City of Merced

2011 Inventory of Community and Government Operations Greenhouse Gas Emissions

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Narrative Report

Produced by Great Valley Center

With Assistance from ICLEI - Local Governments for Sustainability USA
Supported by Pacific Gas and Electric Company

April 2014

Credits and Acknowledgements

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Pacific Gas and Electric Company provides comprehensive climate planning assistance to local governments, from providing energy usage data and assistance with greenhouse gas inventories, to training and guidance on climate action plans.

This program is funded by California utility customers and administered by PG&E under the auspices of the California Public Utilities Commission.

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Executive Summary

The Purpose of Conducting an Inventory

Every day, Merced plays host to a variety of activities necessary for ensuring a properly functioning and robust community. These activities include burning fuel for transportation, generating and treating waste, moving and treating water, and providing light and heat for buildings. All of these activities either directly or indirectly contribute to the addition of carbon dioxide and other greenhouse gases into the environment. This report presents the findings and methodology of a community-wide greenhouse gas (GHG) emissions inventory and a local government operations GHG emissions inventory for Merced in 2011.

The inventories address where and what quantity of emissions are generated through various community and local government activities. Each inventory views emissions from a specific scope. The community-wide inventory measures the GHG emissions resulting from a variety of activities occurring and sources located within the Merced city limits. An analysis of a community's emissions may inform community-scale planning initiatives aimed at reducing GHG emissions. The local government operations (LGO) inventory measures the GHG emissions resulting specifically from the City of Merced's government operations, arranged by sector to facilitate detailed analysis of emissions sources. Through analysis of a local government's emissions profile, the City of Merced can lead by example by tailoring strategies to achieve the most effective GHG emission reductions from its operations.

City of Merced Profile

The City of Merced is located in eastern Merced County within the northern San Joaquin Valley. The City covers approximately 23 square miles with State Route 140 and State Highway 99 running through its boundaries. The City of Merced had an estimated population of 78,986 during the inventory year 2011. At this time there were approximately 23,350 households, 1,413 commercial or industrial establishments, and 28,545 residents employed in the regional workforce. With approximately 463 full-time equivalent employees, there were approximately 5.86 City employees per one thousand residents in 2011.

The City of Merced is located within Climate Zone 12,[1] according to the U.S. Department of Energy. Climate Zone 12 is classified as a Mediterranean climate, by the Köppen Classification System, and is characterized by cool, wet winters and warmer, dry summers. The City of Merced experiences a climate similar to the Stockton area, which recorded 3,570 heating degree days[2] and 1,133 cooling degree days in 2011.[3]

[1] Pacific Energy Center's Guide to: California Climate Zones, retrieved from http://www.pge.com/includes/docs/pdfs/about/edusafety/training/pec/toolbox/arch/climate/california_climate_zones_01-16.pdf

[2] Heating and Cooling Degree Days are a measurement designed to reflect demand for energy needed to heat or cool a facility, and are calculated as the difference between the average daily temperature for a region and a baseline temperature (usually 65° or 80° F). HDD value is the summation of degrees of the average temperature per day below 65° F for the year. CDD is the summation of degrees of the average temperature per day above 80° F for the year

[3] NNDC Climate Data, retrieved from http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp

2011 Inventory in Relation to 2008 Baseline

The year 2008 was selected by the City of Merced as the baseline measure of greenhouse gas emissions. The 2008 study, which is part of the City's Climate Action Plan, presents emissions estimates from various operations, sources and activities which occurred in 2008. The study is meant to present a "snapshot" of emissions during the base year, serving as a starting-point for reducing emissions in the future. This report is meant to serve as a more recent "snapshot" of similar activities and sources occurring during 2011, as a basis for monitoring the City's progress in reducing emissions.

The year 2008 was selected as a baseline specifically in response to Assembly Bill 32, the Global Warming Solutions Act of 2006 (AB 32), which requires the state to reduce its greenhouse gas emissions to 1990 levels by 2020. The AB 32 Scoping Plan was developed to identify strategies for meeting the AB 32 goal, and was adopted by the California Air Resources Board in December 2008. Among many other strategies, it encourages local governments to reduce emissions in their jurisdictions by 15 percent below current levels by 2020 – with "current year" interpreted as any year between 2005 and 2008.

It is important to note that the Merced Climate Action Plan was adopted on October 1, 2012. The results of this 2011 report are not meant to serve as an evaluation of the action plan, as the policy had yet to be fully adopted during the inventory year 2011. The year 2011 was selected as an interim inventory year at the onset of the Green Communities program in 2013 because utility-specific emissions factors and other important indicators of GHG emissions were only available as recent as 2011 at that time.

Inventory Results

Year-Over-Year Comparisons

As part of an ongoing emissions reduction strategy, city staff will monitor changes related to a series of GHG emissions metrics. While year-over-year comparisons of overall emissions estimates may be helpful in determining the city's overall emissions trend, it is recommended that city staff monitor individually the activities and sources assumed to be producing changes in emissions. Doing so will likely garner more valuable information to aid in evaluating the effectiveness of strategies adopted in the Merced Climate Action Plan.

Since the 2008 baseline inventory was completed, new standards guiding reporting framework and emission calculation methods have emerged and have been incorporated into this report. While reviewing the content of this report, it is important to acknowledge the following three conditions: 1) the Merced Climate Action Plan was not in place between 2008 and 2011; 2) the inventories were conducted using different methods; and 3) certain external conditions, such as weather fluctuation, will inevitably have an effect on the City of Merced's emissions. Simply comparing overall emissions may not account for changes such as these.

Community-Wide Emissions

There are a variety of emissions sources and activities included in the community-wide inventory. A subset of these, identified as local government significantly influenced emissions, are most policy relevant. Figure ES 1 shows the significantly influenced activity emissions, while Figure ES 2 shows significantly influenced emissions by emission source.

