009	13,821,810	0.000262	3,630
2010	13,157,170	0.000203	2,680
2011	11,219,720	0.000179	2,020
2012	11,877,650	0.000203	2,420
2013	13,924,720	0.000195	2,720
2014	12,766,050	0.000198	2,540
2015	12,098,390	0.000185	2,240
2016	10,888,880	0.000135	1,470
2017	--	--	--
2018	10,341,149	0.000134	1,390
2019	9,775,190	0.000134	1,310

Figure 2.1 illustrates GHG and kWh activity data between 2005 and 2019. It is important to note that while overall electricity use has been steadily decreasing, GHG emissions have been more variable due to changes in PG&E's power portfolio and the related carbon intensity of the electricity it supplies.

Figure 2.1. Total municipal electricity activity data and GHG estimates, 2006-2019.



2.2.2 Utilities Electricity

The above total electricity data for the City of San Luis Obispo is tied to two major funding sources: the General Fund and the Utilities Fund. The Utilities Fund includes electricity use for the conveyance and treatment of potable drinking water and wastewater. Based on research from staff, it is estimated that approximately 65 percent of total City electricity use can be attributed to critical services related to water and wastewater within the Utilities Fund. In future Lead by Example updates, staff commit to working with the Utilities Department to utilize the in-development Utilities energy management dashboard to gain a deeper understanding of electricity use associated with these critical services and more clearly communicate how energy is used across City operations.

To source potable drinking water, the City actively manages a portfolio of reservoirs that are either owned by the City or partner agencies and jurisdictions. The amount of water conveyed from a given source at any time depends on a variety of factors that are overseen by the Utilities Department. While electricity use associated with pumping at the City-owned Whale Rock reservoir is included in this inventory, pumping at the Nacimiento and Salinas reservoirs are considered out of scope as they are not owned by the City and are simultaneously utilized by other jurisdictions. As new operational emissions reporting protocols emerge, staff will consider including electricity use from these secondary reservoirs in future inventory updates.

2.2.3 Natural Gas – Direct Emissions

Natural gas is primarily composed of methane and includes very small amounts of ethane, propane, butane, pentane, nitrogen, and carbon dioxide. When natural gas is combusted, most of the methane becomes carbon dioxide and water. Traditionally, greenhouse gas emissions inventories account for the emissions that occur as the result of the onsite combustion of natural gas. However, some of the un-combusted gas escapes as fugitive methane. Southern California Gas Company (SoCalGas) provides natural gas utility services to the City. Table 2.3 provides the natural gas activity data in therms from 2005-2019. Activity data for calendar years 2008 through 2013 was not provided by SoCal Gas and is not included in this data set.

Table 2.3. Community natural gas activity data, 2005-2019 (Therms).

Year	Total
2005	133,607
2006	193,517
2007	160,264
2008 – 2013	Data Not Available
2014	182,045
2015	130,865
2016	149,676
2017	154,877
2018	145,790
2019	154,125

Just as with electricity, GHG emissions are estimated from activity data by applying an emission coefficient to the activity data. Table 2.4 shows the emission coefficient for converting therms of natural gas combusted on-site to $MTCO_2e$. Unlike electricity, the inventory assumes no changes in the carbon intensity of combusting natural gas in any given year, as the chemical composition of combusted natural gas does not substantially vary from year to year.

Table 2.4. Local Government Operations Protocol (LGOP) natural gas carbon dioxide equivalent.

Greenhouse Gas	$MTCO_2e$/Therm
CO_2	0.005310
CH_4	0.000043
N_2O	0.000003
CO_2e	**0.005320**

Table 2.5 provides GHG emissions estimates in $MTCO_2e$ for natural gas consumption in the agency from 2005-2019. As noted in the natural gas activity data, there was a total increase in natural gas-related emissions of approximately 13 percent. Activity data for calendar years 2008 through 2013 was not provided by SoCal Gas annual $MTCO_2e$ was not calculated for those years.

Table 2.5. Municipal Natural Gas GHG estimates, 2005-2019 ($MTCO_2e$).

Year	Total (MTCO2e)
2005	720
2006	1,040
2007	860
2008-2013	Data Not Available
2014	970
2015	700
2016	800
2017	830
2018	780
2019	820

2.2.3 Natural Gas – Fugitive Emissions

Methane is a powerful greenhouse gas and 86 times stronger than carbon dioxide over a 20-year time period in the atmosphere. As more is learned about the total natural gas system leakage rate from well head, through the transmission system, to the distributions system, and at the end use, it is becoming clear that fugitive methane emissions from the usage of natural gas is a critical component of the climate crisis. Staff is currently working with technical experts to identify a defensible method for estimating these emissions. Although not included in this report, they will likely be included in future reports and are expected to substantially increase the emissions profile of natural gas consumption.

