Appendix B – Municipal Inventory and Forecast Methodology

City of Sacramento Climate Action Plan Update

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April 2020

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1 Introduction

California considers greenhouse gas (GHG) emissions and the impacts of climate change to be a serious threat to public health, the environment, economic well-being, and natural resources of the State, and has taken an aggressive stance to mitigate the impact on climate change at the State-level through the adoption of legislation and policies. Many cities have developed local climate action plans and aligned goals to correspond with State emissions reduction targets. The two major State GHG-related goals are established by Assembly Bill (AB) 32 and Senate Bill (SB) 32. AB 32 required State agencies to reduce State GHG emissions to 1990 levels by 2020; SB 32 requires a 40 percent reduction below 1990 levels by 2030. The goals set by AB 32 were achieved by the State in 2016[1] and many local jurisdictions are completing GHG inventories to quantify progress toward their own 2020 goals as well as develop targets to align with the requirements of SB 32.

GHG inventories and targets are generally established at the community-level, to capture the full picture of GHG emissions for the jurisdiction. To this end, a 2016 community-wide GHG inventory and forecast was completed for the City of Sacramento and methodologies and results of that inventory are contained in a separate technical appendix (Appendix A). This document by contrast contains methods and results of a municipal-level GHG inventory for the City of Sacramento. The municipal inventory complements the community-wide inventory, with a narrower focus on GHG emissions for City programs, buildings, and staff. While the municipal inventory is a subset of the community inventory, the increased resolution at the municipal level allows the City to take exemplary action in reducing its own GHG emissions and act as a leader for the much larger community-wide effort to achieve substantial GHG reduction targets. Emissions contained within the municipal inventory include activities under direct control of the City of Sacramento.

This technical appendix provides a complete analysis of the previous municipal inventories completed for the City of Sacramento in 2005 and 2013 as well as details on the methodology used by Rincon for the 2016 inventory update, which is also used as the baseline for GHG forecast. Municipal emissions are forecast for the years 2020, 2030, and 2045 to align with State and City targets.

Emissions inventories are an iterative process and each year must be viewed in the context of other inventories and relative trends of each sector to maintain consistency with the emissions inventory methods and factors.

[1] California Air Resources Board. California Greenhouse Gas Emissions Inventory. Accessed at: https://ww3.arb.ca.gov/cc/inventory/inventory.htm. Accessed on: July 2019

2 Municipal Inventory

The methodologies, data sources, calculations, and results associated with the 2016 municipal GHG inventory are included in this section. The municipal inventory is considered a subset of the community inventory (see Appendix A) and has therefore already largely been accounted for in the community inventory.[2] The GHG emissions below are included in this appendix to inform the development of climate action plan strategies that will reduce emissions in internal government operations.

The ICLEI Local Government Operations Protocol[3] (referred to hereafter as ICLEI LGOP) recommends local governments examine their emission sources in the context of operational control when determining whether to include in their inventory. The 2016 municipal GHG inventory is based on this recommendation and for consistency with previous GHG inventory methods and reporting (2005 and 2013).

The 2016 inventory reports the following emission sectors as recommended by ICLEI LGOP:

- City-owned buildings and facilities
- Streetlights and traffic signals
- Water and wastewater treatment and conveyance
- Vehicle fleet
- Solid waste facilities (waste-in-place)

In 2016, municipal operations resulted in 56,463 metric tons of carbon dioxide equivalent (MT CO_2e). The largest emissions sector was vehicle fleet (28 percent) followed by buildings and facilities (27 percent) and waste-in-place (19 percent) emissions. Detailed results can be found in Table 1 and Figure 1. The following sections discuss each emissions sector of the municipal inventory.

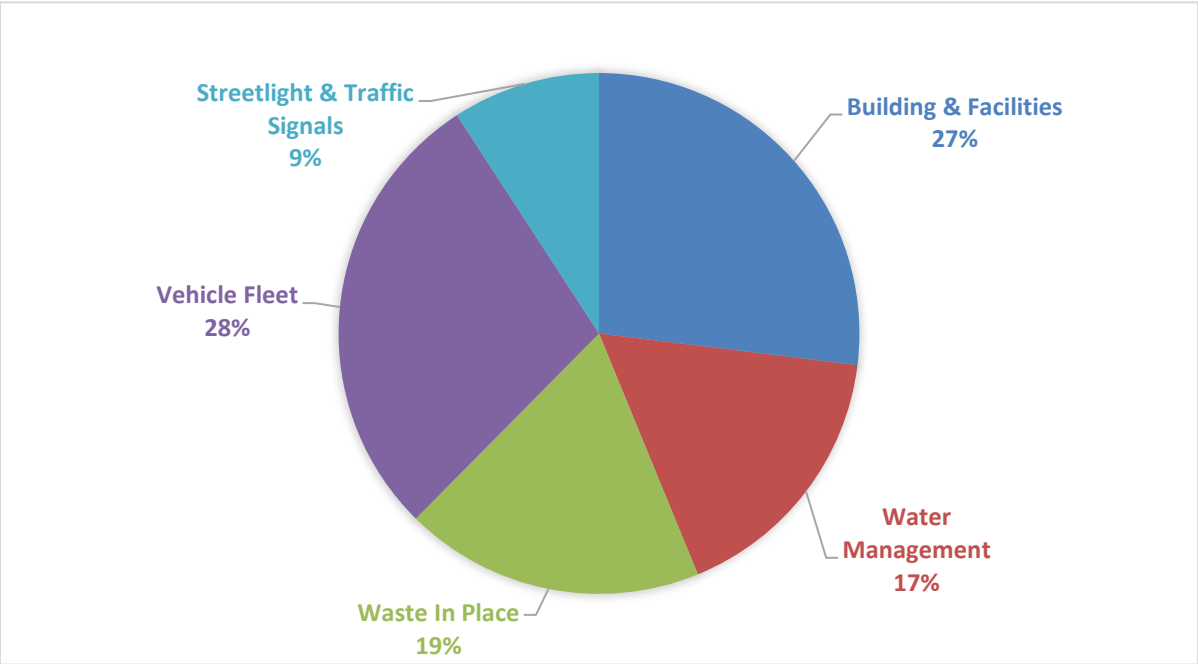
Table 1 2016 Municipal Emissions by Sector

Sector	Emissions (MT CO_2e)
Vehicle Fleet	16,035
Building & Facilities	15,214
Waste-in-Place	10,512
Water Management	9,516
Streetlight & Traffic Signals	5,186
Total	**56,463**

[2] The municipal inventory captures a small amount of GHG emissions that are not captured in the community inventory. This includes GHG emissions from off-road equipment (e.g., from heavy-duty equipment used at City parks or other City land) and fuel use for building needs not supplied by the grid (e.g., fuel in emergency generators or backup equipment). However, all other GHG emission sources captured by the municipal inventory are already captured in the community inventory. The municipal inventory is therefore considered, effectively, to be a subset of the community inventory and the two inventories should not be "added" together.