As illustrated in Figure ES 1, the activity contributing the greatest amount of emissions during the inventory year was transportation with 42% of overall emissions. Activities in the commercial/industrial and residential sectors resulted in the second and third greatest emissions (32% and 21% respectively). As illustrated in Figure ES 2, electricity was the largest source of emissions at 35% of emissions, followed by gasoline at 32% and natural gas at 18%. Actions to reduce emissions from these activities and sources, typically subject to local government influence, will be a key consideration in the City of Merced's GHG emissions reduction strategy.

Figure ES 1: 2011 Community CO_2e Emissions Activities Subject to Local Government Significant Influence

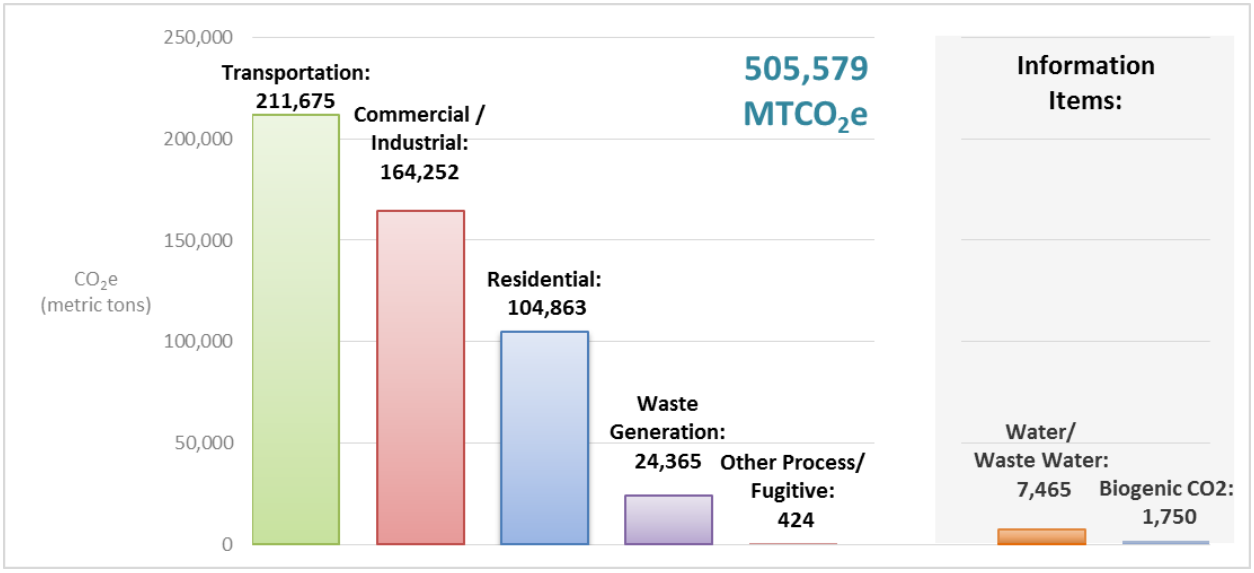
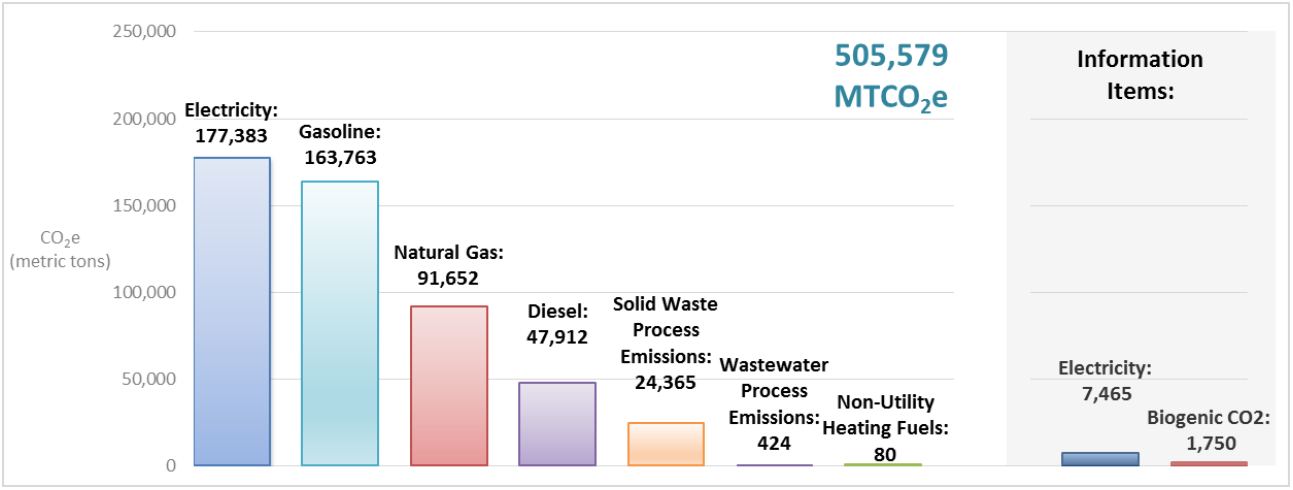


Figure ES 2: 2011 Community CO_2e Emissions Sources Subject to Local Government Significant Influence



Local Government Operations Emissions

The following figures summarize the results of the LGO emissions inventory by sector and source. As illustrated in Figure ES 3, the sector producing the most greenhouse gas emissions in the City of Merced was the wastewater treatment sector at 30%, followed by the vehicle fleet and water delivery sectors at 25% and 22% respectively. As shown in Figure ES 4, electricity was the source with the greatest percentage of emissions at 61%, followed by diesel and gasoline (17% and 10% respectively).