2.3 Total Energy GHG Emissions

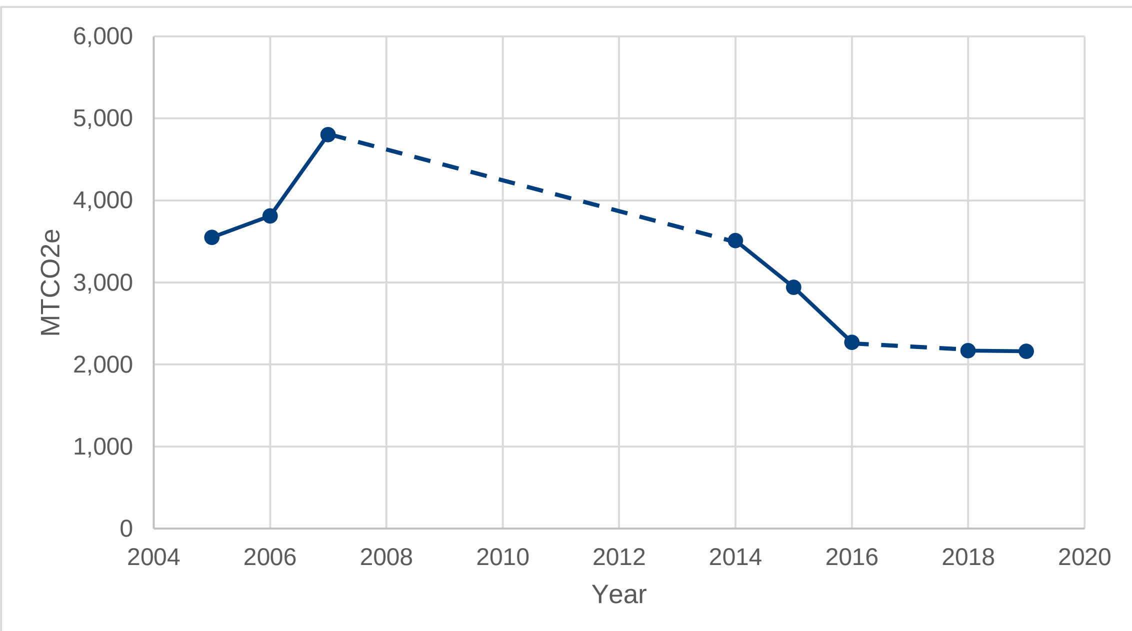
Table 2.6 and Figure 2.2 show the total energy related GHG emissions from electricity and natural gas. Between 2005 and 2019, total energy related GHG emissions decreased by approximately 39 percent. Note that Figure 2.2 provides total energy sector emissions with a dark line; the dashed line indicates a total emissions estimate necessitated by missing data.

As described in the above sub-sections, the net decrease in energy related GHG emissions between 2005 and 2019 can be attributed to a decrease in electricity consumption because of wide-ranging energy efficiency projects. The electricity emissions factor for PG&E also decreased by nearly half between 2005 and 2019 due to a reduced carbon intensity of grid-sourced electricity. Natural gas use showed a slight total increase between 2005 and 2019 but remained relatively stable, and the natural gas emissions factor stayed consistent. These combined factors resulted in a significant decrease in energy GHG emissions in 2019 compared to the baseline year of 2005.

Table 2.6. Energy GHG emissions, 2005-2019 ($MTCO_2e$).

Year	Electricity	Natural Gas	Total
2005	2,830	720	3,550
2006	2,770	1,040	3,810
2007	3,940	860	4,800
2008	3,960	--	--
2009	3,630	--	--
2010	2,680	--	--
2011	2,020	--	--
2012	2,420	--	--
2013	2,720	--	--
2014	2,540	970	3,510
2015	2,240	700	2,940
2016	1,470	800	2,270
2017	--	830	--
2018	1,390	780	2,170
2019	1,310	820	2,130

Figure 2.2. Energy GHG emissions, 2005-2016 ($MTCO_2e$).



3. FLEET

3.1 Fleet Sector Overview

This section presents 2005 and 2019 GHG emissions for the Fleet sector and includes emissions from all on-road trips (including cars, trucks, buses, etc.) and the use of maintenance equipment that have occurred as a result of City operations.

3.2 Inventory Data and Methods

This section provides updated activity data and an emissions estimate for baseline year 2005 and activity data and an emissions estimate for 2019. The inventory utilizes gasoline and diesel fuel usage data sourced from the Public Works Department's third-party fleet management system, AssetWorks, as activity data for each year. Data for transit and fire vehicles were transmitted via email from department staff.