[3] https://ww3.arb.ca.gov/cc/protocols/localgov/pubs/lgo_protocol_v1_1_2010-05-03.pdf

Figure 1 2016 Municipal GHG Emissions ($MTCO_2e$)



2.1 Previous Inventories and Emissions Reduction Progress

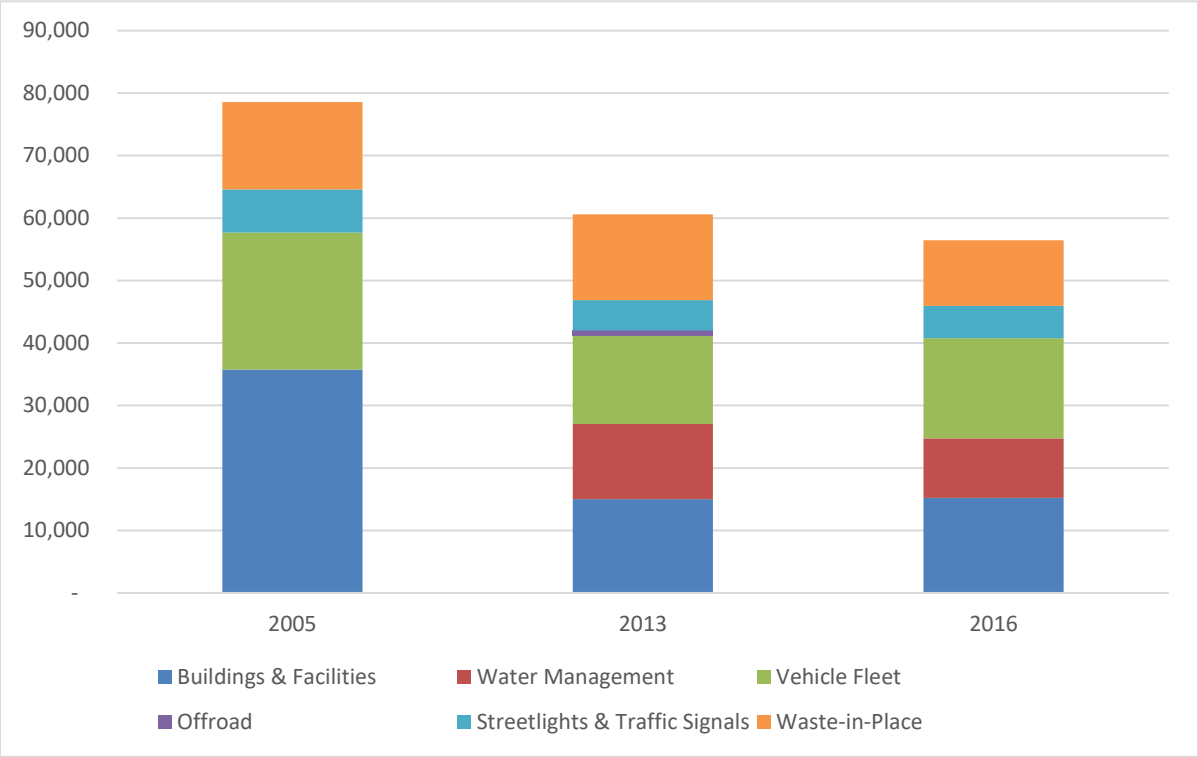
The City of Sacramento has conducted two previous GHG inventories for internal government operations, one for the calendar year 2005 and another for the calendar year 2013. Since 2005, overall GHG emissions have decreased by 22,121 MT CO_2e or 28 percent. An accounting of the methodological changes between each inventory is included in the following section. The building and water management sectors and the waste sector decreased each year from 2005 to 2016. The transportation sector decreased from 2005 to 2013 but increased again in 2016 by 1,092 MT CO_2e. Streetlights and traffic signals followed a similar trajectory, decreasing from 2005 to 2013 but seeing a slight rise in 2016. However, changes to streetlight calculation methodologies could be the cause of this change. A summary of each inventory year are included below in Table 2 and Figure 2.

Table 2 Municipal Inventory Comparison

Sector	2005 (MT CO_2e)	2013 (MT CO_2e)	2016 (MT CO_2e)
Building & Facilities	35,773	15,011	15,214
Water Management		12,043	9,516
Vehicle Fleet	21,927	14,081	16,035
Off-road	N/A	862	
Streetlights & Traffic Signals	6,872	4,870	5,186
Waste	14,012	13,750	10,512
Total Emissions	**78,584**	**60,617**	**56,463**

$MTCO_2e$: metric tons of carbon dioxide equivalent

Figure 2 Municipal Inventory Comparison ($MTCO_2e$)



Methodology Changes

The data sources and emissions factors used for the 2005, 2013, and 2016 inventories are summarized in Table 3. Several minor changes are apparent between each year as methods evolved. One minor change made in the 2013 inventory was the breakout of water management emissions from overall building and facilities use. Notable changes to methods in the 2016 inventory include electricity data for all libraries, inclusion of regional pumping electricity data not included in 2013, and a better breakdown of energy data by building/facility.