Figure ES 3: 2011 Government Operations CO_2e Emission by Sector

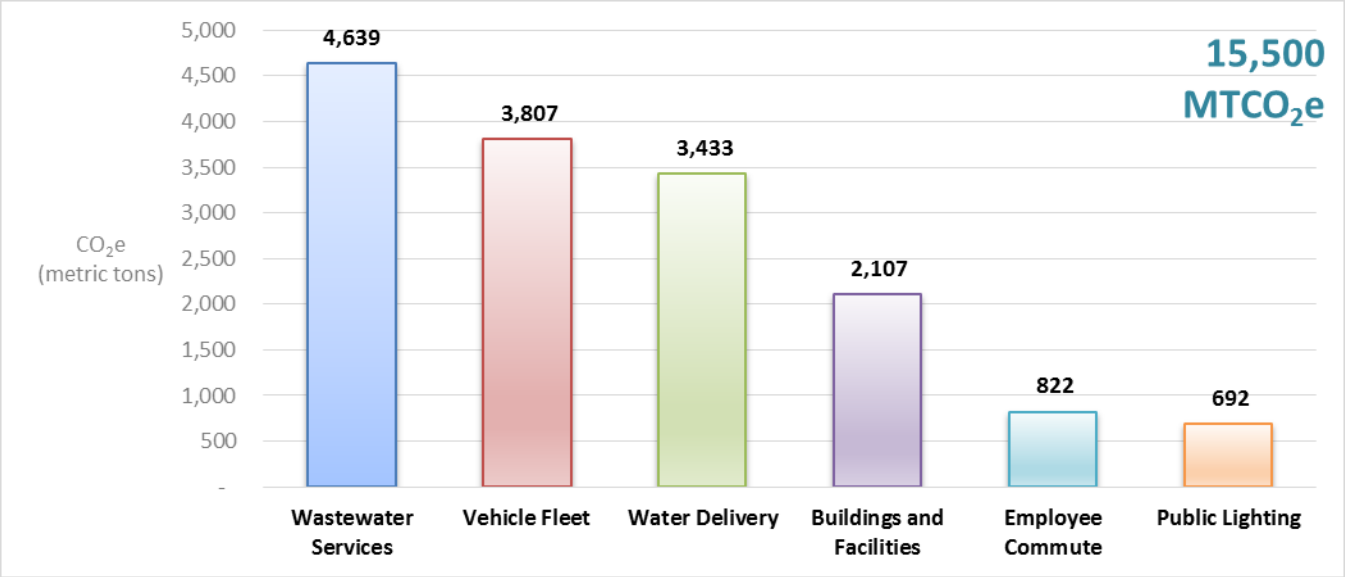
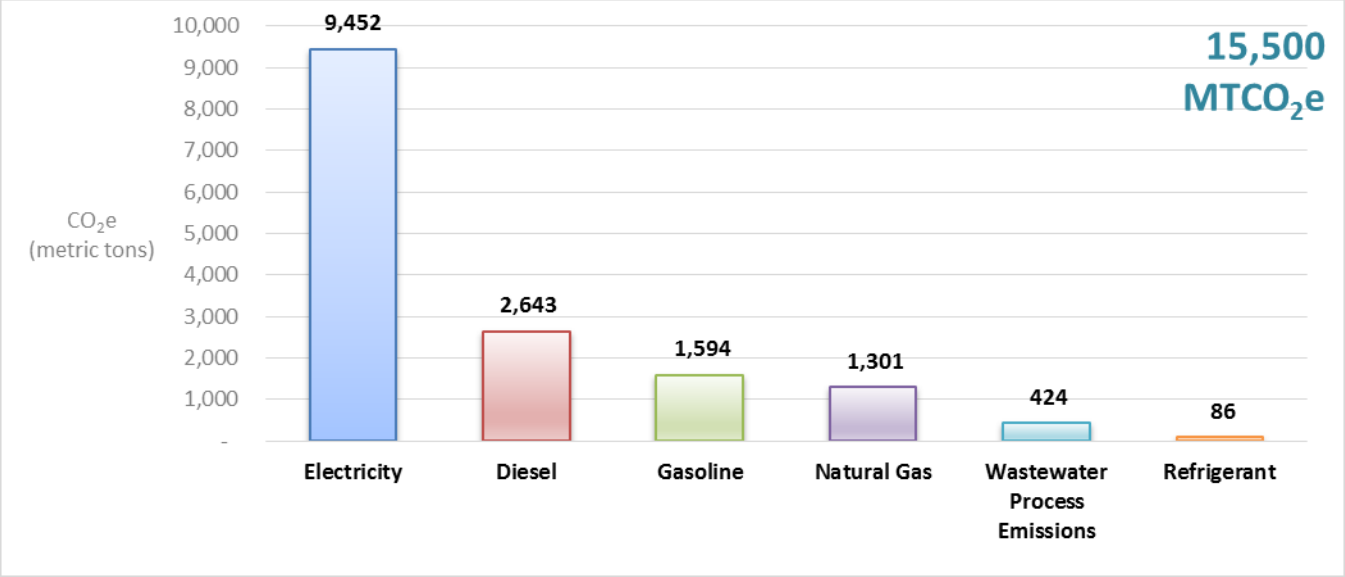


Figure ES 4: 2011 Government Operations CO_2e Emission by Source



The Inventory Results section of this report provides a detailed profile of emissions sources within the City of Merced; information that is key to guiding local reduction efforts. These data will also provide a benchmark, against which, along with the City's 2008 baseline, the City of Merced will be able to compare future performance and demonstrate progress in reducing emissions.

Sustainability & Climate Change Mitigation Activities in Merced

The City of Merced has already implemented programs that have or will lead to ancillary benefits in the form of energy conservation and greenhouse gas mitigation. For instance, in 2012 the City invested $7.2 million in energy upgrades and retrofits for 17 City facilities, seven City parks, and the Merced Regional Airport and replaced thousands of streetlights with more efficient bulbs. The project is expected to reduce the City's demand for electricity by 3.3 million kilowatts each year, equating to roughly $2.3 million in savings each year and reducing approximately 2,276 metric tons of CO_2e per year.[4] The project was partially funded through American Reinvestment and Recovery Act (ARRA) funds.

The City of Merced's goal of reducing emissions to 1990 levels by 2020 is outlined in the Merced Climate Action Plan. Current incentives and targets are outlined in Table ES 1 below.