3.2.1 Gasoline

Staff from the Public Works department provided activity data for the total gallons of gasoline used in calendar year 2005 and 2019. Table 3.1 shows the activity data for gasoline used in 2005 and 2019 (gallons).

Table 3.1. 2005 and 2019 gasoline use (gallons).

Year	Gasoline (gallons)
2005	83,440
2019	75,570

To calculate total GHG emissions, an emissions factor is applied to activity data. Table 3.2 shows the gasoline emissions factor CO_2e. The emissions factor was provided by The Climate Registry's 2019 Default Emission Factor Report. Emissions factors for fuels have been relatively static over time, so a single emissions factor is used for both 2005 and 2019 activity data.

Table 3.2. Gasoline emissions factor ($MTCO_2e$/gallon).

Fuel Type	MTCO2e/gallon
Gasoline	0.00878

The emissions factor was applied to gasoline activity data to calculate the GHG emissions for gasoline in 2005 and 2019, as shown in table 3.3.

Table 3.3. 2005 and 2019 GHG emissions for gasoline use ($MTCO_2e$).

Year	MTCO2e
2005	730
2019	660

3.2.2 Renewable Diesel and Biodiesel

The City's Public Works Department uses a diesel blend of 90 percent renewable diesel and 10 percent biodiesel. The Public Works department began using this renewable and biodiesel blend in 2017. Both renewable and biodiesel are petroleum-free alternatives to conventional diesel sourced from renewable feedstocks such as fats and oils[5]. The production processes for renewable diesel results in a fuel composition that mimics that of conventional diesel. This makes the fuel ideal as a drop-in replacement for conventional diesel uses like heavy-duty fleet vehicles. While biodiesel produces less tailpipe GHG emissions and renewable diesel produces less Scope 3[6] GHG emissions compared to conventional diesel, they are associated with other environmental concerns related to the impacts of feedstock sourcing and production. Because the current blend of renewable and bio-diesel does not have significant impacts on tailpipe emissions per gallon of fuel used (Table 3.5), the City will continue to explore and pursue, when feasible, the transition to zero-emission fuels and vehicles in order to achieve a truly carbon-neutral fleet. Table 3.3 shows the activity data for diesel used in 2005 and 2019 (gallons).

Table 3.4. 2005 and 2019 diesel use (gallons).

Year	Diesel (gallons)
2005	149,040
2019	141,590

Given that the diesel used by the City is a blend of renewable and biodiesel, staff applied two emissions coefficients to diesel activity data to calculate total GHG emissions. The emissions factor was provided by The Climate Registry's 2019 Default Emission Factor Report. Table 3.4 shows the emissions coefficients for renewable diesel and biodiesel, respectively.

Table 3.5. Diesel emissions factors ($MTCO_2e$/gallon).

Year	Fuel Type	MTCO2e/gallon
2005	Diesel	0.01021
2019	Renewable Diesel	0.01021
	Biodiesel	0.00945

To calculate GHG emissions for the diesel blend, emissions coefficients were weighted based on the composition of each respective fuel type and applied to activity data. Therefore, the renewable

[5] https://www.sciencedirect.com/topics/engineering/renewable-diesel
[6] Scope 3 emissions include all other indirect emissions not covered in Scope 1 and 2, such as the emissions resulting from the extraction and production of purchased materials and fuels. More information can be found at: https://ww3.arb.ca.gov/cc/protocols/localgov/pubs/lgo_protocol_v1_1_2010-05-03.pdf.

diesel coefficient was applied to 90 percent of the diesel activity data and the biodiesel coefficient was applied to 10 percent of the activity data. The sum of those two outputs was equal to the total GHG emissions for diesel use. Table 3.5 shows the total GHG emissions for diesel use ($MTCO_2e$).

Table 3.6. 2005 and 2019 GHG emissions for diesel use ($MTCO_2e$).

Year	MTCO2e
2005	1,520
2019	1,430

3.3 Total Fleet GHG Emissions

Table 3.7 shows the total fuel related GHG emissions from gasoline and diesel combined. Between 2005 and 2019, total fuel related GHG emissions decreased by 150 $MTCO_2e$, or approximately seven percent.

Table 3.7. Total fleet GHG emissions ($MTCO_2e$).

Year	Total (MTCO2e)
2005	2,250
2019	2,090

4. EMPLOYEE COMMUTE

4.1 Employee Commute Sector Overview

This section presents the 2005 and 2019 GHG emissions for the Employee Commute sector and includes emissions from all passenger vehicle trips taken by City employees traveling to and from work.