Table 3 Municipal Data Sources and Emissions Factors by Year and Sector

	2005	2013	2016
Data Sources			
Building and Facilities	City energy use from Keith Roberts, included water management energy use. Streetlight and Traffic Signals removed. Included propane but not diesel.	Energy use from EnergyCAP, excludes propane and Library electricity from Pocket-Greenhaven and North Sacramento libraries. Includes diesel generator. May not include all City-operated buildings.	Energy use from EnergyCAP, excludes propane. Includes gasoline and diesel generators.
Water Management		Electricity use by water management system (water, sewer, drainage) from EnergyCAP. Excludes electricity from regional pumping.	Electricity use by water management system (water, sewer, drainage) from EnergyCAP.
Vehicle Fleet	Vehicle fuel use by vehicle type and fuel type. Reported four vehicle types.	Detailed data by vehicle mileage, fuel consumption, and model year. Includes 14 vehicle types.	Utilimarc detailed data by fuel consumption, vehicle mileage, and model year. Includes 31 vehicle types.
Off-road Fleet	Data included in vehicle fleet data from City.	Data broken out from vehicle fleet and reported separately.	Data included in vehicle fleet data from City.
Streetlights and Traffic Signals	Total energy use from SMUD.	Streetlight and traffic signal energy totals from EnergyCAP, extrapolated by light type.	SMUD-owned streetlight and traffic signal energy totals from EnergyCAP, extrapolated by average light use. City-owned streetlight energy totals based on number of streetlights and estimated 4,000 hours of nighttime operation.[1]
Waste-in-Place	Waste in-place tonnage.	Total CH_4 captured at 28th Street Landfill	Total CH_4 captured at 28th Street Landfill.

	2005	2013	2016
Emissions Factors			
Building and Facilities	SMUD[2] 2005	SMUD 2013	SMUD 2016, PG&E 2016, EPA eGRID 2016, TCR 2016 (generators)
Water Management		SMUD and PG&E 2013	SMUD 2016, EPA eGRID 2016
Vehicle Fleet	Fuel-based	Fleet fuel consumption, EMFAC 2014[3], TCR 2013 for non-gasoline fuel	Fleet fuel consumption, mileage and TCR[4] 2016 for CH_4, N_2O, non-gasoline fuel
Off-road Fleet	N/A	Fuel-based	Fuel-based (TCR 2016)
Streetlights and Traffic Signals	SMUD 2005	SMUD 2013	SMUD 2016, EPA eGRID 2016
Waste-in-Place	ARB FOD	ICLEI LGOP 9.1	ICLEI LGOP 9.1
GWP	IPCC SAR (21, 310)	IPCC SAR (21,310)	IPCC AR4 (25, 298)

[1] https://www.smud.org/-/media/Documents/Rate-Information/Rates/01_SLS.ashx\

[2]Sacramento Municipal Utilities District

[3]https://www.arb.ca.gov/emfac/2014/?_ga=2.188515880.1044032860.1584991585-988399991.1554499524

[4] 2016 The Climate Registry Emissions Factors, https://www.theclimateregistry.org/wp-content/uploads/2014/11/2016-Climate-Registry-Default-Emission-Factors.pdf

As noted earlier, the internal operations emissions data presented above are a subset of the communitywide inventory (see Appendix A). These emissions are not added to the community inventory and therefore, no "double-counting" is occurring between community-wide and internal operations. Additional information regarding the 2005 and 2011 Sacramento GHG inventories can be found in the previous 2016 IO CAP Update.[4]

2.2 Inventory Data Sources

The data used to complete the 2016 GHG inventory and forecast came from multiple sources, as summarized in greater detail in Table 4. Data for the 2016 municipal GHG inventory calculations were provided by City staff via personal communication with Helen Selph, Jennifer Venema, John Febbo, and Mark Stevens[5].

[4] City of Sacramento. Climate Action Plan for Internal Operations, 2016 Update. https://www.cityofsacramento.org/-/media/Corporate/Files/Public-Works/Facilities/CityOfSacramento_1606_ClimateActionPlan_InternalOps_FINAL.pdf?la=en Accessed: Nov., 2019.

[5] Helen Selph, Associate Planner; Jennifer Venema, Sustainability Manager; John Febbo, Integrated Waste Planning Superintendent, Mark Stevens, Fleet Manager.

Table 4 Inventory and GHG Emission Factors Sources

Sector	Data	Unit	Source
Activity Data			
Building Energy	Electricity Consumption	kWh	EnergyCAP
	Natural Gas Consumption	Therms	EnergyCAP
Transportation	Fuel Usage, Annual Mileage	Gallon, GGE, VMT	Utilimarc
Streetlights	Electricity Consumption	kWh	EnergyCAP City of Sacramento
Water	Electricity Usage	kWh	EnergyCAP
Solid Waste	Landfill Gas, Methane Content	cf	Sacramento Public Works Department
Emission Factors			
Electricity	SMUD, PG&E, and eGRID electricity emissions factors	CO_2/MWh, CH_4 MWh, N_2O/MWh	The Climate Registry 2016 Reported Emissions Factors, EPA eGRID
Natural Gas	PG&E natural gas emissions factor	CO_2/therm, CH_4/therm, N_2O/therm	The Climate Registry 2016 Reported Emissions Factors
Transportation Fuels	Diesel, Gasoline, CNG, LNG, E85, and Propane emission factors	CO_2/gal or mi, CH_4/gal or mi, N_2O/gal or mi	The Climate Registry 2016 Default Emissions Factors
Streetlights and Traffic Signals	SMUD and EGRID electricity emissions factors	CO_2/MWh, CH_4 MWh, N_2O/MWh	The Climate Registry 2016 Emissions Factors, EPA eGRID
Water Management	SMUD and EGRID electricity emissions factors	CO_2/MWh, CH_4 MWh, N_2O/MWh	The Climate Registry 2016 Reported Emissions Factors, EPA eGRID
Waste	N/A (constants)	N/A	N/A

cf: cubic feet; CO_2: carbon dioxide; CH_4: methane; CNG: compressed natural gas; EPA: Environmental Protection Agency; kWh: kilowatt hours; gal: GGE: gasoline gallon equivalent; LNG: liquid natural gas; MWh: megawatt hour; N_2O: nitrous oxide; PG&E: Pacific Gas & Electric; SMUD: Sacramento Municipal Utility District; VMT: vehicle miles traveled; N/A: not applicable

2.3 Building and Facilities

In 2016, municipal building and facility energy use resulted in 15,214 MT CO2e, comprising the second largest emissions source after the vehicle fleet. Energy use consisted primarily of electricity and natural gas, as well as diesel and gasoline which is used to power emergency generators.