Table ES 1: Numbers of Strategies and Actions and GHG Reduction Targets by Goal[5]

Merced CAP Goals	Number of Distinct Strategies	Number of Distinct Actions	Percent of Total Reduction	Anticipated $MTCO_2e$ by 2020
Enhance Mobility (EM)	5	20	21.0%	31,062
Sustainable Community Design (SC)	5	24	10.0%	14,792
Air Resources (AR)	4	20	10.0%	14,792
Water Conservation (WC)	4	19	5.0%	7,396
Renewable Energy (RE)	2	12	23.0%	34,020
Building Energy Conservation (BE)	6	32	30.5%	45,114
Waste Reduction (WR)	2	13	0.50%	740
Public Outreach	3	16	0.0%	0
TOTALS	**31**	**156**	**100%**	**147,915**

[4] GHG emissions reductions estimated by Siemens Building Technologies.

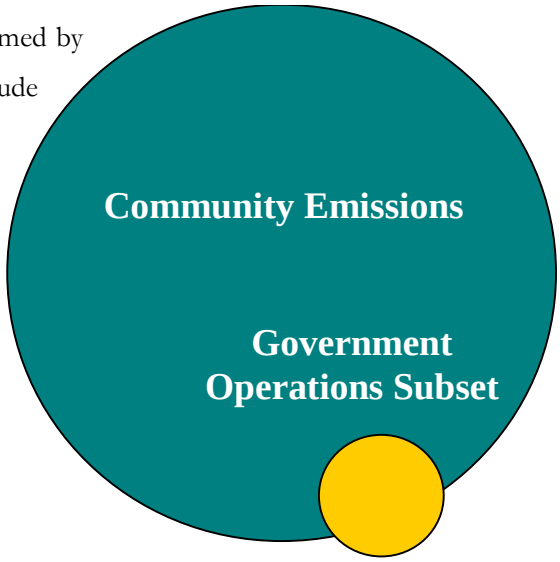
[5] Table reproduced from City of Merced, 2012: Merced Climate Action Plan (sec. 1, pg. 21)

Inventory Methodology

Understanding a Greenhouse Gas Emissions Inventory

The first step toward achieving tangible greenhouse gas emission reductions requires identifying baseline emissions levels and sources and activities generating emissions in the community. This report presents emissions from both the City of Merced community as a whole, and from operations of the City of Merced government. The government operations inventory is mostly a subset of the community inventory, as shown in Figure 1. For example, data on commercial energy use by the community includes energy consumed by municipal buildings, and community vehicle-miles-traveled estimates include miles driven by municipal fleet vehicles.

Figure 1: Relationship of Community and Government Operations Inventories



As more and more local governments prepare GHG emissions inventories, the need for a standardized approach to quantify GHG emissions has increased. This inventory uses the approach and methods provided by the Community Greenhouse Gas Emissions Protocol (Community Protocol) and the Local Government Operations Protocol (LGO Protocol), both of which are described below.

Community Emissions Protocol

The U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions[6] was released by ICLEI in October 2012, and represents a new national standard in guidance to help U.S. local governments develop effective community GHG emissions inventories. It establishes reporting requirements for all community GHG emissions inventories, provides detailed accounting guidance for quantifying GHG emissions associated with a range of emission sources and community activities, and provides a number of optional reporting frameworks to help local governments customize their community GHG emissions inventory reports based on their local goals and capacities. The State of California Governor's Office of Planning and Research recommends that California local governments follow the Community Protocol when undertaking their greenhouse gas emissions inventories.

Local Government Operations Protocol

In 2008, ICLEI, the California Air Resources Board (CARB), and the California Climate Action Registry (CCAR) released the Local Government Operations Protocol for the Quantification and Reporting of Greenhouse Gas Emissions Inventories.[7] The LGO Protocol serves as the national standard for quantifying and reporting greenhouse emissions from local government operations. The purpose of the LGO Protocol is to provide the principles, approach, methodology, and procedures needed to develop a local government operations greenhouse gas emissions inventory.

[6] http://www.icleiusa.org/tools/ghg-protocol/community-protocol
[7] Local Government Operations Protocol. http://www.icleiusa.org/programs/climate/ghg-protocol/ghg-protocol

Quantifying Greenhouse Gas Emissions

Sources and Activities

Communities contribute to greenhouse gas emissions in many ways. Two central categorizations of emissions are used in the community inventory: 1) GHG emissions that are produced by "sources" located within the community boundary, and 2) GHG emissions produced as a consequence of community "activities".

Table 1: Sources and Activities

Source	Activity
Any physical process inside the jurisdictional boundary that releases GHG emissions into the atmosphere	**The use of energy, materials, and/or services by members of the community that result in the creation of GHG emissions.**

By reporting on both GHG emissions sources and activities, local governments can develop and promote a deeper understanding of GHG emissions associated with their communities. A purely source-based emissions inventory could be summed to estimate total emissions released within the community's jurisdictional boundary. In contrast, a purely activity-based emissions inventory could provide perspective on the efficiency of the community, even when the associated emissions occur outside the jurisdictional boundary. In the community-wide inventory, the division of emissions into sources and activities replaces the scopes framework that is used in government operations inventories because it does not have a clear definition for application to community inventories. However, the scopes framework is maintained in the LGO inventory due to its relevance at that level of analysis.

Emission Types

The Community Protocol and LGO Protocol recommend assessing emissions from the six internationally recognized greenhouse gases regulated under the Kyoto Protocol as listed in Table 2. However, emissions of Hydrofluorocarbons, Perfluorocarbons, and Sulfur Hexafluoride were not included in the community-wide inventory, and were included in a limited capacity in the LGO inventory because of the difficulty of obtaining accurate and relevant data on these emissions. Greenhouse gas emissions are commonly aggregated and reported in terms of equivalent carbon dioxide units, or CO_2e. This standard is based on the Global Warming Potential (GWP) of each gas, which is a measure of the amount of warming a greenhouse gas may cause, measured against the amount of warming caused by carbon dioxide. Converting all emissions to equivalent carbon dioxide units allows for the consideration of different greenhouse gases in comparable terms. For example, methane is twenty-five times more powerful than carbon dioxide in its warming effect, so one metric ton of methane emission is equal to twenty-five metric tons of carbon dioxide equivalents. See Table 2 for the GWPs of the commonly occurring greenhouse gases.