4.2 Inventory Data and Methods

This section provides VMT activity data and emissions estimates for the baseline year of 2005 and inventory year 2019. Active Transportation staff collects biennial commute data that Office of Sustainability staff used for the purposes of the inventory.

Employee commute data was collected by staff and then anonymized for analysis. VMT attributed to trips where employees walked, rode a bicycle, took a bus, or drove an electric vehicle were removed from the data set. For all active transportation modes, no direct GHG emissions are produced as a result of activity. Direct emissions related to electric vehicles was not included in this analysis. For those that utilized transit, those emissions are accounted for in the Fleet sector of the inventory.

For single-occupancy and carpool trips, staff calculated the sum of VMT per vehicle type. Vehicle types were classified according to the California Air Resources Board (CARB) Emissions Factor (EMFAC) Model. Table 4.1 shows annual VMT per vehicle classification and percentage of total VMT.

Table 4.1 2005 and 2019 total VMT per vehicle classification for combined single-occupancy and carpool modes.

Year	Vehicle Classification	Total VMT	% EMFAC VMT
2005	Passenger Cars	870,460	46%
	Light-Duty Trucks (0-3,750 lbs.)	81,590	4%
	Light-Duty Trucks (3,750-5,750 lbs.)	386,610	20%
	Light-Heavy-Duty Trucks (8,501-10,000 lbs.)	117,460	6%
	Light-Heavy-Duty Trucks (10,001-14,000 lbs.)	18,160	2%
	Motorcycles	39,882	2%
	Medium-Duty Trucks (5,751-8,500 lbs.)	306,120	16%
	Other	70,768	4%
	Total	1,902,716	100%
2019	Passenger Cars	819,610	43%
	Light-Duty Trucks (0-3,750 lbs.)	263,240	14%
	Light-Duty Trucks (3,750-5,750 lbs.)	225,680	12%
	Light-Heavy-Duty Trucks (8,501-10,000 lbs.)	368,290	19%
	Motorcycles	112,920	6%
	Medium-Duty Trucks (5751-8500 lbs.)	113,930	6%
	Total	1,903,670	100%

Table 4.2 shows 2005 and 2019 total VMT for the vanpool. Between 2005 and 2019, annual VMT activity data for single-occupancy and carpool increased by 111,600 VMT, or approximately six percent. In the same time period, annual VMT for vanpool increased by 23,820 VMT, or approximately 130 percent. Table 4.3 shows total VMT for single occupancy, carpool, and vanpool modes. Overall, annual VMT increased by 26,560 VMT between 2005 and 2019, or approximately one percent.

Table 4.2 2005 and 2019 total VMT for vanpool.

Year	Annual VMT
2005	17,900
2019	43,520

Table 4.4 2005 and 2019 total VMT for single-occupancy, carpool, and vanpool modes.

Year	Annual VMT
2005	1,920,620
2019	1,947,180

Similar to the Fleet and Building & Facility Energy sectors, emissions factors are applied to activity data to calculate GHG emissions. Emissions factors were provided by the 2005 and 2019 EMFAC Model, respectively, with an individual emissions factor provided for each vehicle classification based on the fuel used and the weight of the vehicle. Table 4.4 shows the emissions factors for single-occupancy and carpool trips by vehicle classification.

Table 4.4 2005 and 2019 emissions factors by vehicle classification for single-occupancy and carpool trips.

Year	Vehicle Classification	MTCO2e/VMT
2005	Passenger Cars	0.000339
	Light-Duty Trucks (0-3,750 lbs.)	0.000396
	Light-Duty Trucks (3,750-5,750 lbs.)	0.000470
	Light-Heavy-Duty Trucks (8,501-10,000 lbs.)	0.000765
	Motorcycles	0.000154
	Medium-Duty Trucks (5,751-8,500 lbs.)	0.000583
2019	Total	0.000250
	Passenger Cars	0.000296
	Light-Duty Trucks (0-3,750 lbs.)	0.000333
	Light-Duty Trucks (3,750-5,750 lbs.)	0.000703
	Light-Heavy-Duty Trucks (8,501-10,000 lbs.)	0.000192
	Motorcycles	0.000401

Table 4.5 shows the emissions factors for vanpool trips for 2005 and 2019. The emissions factor used for vanpool trips was the emissions factor for the LHD1 vehicle class, or light-heavy-duty trucks (8,501 to 10,000 lbs.). This vehicle classification was chosen based on the type of vehicle typically used for vanpools.

Table 4.5 2005 and 2019 emissions factors for vanpool.