Electricity, natural gas, and generator fuel for building and facilities were provided by SMUD, Tesla/Solar City (on-site solar), Public Works Department fuel contracts, and PG&E. Grid-supplied building and facility energy data were collected by the City of Sacramento staff using EnergyCAP software, run through internal analysis, and provided to Rincon (as summarized in Table 5).

Table 5 Municipal Building and Facilities Energy Use

Emission Source	Energy Usage	Unit	Emissions Factor	Emissions (MT CO_2e)[1]	Percent (%) of Total
SMUD Purchased Electricity (except H2O management)	40,323.72	MWh	0.2236 MT CO_2/MWh	9,053	59%
PG&E Purchased Electricity[2]	86	MWh	0.1332 MT CO_2/MWh	12	0.08%
Solar City Purchased Electricity	4,353	MWh	0.0 MT CO_2/MWh	0	0%
PG&E Natural Gas Use	900,788	therms	0.0053 MT CO_2/therm	6,130	40%
Gasoline Generators	44	gallons	0.0088 MT CO_2/gal gasoline	0.4	0.0025%
Diesel Generators	1,661	gallons	0.0102 MT CO_2/gal diesel	19	0.13%
Total Emissions	**–**	**–**	**–**	**15,214**	**–**

[1] MT CO_2e: metric tons of carbon dioxide equivalent

[2] PG&E electricity provided for Camp Sacramento operations only.

Buildings and facilities in this sector include City-owned and operated offices, corporation yards, parking lot facilities, and irrigation systems at City-owned parks. Electricity use includes lighting, appliances, and equipment in City buildings and facilities.[6] Natural gas was most often used for space heating and water heating. Diesel and gasoline fuel were used for City-operated back-up generators, which are used intermittently during power outages and for regular testing. Generator fuel use was provided by the City of Sacramento's Utilimarc program for tracking fuel purchases. Electricity use for water supply and management by the Department of Utilities is included in a separate section and has been removed from the Buildings and Facilities category. Electricity for vehicle charging has not been broken out and is included in overall building electricity.[7] A detailed breakdown of building energy use by emission source and building type can be found in Table 6.

The 2016 inventory likely includes more buildings than the 2013 inventory. At a minimum, the 2016 inventory includes the Pocket-Greenhaven Library electricity consumption which was not icnluded in the 2013 inventory (approximately 523,823 kWh or 117 MT CO_2e). The 2013 inventory noted that data from this library was not available at the time of inventory creation. Additional buildings such as the McKinley Library may also be an addition to the 2016 inventory. However, because the 2013 inventory does not include a detailed list of buildings accounted for in the analysis, it is not possible to identify if the library was accounted for in a different portion of the building inventory. However, all future inventories will provide a complete list of building by building end uses to avoid this issue.

[6] Electricity use for streetlights and traffic signals is accounted for in a separate sector. Refer to Section 2.7.

[7] At the time of report preparation, data was unavailable for all electricity related to EV charging; as of late 2019, only one City facility had a separate submeter for EV charging, City Hall Parking Garage.

Table 6 Municipal Buildings and Facilities Emissions

Facility Type	Energy Consumption	CO_2 (MT)	CH_4 (MT)	N_2O (MT)	CO_2e (MT)	Fuel Type
Electricity (kWh)						
Camp Sac	85,960	11.45	0.00	0.00	12	Electricity
Solar City (Purchased)	4,353,000	0.00	0.00	0.00	0	Electricity
Police	6,319,471	1,413.03	0.09	0.01	1419	Electricity
Fire	2,147,681	480.22	0.03	0.00	482	Electricity
Public Works	10,495,687	2,346.82	0.16	0.02	2356	Electricity
Libraries[1]	3,331,210	744.85	0.05	0.01	748	Electricity
Parks & Recreation	5,890,602	1,317.13	0.09	0.01	1323	Electricity
Cultural and Community Services	11,075,055	2,476.37	0.17	0.02	2487	Electricity
Youth Parks and Community Enrichment	34,862	7.80	0.00	0.00	8	Electricity
Community Development Department	356,474	79.71	0.01	0.00	80	Electricity
Other-City-Related-Accounts	300,243	67.13	0.00	0.00	67	Electricity
Unknown Accounts	3,366	0.75	0.00	0.00	1	Electricity
Downtown Plaza- Central Garage (Lot U)	136,758	30.58	0.00	0.00	31	Electricity
Old Sac Waterfront	111,726	24.98	0.00	0.00	25	Electricity
1109 2nd St. Building	37,154	8.31	0.00	0.00	8	Electricity
1115 2nd St. Building	3,791	0.85	0.00	0.00	1	Electricity
Old Sac Promenade	48,342	10.81	0.00	0.00	11	Electricity
1012 2nd St. Building	31,298	7.00	0.00	0.00	7	Electricity
Total	**44,762,680**	**9,027.8**	**0.60**	**0.07**	**9,065[2]**	**--**
Diesel and Gasoline (Gallons)						
Generators	1,661	16.96	0.0009	0.0069	19	Diesel
Generators	44	0.39	0.0000	0.0000	0	Gasoline
Total	**1,705**	**17.35**	**0.00095**	**0.0069**	**19**	--
Natural Gas (Therms)						
Police	78,736	417.85	3.78	0.079	536	Natural Gas
Fire	75,832	402.44	3.64	0.076	516	Natural Gas
Utilities	205,861	1,092.51	9.88	0.206	1401	Natural Gas
Public Works	141,931	753.23	6.81	0.142	966	Natural Gas
Libraries[1]	68,891	365.61	3.31	0.069	469	Natural Gas
Parks & Recreation	54,074	286.97	2.60	0.054	368	Natural Gas
Convention and Cultural Services	249,902	1,326.24	12.00	0.250	1701	Natural Gas
Community Development Department	25,389	134.74	1.22	0.025	173	Natural Gas
Old Sac Waterfront	172	0.91	0.01	0.000	1	Natural Gas

Total	**900,788**	**4,780.5**	**43.2**	**0.9**	**6,130**	**–**

[1]Includes activity data for all libraries in City limits that are City-owned buildings.

[2] Numbers may not sum due to rounding

MT = metric tons

Approximately 60 percent of building and facility emissions occurred from electricity usage, while 40 percent were attributable to natural gas and generator emissions. Overall, buildings and facilities were 27 percent of total municipal operations emissions.