Table 2: Greenhouse Gases and Global Warming Potential

Greenhouse Gas	Chemical Formula	Global Warming Potential[8]
Carbon Dioxide	CO_2	1
Methane	CH_4	25
Nitrous Oxide	N_2O	298
Hydrofluorocarbons	Various	124-14,800
Perfluorocarbons	Various	7,390-12,200
Sulfur Hexafluoride	SF_6	22,800

Emissions Scopes

For the LGO inventory, emissions are categorized by scope, rather than into sources and activities. Using the scopes framework helps prevent double counting.

There are three emissions scopes for government operations emissions:

- **Scope 1:** All direct emissions from a facility or piece of equipment operated by the local government. Examples include tailpipe emissions from local government, and emissions from a furnace in a local government building.
- **Scope 2:** Indirect emissions associated with the consumption of purchased or acquired electricity, steam, heating, and cooling.
- **Scope 3:** All other indirect or embodied emissions not covered in Scope 2. Examples include contracted services, embodied emissions in good purchased by the local government, and emissions associated with disposal of government generated waste.

Scope 1 and Scope 2 emissions are the most essential components of a government operations greenhouse gas analysis as they are the most easily affected by local policy making.

Quantification Methods

Greenhouse gas emissions can be quantified in two ways:

- Measurement-based methodologies refer to the direct measurement of greenhouse gas emissions (from a monitoring system) emitted from a flue of a power plant, wastewater treatment plant, landfill, or industrial facility.
- Calculation-based methodologies calculate emissions using activity data and emission factors. To calculate emissions accordingly, the basic equation below is used: *Activity Data* $\times$ *Emission Factor* $=$ *Emissions*

All emissions sources in this inventory are quantified using calculation based methodologies. Activity data refer to the relevant measurement of energy use or other greenhouse gas-generating processes such as fuel consumption by fuel type,

[8] The IPCC Fourth Assessment Report (2007) provides estimates for global warming potential for each gas type, available at http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm

metered annual electricity consumption, and annual vehicle miles traveled. Please see appendices for a detailed listing of the activity data used in composing this inventory.

Known emission factors are used to convert energy usage or other activity data into associated quantities of emissions. Emissions factors are usually expressed in terms of emissions per unit of activity data (e.g. lbs CO_2/kWh of electricity). For this inventory, calculations were made using the Statewide Energy Efficiency Collaborative (SEEC) Climate and Energy Management Suite (CEMS). CEMS is a web-based management suite, which includes government operations and community emissions calculation modules, forecasting modules and planning modules. The suite was developed by ICLEI.

Information Items

Information items are emissions sources that are not counted toward total emissions in the inventory, but are reported separately in order to provide a more complete picture of emissions.

A common emission that is categorized as an information item is carbon dioxide emitted in the combustion of biogenic fuels – or, fuels of biogenic origin (e.g. wood, landfill gas, organic solid waste, biofuels, etc.). Common sources of biogenic emissions are the combustion of landfill gas from landfills or biogas from wastewater treatment plants, as well as the incineration of organic solid waste at incinerators.

Carbon dioxide emissions from the combustion of biogenic fuels are not counted toward total emissions based on established international principles. Methane and nitrous oxide emissions from biogenic fuels are, however, included in the stationary combustion sections for the appropriate activities and sources. These principles indicate that biogenic fuels (e.g., wood, biodiesel), if left to decompose in the natural environment, would release CO_2 into the atmosphere, where it would then enter back into the natural carbon cycle. Therefore, when wood or another biogenic fuel is combusted, the resulting CO_2 emissions are akin to natural emissions and should therefore not be considered as human activity-generated emissions. The CH_4 and N_2O emissions, however, would not have occurred naturally and are therefore included in the inventory of emissions.

Information items quantified for this inventory include:

- Biogenic CO_2 emissions from incineration of biogenic-origin wastes (e.g. wood, plant debris, etc.)
- Biogenic CO_2 emissions from combustion of wood as a household heating fuel
- Biogenic CO_2 emissions from combustion of digester gas from wastewater treatment
- Use of energy for potable water extraction, treatment, conveyance and delivery, which is a subset of the built environment, split between residential and commercial/industrial sectors
- Use of energy for wastewater collection and treatment, which is a subset of the built environment, split between residential and commercial/industrial sectors

Community Emissions Inventory Results

Following the Community Protocol, this inventory report organizes emissions in two frames. Each frame includes a particular set of emissions sources and activities, and each helps to tell a different story about community emissions. This report looks at the City of Merced community emissions through the following frames:

- Local Government Significant Influence
- Community-Wide Activities

Community Profile

To put emissions inventory data in context, it is helpful to have some basic information about the community, such as population and number of households. This information is provided in Table 3.

Table 3: City of Merced Community Indicators

Estimated 2011 Population[9]	**78,986**
Estimated 2011 Households[10]	**23,350**
Estimated 2011 Employed Workforce[11]	**28,545**
Estimated 2011 Business Establishments[12]	**1,413**

Significantly Influenced Emissions Frame

The City of Merced has chosen first to focus on emissions over which the city government has significant influence. This frame emphasizes policy relevance, highlighting a set of emission sources and activities that the City of Merced has the greatest opportunity to address. This frame includes all of the five Basic Emissions Generating Activities required by the Community Protocol: 1) use of electricity by the community; 2) use of fuel in residential and commercial stationary combustion equipment; 3) on-road passenger and freight motor vehicle travel; 4) use of energy in potable water and wastewater treatment and distribution; and 5) generation of solid waste by the community. In addition to these most common activities, the inventory also includes emissions from wastewater treatment within the community. Table 4 summarizes significantly influenced emissions by source or activity, as applicable, and organized by sector.