Year	MTCO2e/VMT
2005	0.000764904
2019	0.000702558

Emissions factors were then applied to activity data to calculate the annual GHG emissions of each vehicle classification. Table 4.6 shows the annual GHG emissions for single-occupancy and carpool trips by vehicle classification. Table 4.7 shows the annual GHG emissions for vanpool trips.

Table 4.6 2005 and 2019 GHG emissions per vehicle classification for single-occupancy and carpool (MTCO2e).

Year	Vehicle Classification	MTCO2e
2005	Passenger Cars	300
	Light-Duty Trucks (0-3,750 lbs.)	30
	Light-Duty Trucks (3,750-5,750 lbs.)	180
	Light-Heavy-Duty Trucks (8,501-10,000 lbs.)	90
	Motorcycles	0
	Medium-Duty Trucks (5,751-8,500 lbs.)	180
2019	Passenger Cars	210
	Light-Duty Trucks (0-3,750 lbs.)	80
	Light-Duty Trucks (3,750-5,750 lbs.)	80
	Light-Heavy-Duty Trucks (8,501-10,000 lbs.)	260
	Motorcycles	20
	Medium-Duty Trucks (5751-8500 lbs.)	50

Table 4.7 2005 and 2019 GHG emissions for vanpool.

Year	MTCO2e
2005	10
2019	30

4.3 Total Employee Commute GHG Emissions

Table 4.8 shows the total GHG emissions from employee commute. Between 2005 and 2019, total GHG emissions decreased by 80 $MTCO_2e$, or approximately ten percent. While annual VMT increased between 2005 and 2019 (Table 4.3) and employee commute data showed a decrease in light-duty vehicle use proportional to other medium and heavier-duty vehicles (Table 4.1), annual emissions showed a net decrease between 2005 and 2019. This could be attributed to a number of factors. First, the survey that is used to collect employee commute data is optional and not representatively reflective of the entire employment of the City. This can yield inconsistent and incomplete data. Additionally, as seen in Table 4.4 and Table 4.5, there is an observed overall decrease in the GHG emissions intensity of passenger vehicles between 2005 and 2019 as a result of federal emissions standards.

Table 4.8 Total employee commute GHG emissions (MTCO2e).

Year	Total GHG Emissions (MTCO2e)
2005	810
2019	730

5. WASTEWATER

5.1 Wastewater Sector Overview

The treatment of wastewater produces direct and indirect GHG emissions. Indirect emissions related to energy use are included in Chapter 2 Building and Facility Energy Use. Direct emissions reported in this document are limited to methane produced by biogas generation. Due to data and method limitations, this information is provided for reference but is not included in the municipal operations inventories.

5.2 Inventory Data and Methods

The Wastewater Resource Recovery Facility (WRRF) is responsible for treating wastewater within the City and has contractual agreements to treat the wastewater from Cal Poly and the San Luis Obispo County airport. The facility is rated for 5.1 million gallons of wastewater and operates 24 hours a day, 365 days a year. The WRRF provides wastewater treatment starting with preliminary treatment and ending with disinfection. The system processes included screening and grit removal, clarification, biological nutrient removal, mono-media filtration, and disinfection. The treated wastewater is discharged to San Luis Obispo Creek at the southern end of the property. Solids removed by the treatment processes are either dewatered (grit and screenings) or thickened, stabilized in anaerobic digesters, and dewatered (biological sludge). Biosolids are trucked and disposed of off-site.

5.2.1 Stationary CH_4 from Incomplete Combustion of Digester Gas

Anaerobic digesters are used to treat the solids stream in the wastewater process. These digesters produce biogas as a part of the anaerobic process and conversion into biosolids. Staff from Utilities provided process data for the measured standard cubic feet of digester gas produced per day (ft^3/day) and the fraction of CH_4 present in biogas. Using that information, GHG emissions from the incomplete combustion of digester gas were calculated. Staff utilized an equation from the Local Government Operations Protocol where activity data was inputted, and other constants and factors were provided. Table 5.1 shows the full LGOP equation, including provided constants and factors and inputted activity data.

Table 5.1 Stationary CH4 from Incomplete Combustion of Digester Gas equation.

CH_4 emissions (MTCO2e) = (Digester Gas x F_{CH4} x $\rho(CH_4)$ x (1-DE) x 0.0283 x 365.25 x 10^{-6}) x GWP		Value	Year	
			2013	**2019**
CH4 emissions	= Digester gas methane generation potential	Computed	210	320
Activity Data (Digester Gas)	=Measured standard cubic feet of digester gas produced per day [ft^3/day]	User Input	64,094	95,650
F_{CH4}	= CH_4 fraction in biogas	User Input	0.56516	0.56516
$\rho(CH_4)$	= Methane density	662	662	662
DE	= CH_4 destruction efficiency	0.99	0.99	0.99
0.0283	= Cubic feet to cubic meters	0.0283	0.0283	0.0283
365.25	= Days per year	365.25	365.25	365.25
0.000001	= Grams to metric tons	0.000001	0.000001	0.000001
GWP (AR5)	= GWP of methane	86	86	86

The data management system used by the Utilities Department that sourced digester gas activity data was installed in 2012. Therefore, 2013 is the earliest available year with complete and accessible activity data. Staff were not able to calculate a 2005 baseline inventory for this emissions source.