2.4 Water Management

The City provides water-related utility services to residents and businesses in the form of water intake, treatment, and distribution; wastewater collection and conveyance; and stormwater drainage. In 2016, pumping and other activities associated with these water-related services (referred to hereafter as the "water management" sector) produced 87,811 acre-feet of water. This sector comprised 17 percent of the City's total municipal GHG emissions in 2016. Water management activity represented the fourth largest sector of emissions in the city after the vehicle fleet emissions, building and facility energy use, and waste. More detail on the sector is available in Table 7.

Table 7 Municipal Water Management Emissions

Activity	Electricity (kWh)	CO_2 (MT)	CH_4 (MT)	N_2O (MT)	Emissions (MT CO_2e)
Water Supply Conveyance	35,190,068	7,868.45	0.527	0.064	7,882
Wastewater Conveyance	2,551,344	570.48	0.038	0.005	571
Stormwater Drainage	4,645,541	1,038.74	0.070	0.008	1,040
Total	**42,386,953**	**9,477.66**	**0.63**	**0.08**	**9,516**

2.5 Vehicle Fleet

The City's 2016 vehicle fleet consisted of a variety of vehicle types using both conventional and alternative fuels. Fuel consumption from vehicle fleet operations contributed to approximately 16,035 MT CO_2e in 2016, comprising 28 percent of the City's annual operational GHG emissions (Table 8). This sector captures fuel usage for both on-road and off-road vehicle activities. All fuel use is presented by fuel type for this sector.

Table 8 Municipal Fleet Emissions

Fuel Type	Units (Gallons)	CO_2 Factor	CO_2 (MT)	CH_4 (MT)	N_2O (MT)	Total (MT CO_2e)
Gasoline	1,146,935	0.00878	10,070	0.12	0.2	10,125
Diesel	5,173	0.01021	53	0.003	0.022	59
Biodiesel	512,081	N/A	0	0.29	2.1	643
CNG	67,880	0.006896	468	0.53	0.05	495
RNG	18,228.30	N/A	0	0.14	0.05	18
Propane	7,538	0.00568	43	0.02	0.0	44
LNG	945,258	0.00446	4,216	1.86	0.17	4,312
E-85	53,808	0.0062651	337	0.01	0.0	340
Total	**–**	**–**	**15,187**	**2.97**	**2.60**	**16,035**

In 2016, the City operated 2,330 vehicles including maintenance trucks, vans, solid waste collection vehicles, police and fire vehicles, and light duty passenger vehicles. This included 38 CNG, 461 diesel, 222 E85, 90 LNG, 45 propane, and 1,474 unleaded gasoline vehicles.

Fleet emissions were calculated using the LGOP recommended methodologies 7.1.1 and 7.1.3 for CO_2, CH_4, and N_2O in mobile combustion. The LGOP recommends quantifying CO_2 levels through total annual fuel consumption by fuel type and appropriate emissions factors for each. Annual fuel use was provided by the City of Sacramento while emissions factors utilized were identified by The Climate Registry (TCR)[8], an industry-standard independent third-party verifier for reporting GHG emissions. CH_4 and N_2O levels were calculated either by using the same methodology when emissions per gallon emission factors were available (Gasoline, Diesel, and Propane) or by mileage of each vehicle type when mileage-based emission factors were available (CNG, RNG, LNG, and Ethanol). This method was used for all fleet fuel consumption, both on-road and off-road.

2.6 Waste-in-Place

Waste-in-place emissions are inventoried under LGOP recommended Calculation 9.1 for landfills with landfill gas collection systems. In 2016, the 28th Street Landfill collected 243,718,413 cubic feet of gas with an average methane content of 29.10 percent. Total emissions from the 28th Street Landfill were 10,512 MT CO_2e. This value differs from the community-wide inventory for the same year because it includes only the 28th street landfill which is under the City's direct control. The method for calculation is also different and leverages actual measures CH_4 emissions at the site as well as several assumptions defined by Calculation 9.1 of the LGOP.

GHG emissions in the waste category are attributed to waste-in-place emissions at the City-owned-and-operated 28th Street Landfill. Waste-in-place emissions are the result of anaerobic decomposition of organic material from the existing accumulated waste in a landfill. The anaerobic decomposition occurs at covered landfills where the deposited waste is not exposed to the oxygen in the atmosphere. Previously, the 28th Street Landfill served as the disposal location for solid waste

[8] The Climate Registry. 2016 Default Emission Factors. https://www.theclimateregistry.org/wp-content/uploads/2014/11/2016-Climate-Registry-Default-Emission-Factors.pdf Accessed: Oct. 2019

generated within the City between 1968 and 1994. Since the 28th Street Landfill's permanent closure in 1997, a methane gas recovery system was installed and operated by a third-party contractor that collects and disposes of much of the gas that is generated from the closed landfill. From the early 1990s until 2010, the City sold a portion of the captured landfill gas to Blue Diamond Almond for their industrial operations, flaring the remaining captured CH_4. However, in 2013, due partially to the declining quality of landfill gas, the landfill flared all CH_4 that was captured through its landfill gas (LFG) collection system, rather than sell it for combustion. Fugitive CH_4 emissions which were not flaring in 2016 resulted in an estimated 10,512 $MTCO_2e$. The IPCC considers any CO_2 (non-methane) emissions from flaring or fugitive emissions from landfills to be of biogenic origin and not significant to overall solid waste emissions.

2.7 Streetlights and Traffic Signals

Electricity in this sector falls into three categories, traffic signals, City-owned streetlights (metered and non-metered), and SMUD-owned streetlights. Electricity usage for traffic signals and SMUD owned streetlights was provided by with the EnergyCAP data. Electricity data for unmetered streetlights was not available through EnergyCAP. Instead, the City provided a comprehensive list of all City-owned streetlights and wattage estimates. This information along with a SMUD-provided operational assumption of approximately 4,000 hours of streetlight use per year was used to estimate unmetered streetlight electricity use.[9]

In 2016, the operation of streetlights and traffic signals in the City required approximately 23,097,333 kWh of electricity and resulted in 5,186 $MTCO_2e$, contributing 9 percent of the City's total annual GHG emissions (Table 9). In 2016 the City operated 41,591 streetlights and at least 631 traffic signals.[10] This sector captures electricity for all streetlights and traffic signals operated by the City, including both City-owned and SMUD-owned streetlights.