[9]California Department of Finance, Historical County and City Estimates, available at: http://www.dof.ca.gov/research/demographic/reports/view.php

[10] United States Census Bureau, American FactFinder, Selected Housing Characteristics for nearest obtainable year or multi-year average, available at: http://www.census.gov/

[11] Ibid.

[12] United States Census Bureau, County Business Patterns (CBP)/Zip Code Business Patterns (ZBP) for select year, available at: http://www.census.gov/econ/cbp/

Table 4: Significantly Influenced GHG Emissions by activity and source

Source or Activity by Sector	Emissions (metric tons CO_2e)	Percent of Emissions	Activity Data Quantity	Units
Residential				
Residential Use of Electricity	47,111	9%	195,707,879	kWh
Residential Stationary Combustion of Natural Gas	57,672	11%	1,084,569	MMBtu
Residential Stationary Combustion of Non-Utility Heating Fuels	80	0%	1,259	MMBtu
Commercial/Industrial				
Commercial/Industrial Use of Electricity	130,272	26%	279,345,809	kWh
Commercial Stationary Combustion	33,980	7%	639,022	MMBtu
Transportation				
On-road Passenger Vehicle Travel: Gasoline	163,763	32%	352,014,983	Vehicle Miles
On-road Passenger Vehicle Travel: Diesel	47,912	9%	26,850,716	Vehicle Miles
Solid Waste				
Landfilled Waste: Methane Recovery	12,675	3%	51,474	Tons
Landfilled Waste: No Methane Recovery	11,478	2%	11,653	Tons
Incinerated Waste	212	0%	631	Tons
Other Process/Fugitive Emissions				
Wastewater Treatment Process N_2O from Treatment	210	0%	1	MT N_2O
Wastewater Treatment Process N_2O from Effluent	210	0%	1	MT N_2O
Wastewater Treatment Emissions from Digester Gas	4	0%	-	-
Total Significantly Influenced Emissions	**505,579**	**100%**		
Information Items				
Use of Electricity in Potable Water Collection, Treatment and Distribution	3,256		7,880,656	kWh
Use of Electricity in Waste Water Collection and Treatment	4,209		6,297,953	kWh
Biogenic CO_2 from Digester Gas Combustion	756		-	-
Biogenic CO_2 from Waste Incineration	370		410	Tons
Biogenic CO_2 from Non-Utility Heating Fuels	624		6,648	MMBtu

Note: For Digester Gas activity data, please see Methods in Section A-2

As illustrated in Figure 2 below, the sector contributing the greatest amount of emissions was transportation (roughly 42% overall), followed by the commercial/industrial sector and residential sector (32% and 21% respectively). Figure 3 breaks down significantly influenced emissions by activity relevant to each sector. Figure 4 breaks down significantly influenced emissions by source relevant to each sector.

These figures only show emissions that are included in the significant influence frame, and are not intended to be comprehensive of all in-boundary sources or community activities. Also note that source emissions and activity emissions generally should not be added together because of the danger of double counting.

Figure 2: Significantly Influenced Emissions by Sector, Including Activities and Sources ($MTCO_2e$)