It is important to note that between 2013 and 2019, the WRRF employed a co-generation system to convert digester gas to electricity that is used at the facility. In 2018, the Utilities Department deployed a pilot program to increase biogas production by supplementing the digesters with a mix of microorganisms and enzymes. These supplements effectively increased biogas production for on-site energy production via the co-generation system. This resulted in a net increase in measured standard cubic feet of digester gas produced per day (Table 5.1), and subsequently, an assumed decrease in flared biogas (not integrated into the quantification for stationary CH_4).

5.2.2 Process N_2O Emissions from Wastewater Treatment with Nitrification/Denitrification

According to the Local Government Operations Protocol for quantifying GHG emissions for wastewater treatment, process nitrous oxide (N_2O) emissions from wastewater treatment with nitrification and denitrification should be calculated. However, the WRRF process only completes the nitrification process and there are no guidance documents associated with quantifying the emissions associated only with this process. Given the likely minimal nature of these emissions as shown in the above calculations, the City omitted process N_2O emissions quantification from the total 2005 and 2019 GHG emissions for the Wastewater sector.

5.2.3 Other Wastewater Treatment Emissions

Electricity is used power the processes to treat wastewater at the WRRF. Emissions associated with energy use at the WRRF are included in Chapter 2 Building and Facility Energy.

5.2.43. Potable Water Emissions

The Wastewater section does not include GHG emissions quantifications for the treatment or conveyance of potable water. Emissions from the City's Water Treatment Plant included in this inventory are directly related to energy use, which is represented in Chapter 2 Building and Facility Energy, above.

5.3 Total Wastewater GHG Emissions

Table 5.2 shows the total GHG emissions of stationary CH_4 from incomplete combustion of digester gas. In 2019, total GHG emissions for stationary CH_4 from incomplete combustion of digester gas was 320 $MTCO_2e$. Staff ultimately determined the method for estimating emissions for this activity is not justifiable and does not accurately represent emissions associated with the wastewater treatment process, so the below values are only included as an informational item and are not included in the 2019 Municipal GHG Inventory.

Table 5.2 2019 total GHG emissions from wastewater treatment processes.

Year	**Total GHG Emissions (MTCO2e)**
2013	210
2019	320

6. SOLID WASTE

4.1 Solid Waste Sector Overview

This section presents the GHG emissions for the solid waste sector, specifically emissions generated from the disposal of waste that has occurred as a result of City operations. This section presents the updated 2005 GHG emissions along with modeled emissions for 2019.

4.2 Updated Inventory Data and Methods

This section provides updated solid waste activity data for the baseline year of 2005, as well as activity emissions estimates for years 2005 through 2019 to estimate the City's total greenhouse gas emissions. The City of San Luis Obispo deposits all trash (not including recycling or organic waste) generated as a result of municipal operations into the Cold Canyon Landfill. The Cold Canyon Landfill provided solid waste disposal data that was used in this analysis. Table 4.1 and Figure 4.1 provide annual municipal operation solid waste disposal tonnage for 2005 to 2019.

There is no available solid waste disposal data for calendar year 2019 as was calculated for previous years. Staff use a per full-time employee (FTE) metric to project waste for 2019 based on recorded waste generation from previous years. Table 4.2 shows the FTE factor used to calculate 2019 annual solid waste disposal tonnage, which estimates that approximately 1.004 tons of solid waste are disposed per employee. Although this method is consistent with Local Government Operations Protocol methods, staff will seek to update the inventory with empirical data in Fiscal Year 2021-22.