Table 9 Streetlight and Traffic Signal Emissions

Source (Number)	Electricity (kWh)	CO_2 (MT)	CH_4 (MT)	N_2O (MT)	Emissions (MT CO_2e)
Traffic Signals (631)	1,995,276	446.1	0.0299	0.0036	448
City-Owned Streetlights (38,135)	19,348,584	4326.3	0.2896	0.0351	4,344
SMUD-Owned Streetlights (3,456)	1,753,473	392.07	0.0262	0.0032	394
Total	**23,097,333**	**5164.5**	**0.35**	**0.0419**	**5,186**

[9] https://www.smud.org/-/media/Documents/Rate-Information/Rates/01_SLS.ashx

[10] 630 traffic signal accounts were registered with SMUD with one additional Master Account with an unknown number of associated signals. 631 is used here as the minimum value.

3 Municipal Forecast

A baseline municipal GHG emissions inventory (i.e., the City of Sacramento's 2016 municipal inventory) sets a reference point for municipal emissions for a single year. As the demographics of the City change, municipal emissions may change as well, such that municipal emissions in the future may be quite different. A municipal GHG emissions forecast attempts to quantitatively capture these future changes, and is based primarily on projected population growth within the City, as well as existing programs and regulations at the City and State level as of the 2016 inventory. The projections from the municipal emissions forecast provides the basis for determining the City's Climate Action Plan policies on a municipal level. Municipal policies are developed based on the difference or gap between the municipal forecast and the municipal reduction targets set by the City.

This section quantifies the projected municipal GHG emissions for the City of Sacramento in the horizon years 2030 and 2045. The forecast additionally includes reductions from State regulations in order to provide a more accurate picture of future emissions growth and highlight the City's responsibility for achieving further reductions necessary for attainment of municipal GHG emissions targets. This "gap analysis" provides the City with the total municipal emissions reductions that would be necessary to achieve goals, as well as information on the emissions sectors and sources which have the most GHG reduction opportunities. Further details on State regulations and programs aimed at reducing GHG emissions are provided in Appendix A.

3.1 Forecast Methods and Results Summary

The driving factor for the municipal forecast was population growth, as an increasing population is anticipated to lead to increased municipal staff and increased usage of municipal facilities and services. Population projections were obtained from the 2035 Sacramento General plan population forecast. While it is not known if the City will build or acquire new buildings or facilities by 2045, it was conservatively assumed that any newly constructed or acquired building or facility would be at least as energy-intensive as the building or facility it replaced. Therefore, building and facility energy use projected into 2030 and 2045 is the same as energy use in 2016. Waste-in-place emissions are expected to decrease, as the 28th St. Landfill is no longer operating and will continue to add organic material into 2045, decreasing overall emissions from off-gassing. All other sectors – water management, streetlights and traffic signals, and vehicle fleet – represent services for the general population and should therefore increase with the population. For simplicity, growth in these service sectors were assumed to increase linearly with population. The exception is electricity usage for stormwater drainage under the water management sector, which will vary from year to year based on total precipitation in each year and was carried forward unchanged from 2016 to 2030 and 2045 for reasons further discussed in Section 3.3.

Overall municipal GHG emissions in the City of Sacramento are forecast to decrease 42 percent by 2045 under existing programs and regulations (Table 10). Due to SB 100 requiring 100 percent GHG-free electricity in 2045, electricity-related emissions from buildings and facilities, streetlights and traffic signals, and water management are expected to reduce to zero by 2045. Emissions from natural gas, waste, and fuel usage from the vehicle fleet are expected to constitute the majority of emissions by 2045.

Table 10 Municipal Forecast Summary

Year	2005	2016	2030	2045
Population	369,365	487,758	600,231	699,903
Projected Population Increase (%)	–	–	23.1 1.7% per year	16.6 .1% per year
Buildings and Facilities	35,773	15,214	10,965	6,149
Water Management		9,516	6,093	0
Waste-in-Place	14,021	10,512	6,775	3,722
Streetlights and Traffic Signals	6,872	5,186	3,390	0
Vehicle Fleet	21,927	16,035	19,732	23,009
Municipal Emissions (MT CO_2e)	**78,584**	**56,463**	**46,954**	**32,880**
Municipal Emissions per Capita (MT CO_2e/person)		**0.116**	**0.078**	**0.047**
Reduction from 2016 (%)	**–**	**–**	**17%**	**42%**

MT CO_2e: metric tons of carbon dioxide equivalent

SB 100 is the only state regulation included in the muncipal forecast. Although, it will reduce municipal GHG emissions substantially by 2045 as shown in Table 11. However, a gap remains between the municipal forecast and the City's municipal targets. The reductions to close the gap will come from existing and newly identified municipal measures included in this and future iterations of the Sacramento Climate Action Plan.

Table 11 Estimated GHG Emissions Savings from SB100

Year	2016	2030	2045
Projected Electricity Use (kWh)	40,409,680	40,409,680	40,409,680
BAU Emissions (MT CO_2e)	9,065	9,065	9,065
Emissions with SB100 (MT CO_2e)	9,065	4,816	0
Savings (MT CO_2e)	0	4,249	9,065

3.2 Buildings and Facilities

As described in Section 3.1, it was conservatively assumed that building and facility energy use projected into 2030 and 2045 will be the same as energy use in 2016. That is, the City will use roughly the same amount of electricity, natural gas, gasoline, and diesel each year through 2045. However, while municipal building and facility energy use is expected to remain the same, GHG emissions from electricity in general are expected to decrease each year, due to the Renewable Portfolio Standard (RPS) and SB 100. The RPS program requires investor-owned utilities, publicly owned utilities, electric service providers, and community choice aggregators to increase procurement from eligible renewable energy resources to 50 percent of total procurement by 2026 and 60 percent of total procurement by 2030. The RPS program further requires these entities to increase procurement from GHG-free sources to 100 percent of total procurement by 2045. Further details on the RPS program are contained in Appendix A. After factoring in emissions reductions

from the RPS program, overall GHG emissions from municipal buildings and facilities will therefore decrease through 2045, from 15,214 MT CO_2e in 2016 to 10,965 MT CO_2e in 2030 to 6,149 MT CO_2e in 2045 (Table 12).