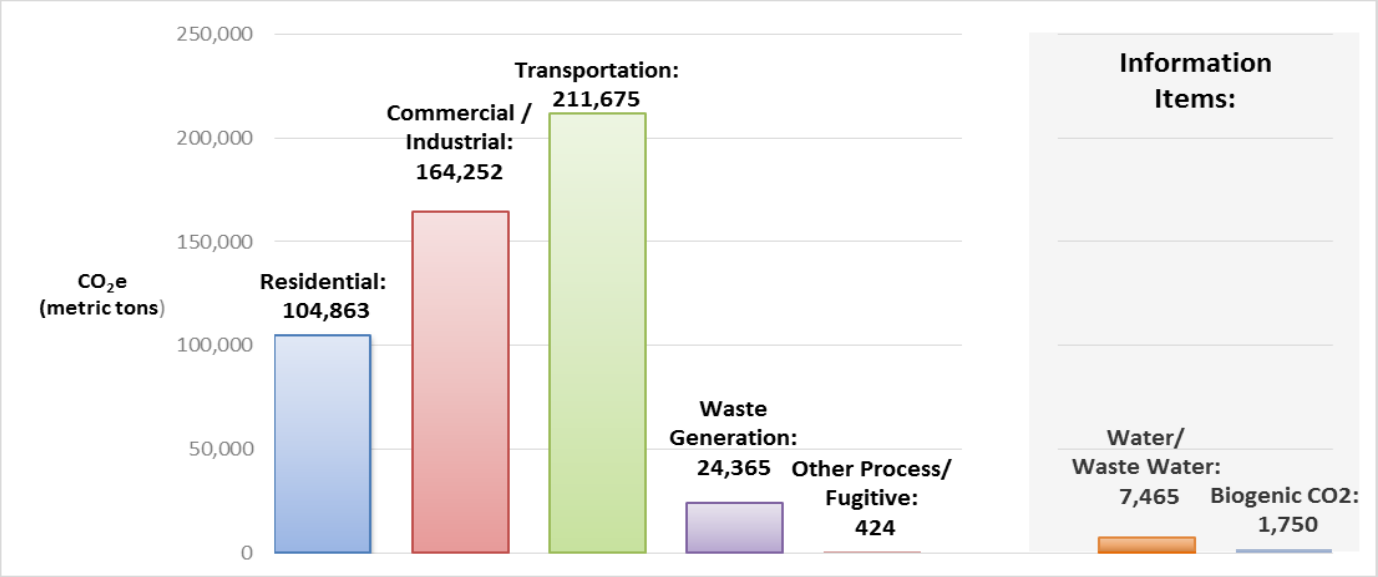
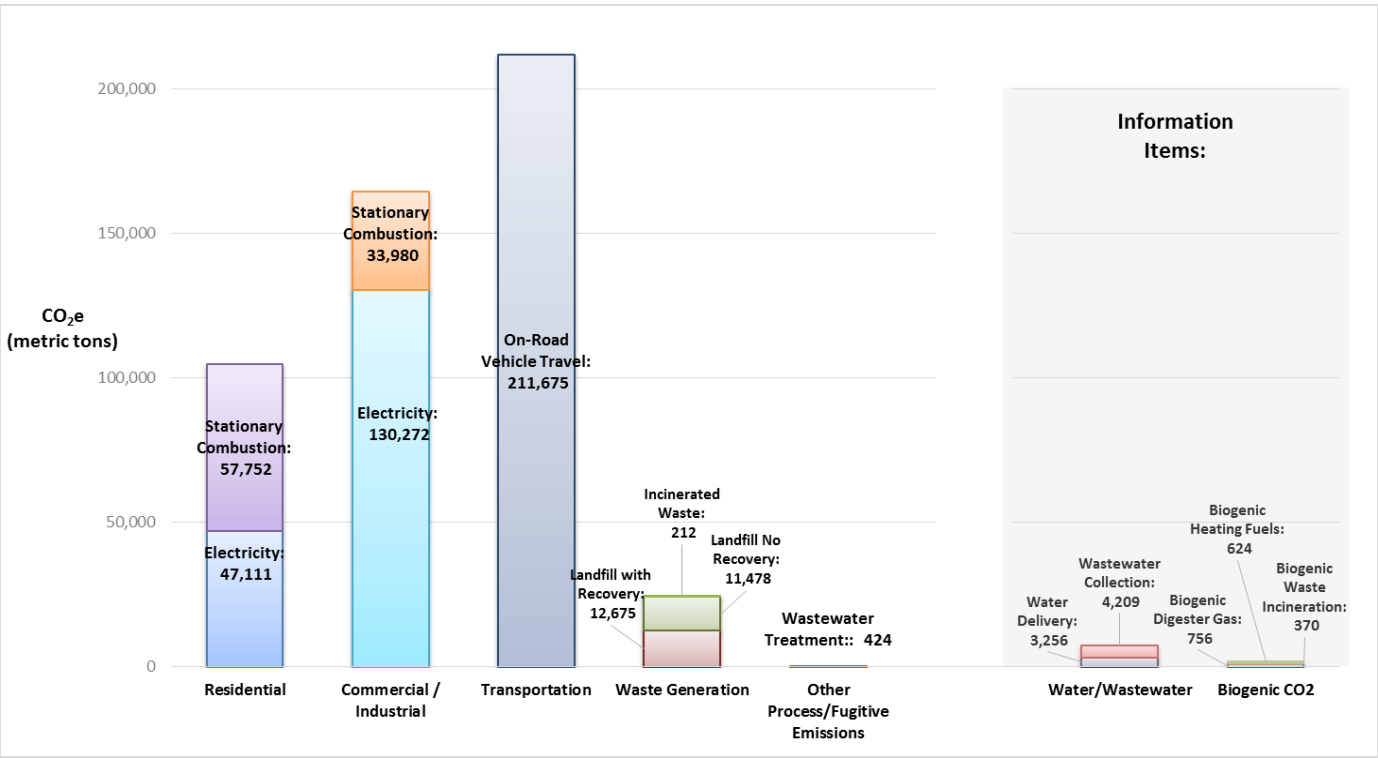
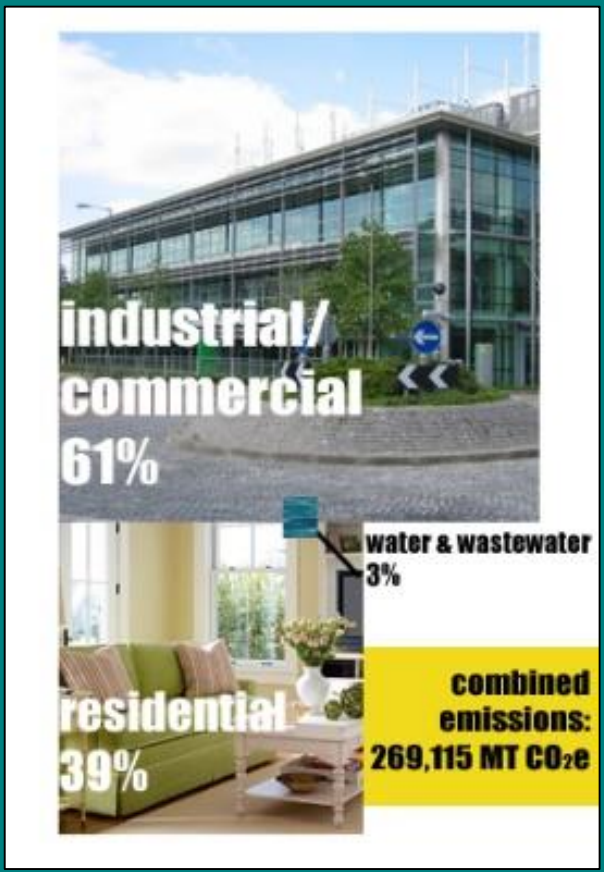


Figure 3: Detailed Significantly Influenced Activity Emissions ($MTCO_2e$)