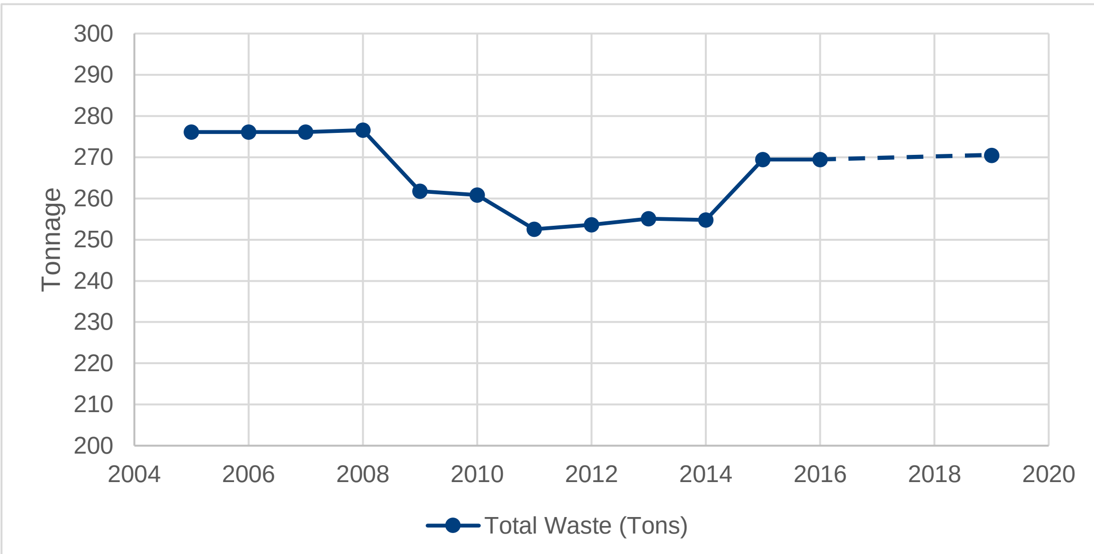
Table 4.1. City solid waste activity data, 2008-2019 (Disposal Ton).

Year	Total Waste (Tons)
2005	276
2006	276
2007	276
2008	277
2009	262
2010	261
2011	253
2012	254
2013	255
2014	255
2015	269
2016	269
2017	--
2018	--
2019	270

Table 4.2. Full-time employee (FTE) factor used to calculate 2019 annual solid waste disposal tonnage.

Solid Waste Coefficient (tons per FTE)
1.003636

Figure 4.1. Total City solid waste (Disposal Ton).



4.3 Total Solid Waste GHG Emissions

To estimate the solid waste GHG emissions, the carbon dioxide equivalency emissions factor was multiplied by the disposal ton activity data. Once these were applied, the annual solid waste disposal ton emissions were calculated. As shown in Table 4.7, from 2005 to 2019, the solid waste sector remained relatively consistent in terms of total emissions.

Table 4.1~~7~~. Total solid waste disposed emissions ($MTCO_2e$).

Year	Total Waste (Disposal Ton)	Solid Waste Total Emissions MTCO2e
2005	276	120
2006	276	120
2007	276	120
2008	277	120
2009	262	110
2010	261	110
2011	253	110
2012	254	110
2013	255	110
2014	255	110
2015	269	120
2016	269	120
2017	--	--
2018	--	--
2019	270	120

7. FORECAST

The adjusted business as usual (ABAU)[7] GHG emissions forecast estimates how municipal emissions would change over time if no action were taken to reduce emissions. The forecast is based on changes to the number of Full Time Employees (FTE), building and facility square footage, and wastewater treatment service population.

Given projected changes to the three demographics mentioned above, total municipal emissions are expected to increase slightly relative to 2019 (and remain decreased relative to 2005). As shown in Table 7.1, emissions in 2025 are projected to be 5,070 $MTCO_2e$ (approximately 25 percent below 2005 levels), and in 2030 are expected to be at 5,150 $MTCO_2e$ (approximately 23 percent below 2005 levels).

Table 7.1. BAU forecasted GHG emissions, 2005-2030 ($MTCO_2e$).

Sector	2005	2019	2025	2030	% change from baseline in 2030
Building & Facility Energy	3,550	2,130	2,110	2,290	-35.5%
Fleet	2,250	2,090	2,130	2,130	-5.3%
Employee Commute	810	730	710	610	-24.7%
Solid Waste	120	120	120	120	0.0%
TOTAL	6,730	5,070	5,070	5,150	-23.5%
Change from 2005	--	-1,660	-1,660	-1,580	--

The results of the municipal operations GHG emissions inventory and forecast show total emissions remaining steady in 2025 relative to baseline years 2005 and 2019 followed by a steady increase in total emissions between 2025 and 2030. As described in previous sections, the overall decrease in GHG emissions between 2005 and 2019 can be attributed largely to decreases in facility and fleet energy use and corresponding decreases in emissions factors for respective fuel sources.

The anticipated increase in emissions between 2019 and 2025 and again between 2025 and 2030 can be closely tied with forecasted increases in demographic data used to project emissions. For example, when conducting this forecast, staff worked closely with other departments to reasonably and justifiably forecast the expected number of City employees, building and facility square footage as new and replacement development projects are implemented, and service population. These growth factors directly contribute to the forecasted increase in total emissions between 2019 and 2030.