Table 12 Activity and Emissions Data for Municipal Buildings and Facilities

	2016	2030	2045
Activity Data			
Purchased Electricity – SMUD (kWh)	40,323,720	40,323,720	40,323,720
Purchased Electricity – PG&E (kWh)	85,960	85,960	85,960
Purchased Electricity – Solar City (kWh)	85,960,000	85,960,000	85,960,000
Natural Gas Use – PG&E (therms)	900,788	900,788	900,788
Gasoline Use (gallons)	44	44	44
Diesel Use (gallons)	1,661	1,661	1,661
Emissions Factors			
SMUD Electricity (MT CO_2e/kWh)	0.00022	0.00012	0.0
PG&E Electricity (MT CO_2e/kWh)	0.00013	0.00008	0.0
Solar City Electricity (MT CO_2e/kWh)	0.00000	0.00000	0.0
PG&E Natural Gas (MT CO_2e/therm)	0.00681	0.00681	0.00681
Gasoline (MT CO_2e/gallon)	0.00883	0.00883	0.008823
Diesel (MT CO_2e/gallon)	0.01147	0.01147	0.01147
Emissions (MT CO_2e)			
Electricity – SMUD	9,053	4,809	0
Electricity – PG&E	12	7	0
Electricity – Solar City	0	0	0
Natural Gas – PG&E	6,130	6,130	6,130
Gasoline	0.4	0.4	0.4
Diesel	19	19	19
Total	**15,214**	**10,965**	**6,149**

MT CO_2e: metric ton of carbon dioxide equivalent; kWh: kilowatt hour

3.3 Water Management

Electricity used for water management attributable to water supply conveyance and wastewater conveyance will increase each year as the population grows, to service more people and meet projected demand. As mentioned above, electricity usage attributable to stormwater drainage varies from year to year based on precipitation levels, independent of population growth. Inventory year 2016 was the ninth wettest year on record in Sacramento, suggesting that electricity usage for stormwater drainage was particularly high in 2016. This forecast made the conservative assumption that 2030 and 2045 may also be particularly wet years, especially considering that climate change is

expected to bring more intense rainfall to Northern California. The electricity usage for stormwater drainage from 2016 was therefore carried forward into 2030 and 2045. Emissions totals for electricity usage from water management factored in anticipated changes to emissions factors due to the RPS program (Table 13)

Table 13 Water Management Activity and Emissions Data

	2016	2030	2045
Activity Data			
Water Supply Conveyance (kWh)	35,190,068	43,304,613	50,495,600
Wastewater Conveyance (kWh)	2,551,344	3,139,663	3,661,023
Stormwater Drainage (kWh)	4,645,541	4,645,541	4,645,541
Emissions Factors			
SMUD Electricity (MT CO_2e/kWh)	0.00022	0.00012	0.0
Emissions (MT CO_2e)			
Water Supply Conveyance	7,901	5,164	0
Wastewater Conveyance	573	374	0
Stormwater Drainage	1,043	554	0
Total	**9,516**	**6,093**	**0**

MT CO_2e: metric ton of carbon dioxide equivalent; kWh: kilowatt hour

3.4 Waste-in-Place

Waste-in-Place emissions are expected to decrease over time due to no new organic material being added to the 28th Street landfill. As described in Section 2.6, waste-in-place emissions are entirely attributed to flaring of off-gassed CH_4 from the permanently closed 28th Street Landfill. To estimate how emissions may decrease over time the annual percent reduction (4 percent) was calculated for the period between 2013 and 2016. In 2016, the landfill collected and flared 243,718,413 cubic feet of gas with an average methane content of 29.10 percent. Emissions from gas flaring at the landfill were 10,512 MT CO_2e. The estimated gas capture based on historic subsidence and associated emissions based on Equation 9.1 of the LGOP protocol are included below in Table 14.

Table 14 Waste-in-Place Collected Gas and Emissions Estimates

	2016	2030	2045
Data			
Collected Gas	243,718,413	157,070,840	86,282,675
Emissions	10,512	6,775	3,722

3.5 Streetlights and Traffic Signals

Emissions from streetlights and traffic signals are based on electricity usage. Electricity usage associated with streetlights and traffic signals will increase as population increases (Table 15).

Table 15 Streetlights and Traffic Signals Activity and Emissions Data

	2016	2030	2045
Activity Data (kWh)			
Traffic Signals	1,995,276	2,455,371	2,863,099
City-owned streetlights	19,348,584	23,810,211	27,764,037
SMUD-owned streetlights	1,753,473	2,157,810	2,516,127
Emissions Factors			
SMUD Electricity (MT CO_2e/kWh)	0.00022	0.00012	0.0
Emissions (MT CO_2e)			
Traffic Signals	448	293	0
City-owned streetlights	4,344	2,839	0
SMUD-owned streetlights	394	257	0
Total	**5,186**	**3,390**	**0**

MT CO_2e: metric ton of carbon dioxide equivalent; kWh: kilowatt hour

3.6 Vehicle Fleet

Emissions from the City's vehicle fleet were calculated based on total fuel usage in the year 2016. To project these numbers forward into 2030 and 2045, all fuel usage was assumed to increase at the same rate of population, as vehicle usage increases to provide services to more people every year (Table 16). Because vehicle fleet emissions are calculated using fuel specific factors (MT CO_2e per gallon of fuel) these emission factors will not change over time as they are tied to the direct properties of the fuel. However, the efficiency of the fleet may increase over time lowering the total fuel combusted. This efficiency increase is difficult to calculate for several reasons. The first is that a large portion of the fuel combusted was in heavy duty vehicles which are not covered under current legislation. Furthermore, the estimates in the EMFAC model tool which is used to calculate future vehicle emissions is based on the countywide fleet. It is not clear that the City fleet (which is already made up of generally newer and more efficient vehicles) would have the same impact due to current legislation like Pavley. Therefore, to be conservative no adjustments were made to the City fleet. Emissions reductions will be calculated as part of the GHG reduction measures.

Table 16 Activity and Emissions Data for Municipal Vehicle Fleet

	2016	2030	2045
Activity Data (gallons)			
Gasoline	1,146,935	1,411,409	1,645,782
Diesel	5,173	6,365	7,422
Biodiesel (99%)	512,081	630,163	734,806
CNG	67,880	83,532	97,403
RNG	18,228	22,432	26,156
Propane	7,538	9,276	10,816
LNG	945,258	1,163,227	1,356,388
Ethanol	53,808	66,216	77,212
Emissions Factors (MT CO_2/gallon)			
Gasoline		0.00886	
Diesel		0.01147	
Biodiesel (99%)		0.00126	
CNG		0.00732	
RNG		0.00097	
Propane		0.00577	
Emissions (MT CO_2e)			
Gasoline	10,125	12,459	14,528
Diesel	59	73	85
Biodiesel (99%)	643	791	922
CNG	495	610	711
RNG	18	22	25
Propane	44	54	62
LNG	4,312	5,306	6,187
Ethanol	340	418	487
Total	**16,035**	**19,732**	**23,009**

4 Municipal Target Setting

Municipal emissions reduction targets can be set the same way as community-wide reduction targets: as either an efficiency target (MT CO_2e per capita or per service population per year) or as a community wide mass emissions target (total MT CO_2e). Target setting is an iterative process which must be informed by the reductions that can realistically be achieved through the development of feasible GHG reduction measures. Furthermore, the General Plan Update may impact the forecast results. As such, the targets identified herein should remain provisional until the General Plan Update values are finalized and the quantification and analysis of potential GHG reduction measures completed.

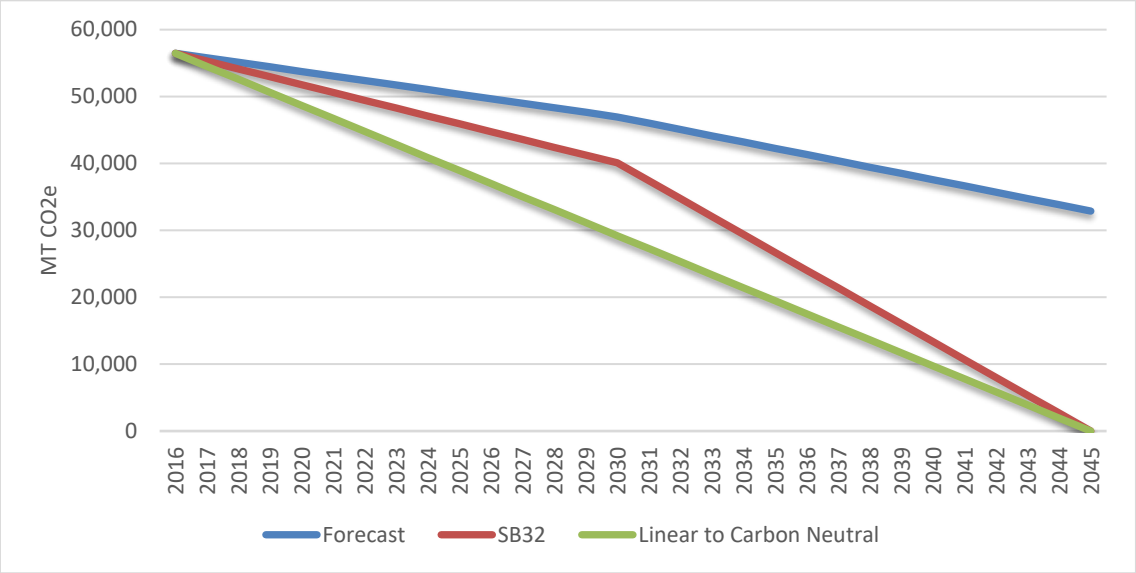
The City of Sacramento has achieved both efficiency and absolute emissions reductions in municipal operations between 2005 and 2016. The purpose of target setting is to develop the trajectory toward achieving the State's 2030 goal and prepare for the deep decarbonization needed by 2045 in a cost-effective manner by setting an incremental path toward achieving the EO B-55-18 goals. There are two primary target pathways available to be consistent with State reduction goals:

- **SB 32 Target Pathway (red)** is the pathway toward achieving the minimum reductions required by State law. This will require minimal reductions until 2030 and then steep reductions from 2030 to 2045.
- **Linear Carbon Neutrality Pathway (green)** is an incremental linear pathway from current per capita emissions levels straight to carbon neutrality in 2045. This pathway is also compliant with the 2030 State goal.

At this time Rincon suggests setting a municipal target that meets or exceeds the targets set for the community. The City has already set a reduction target of 33 percent below 2005 levels by 2020 which is more aggressive than the AB32 requirement of a return to 1990 levels or approximately a 15 percent reduction below 2005 levels by 2020. The two suggested reduction pathways are shown graphically in Figure 2.

Per Capita based municipal emissions targets were not included in this analysis. While a per capita target works well for the community, it is not recommended for the City since municipal emissions are not as directly tied to population growth. Therefore, Rincon suggests setting a mass emissions reduction target of at least 55 percent below 2005 levels by 2030 and carbon neutrality by 2045 and thereafter. This pathway would be consistent with SB32 and Executive Order B-55-18 and is shown in Figure 3 (in red). However, a more aggressive target such as a linear reduction to carbon neutrality in 2045, shown in green in Figure 3, could also be considered. In order to achieve the SB32 compliant pathway (red), the City would need to reduce 48 percent below 2005 levels, 29 percent below 2016 levels, or an estimated 15 percent below 2030 forecast levels by 2030. To reach the linear to carbon neutral target shown in green, the City would need to reduce 60 percent below 2005 levels, 48 percent below 2016 or 38 percent below 2030 forecast levels by 2030. Emission levels for each target pathway, relative to historical actuals and the forecast, are presented in Table 17.

Figure 3 Municipal Target Reduction Pathways



Based on the results of the community target setting and the municipal measure quantification process, the City may choose either of these targets for consistency with state targets.

Table 17 Municipal Target Reduction Pathways

Target Pathway	2005 ($MT CO_2e$)	2016 ($MT CO_2e$)	2030 ($MT CO_2e$)	2045 ($MT CO_2e$)
Historical Actual & Forecast	78,584	56,463	46,954	32,880
SB 32	-	-	40,078	0
Linear to Carbon Neutral	-	-	29,205	0

$MT CO_2e$: metric tons of carbon dioxide equivalent