For example, staff were able to confirm four planned development projects between 2019 and 2030, two of them large-scale facilities (new Police Department headquarters and the Palm-

[7] A business as usual emissions forecast projects greenhouse gas emissions based on expected changes in demographic data, such as new building square footage and growth in the number of total employees, while using the same emissions coefficients for the base inventory year (e.g. 2019). An adjusted business as usual emissions forecast utilizes those same metrics while also using projected emissions coefficients for each forecast year (e.g. expected fuel and electricity emissions coefficients). Staff decided to create an adjusted business as usual forecast in this analysis for accuracy and completeness.

Nipomo parking garage). These new developments are expected to add a total of 265,094 additional indoor air-conditioned and outdoor non air-conditioned square feet to the City's portfolio by 2030, or an increase of approximately 51 percent. As shown in Table 7.1, this demographic information has a significant impact on forecasted building and facility energy emissions.

8. AREAS FOR IMPROVEMENT

A greenhouse gas emissions inventory is only a snapshot of the total emissions occurring in City operations. The report as presented includes emissions sectors and categories as required by accounting protocol and represent those sectors that have defensible and transparent methods and data. As the City continues its path of climate action toward municipal carbon neutrality, the following areas for improvement will be closely monitored:

- Wastewater - The Local Government Operations Protocol requires local governments to account for direct process emissions that occur from the treatment of wastewater. It is known that the treatment of wastewater can release Nitrous Oxide and Methane, both of which are powerful greenhouse gases. Although the GPC provides accounting methods for estimating the direct release of Methane emissions, an accounting protocol does not exist for estimating the direct release of Nitrous Oxide from the specific type of treatment that occurs at the San Luis Obispo Water Resource Recovery Facility (nitrification, but no denitrification). The City will continue to explore solutions to this accounting issue and intends to seek support from partners and academic institutions to find a quantification method for direct Nitrous Oxide emissions.

- Fugitive Methane – From the well head to the appliance, methane leaks directly into the atmosphere as the result of natural gas development and transmission. Some estimates of total system leakage are high enough to make natural gas consumption as bad a climate polluter as coal. A common protocol for amending the natural gas emissions coefficient to account for this leakage is not available. The City will consider updating the coefficient in future years when such information is vetted and available.

- Employee Commute – Emissions for employee commute can only be feasibly measured based on voluntary data submission. Since not every employee participates in the voluntary survey, the annual greenhouse gas emission estimates are based on incomplete data. Staff have in recent years, though, implemented more incentive opportunities which has enhanced participation. As more accurate data collection methods emerge and/or the City includes more incentives to support employee participation, emissions for employee commute will be more accurate in future inventory years.

- Procurement, Budget, and Finance – In accordance with the Local Government Operations Protocol, the City has only measured and recorded Scope 1 and 2 emissions, or emissions from sources owned and/or controlled by the City and from the purchased use of electricity, respectively. This leaves significant gaps in the ability to quantify emissions from activities related to procurement, budget, and finance. Therefore, those activities are not included in the 2019 inventory. As new data collection methods for Scope 3 emissions emerge to feasibly and accurately calculate those types of emissions, the City will explore integrating those quantification strategies in future inventory updates.

- Natural Solutions – This inventory does not account for ambient carbon emissions sequestered or emitted within the City's urban forest network or Greenbelt (except fuel use for maintenance equipment under the Fleet sector). In accordance with the Local Government Operations Protocol, the City does not currently estimate or inventory direct emissions as a result of landscape management practices, including the application of synthetic fertilizers. Sequestered emissions from reduction actions within the Natural Solutions pillar were estimated and are included in the Lead by Example: A Plan for Carbon Neutral City Operations reduction measure forecast. However, these sequestered emissions cannot be compared to a baseline or business as usual scenario like other sectors due to the fact that they are not inventoried. Staff will continue to explore feasible approaches to inventorying direct emissions under the Natural Solutions sector in future emissions inventory updates.

List of Abbreviations

CH_4: Methane

CO_2: Carbon dioxide

CO_2e: Carbon dioxide equivalent

EV: Electric Vehicle

FTE: Full-time employee

GHG: Greenhouse gas

kW: Kilowatt

kWh: Kilowatt-hour

LGOP: Local Government Operations Protocol

$MTCO_2e$: Metric tons of carbon dioxide equivalent

N_2O: Nitrous oxide

PG&E: Pacific Gas & Electric Company

VMT: Vehicle miles traveled

WRRF: Water Resource Recovery Facility

3CE: Central Coast Community Energy