DISCUSSION: Energy Intensity of Water and Wastewater



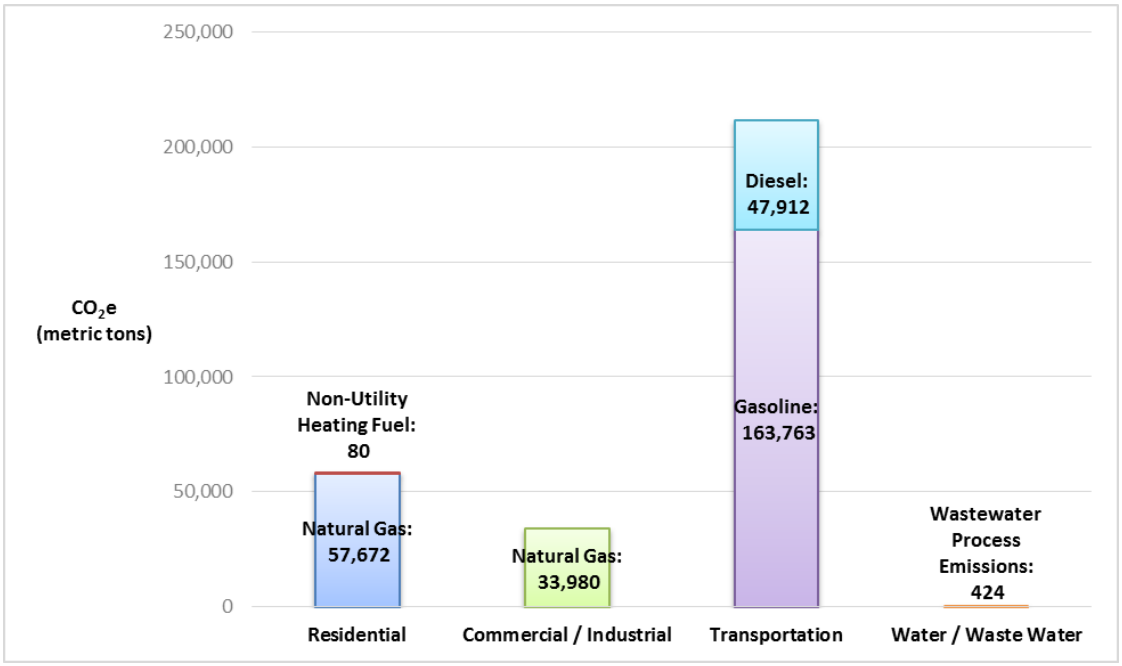
The delivery of water to- and collection of wastewater from- residents and business establishments within a community are core local government services. This service also tends to be energy intensive. Whether provided by a special district or, as is the case in Merced, by the City itself, emissions from energy demand in the water and wastewater sectors are unavoidable. However, the fact that these emissions are government services provides the City with an opportunity to take the lead in addressing an energy intensive activity.

The infographic at left includes emissions occurring in the water/wastewater sector only within the government's operational boundaries and is limited to the following operations: water extraction and treatment; water delivery; wastewater collection; wastewater treatment. End-user energy demand and resulting emissions were not included in the water/wastewater breakdown.

As is illustrated at left, water and wastewater emissions accounted for 3% of the combined emissions from the residential and commercial/ industrial sectors, or roughly 7,465 MT CO_2e.

Figure 4 breaks down significantly influenced emissions by in-bound sources relevant to each sector. As illustrated in Figure 4, gasoline was the greatest source of in-boundary emissions at roughly 54%.

Figure 4: Detailed Significant Influence In-Boundary Source Emissions ($MTCO_2e$)



Community-Wide Activities Frame

The City of Merced has chosen to also look at emissions through the community-wide activities frame. This frame includes emissions that result from the use of energy, materials, and services by all members of the community, regardless of whether the City of Merced has significant influence over those emissions. These emissions may be occurring within or outside of the community boundary. When used for comparison across communities, this framework is helpful in illustrating relative urban efficiencies. Table 5 summarizes emissions from community-wide activities.

This frame includes all of the major sources and activities documented in the Significant Influence frame, except for transportation. Due to data limitations, transportation-related emissions tied to community travel to and from the City of Merced could not be estimated. Since the method used to calculate transportation emissions in the previous frame includes emissions occurring from travel through the City's boundary, including pass-through travel from outside sources, that value cannot be reported solely as a Merced community activity.

Table 5: Community-Wide Activity GHG Emissions by Activity

Activity by Sector	Emissions (metric tons CO_2e)	Percent of Emissions	Activity Data Quantity	Units
Residential				
Residential Use of Electricity	47,111	16%	195,707,879	kWh
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Commercial/Industrial				
Commercial/Industrial Use of Electricity	130,272	44%	279,345,809	kWh
Commercial Stationary Combustion of Natural Gas	33,980	29%	639,022	MMBtu
Solid Waste				
Landfilled Waste: Methane Recovery	12,675	11%	51,474	Tons
Landfilled Waste: No Methane Recovery	11,478	0%	11,653	Tons
Incinerated Waste	212	1%	631	Tons
Other Process/Fugitive Emissions				
Wastewater Treatment Process N_2O from Treatment	210	0%	1	MT N_2O
Wastewater Treatment Process N_2O from Effluent	210	0%	1	MT N_2O
Wastewater Treatment Emissions from Digester Gas	4	0%	-	-
Total Community-Wide Activity Emissions	**293,904**	**100%**		
Information Items				
Use of Electricity in Potable Water Collection, Treatment and Distribution	3,256		2,835,748	kWh
Use of Electricity in Waste Water Collection and Treatment	4,209		565,283	kWh
Biogenic CO_2 from Digester Gas Combustion	756		-	-
Biogenic CO_2 from Waste Incineration	370		1,603	Tons
Biogenic CO_2 from Non-Utility Heating Fuels	624		6,648	MMBtu

Note: For Digester Gas activity data, please see Methods in Section A-2

Government Operations Emissions Inventory Results

Emissions by Scope

As was described in the introduction, scopes are used to keep track of emissions in order to avoid double counting within and between entities. Table 6 lists government operations emissions by scope. Scope 1 emissions come from fuel use in government facilities and vehicles; Scope 2 emissions come from electricity use, and Scope 3 are other indirect emissions. CO_2 from biogenic sources, if applicable, are listed as information items, as they are part of the active carbon cycle.

Table 6: Government Operations Emissions by Scope

Total Emissions	CO_2e	CO_2	CH_4	N_2O
SCOPE 1	5,226	4,598	2	2
SCOPE 2	9,452	9,412	0.3	0.1
SCOPE 3	822	812	0.0	0.0
INFORMATION ITEMS	756	756	-	-

Emissions by Sector

For developing emissions reduction policies it is often most useful to look at emissions broken down by sector, as each sector will have a particular set of strategies to reduce emissions. Table 7 and Figure 5 show the City of Merced government operations emissions broken down by sector, and Table 8 and Figure 6 break down emissions by source. The remainder of this section breaks down these emissions in further detail within each sector.

As shown in Table 7 and Figure 5, the sector producing the most greenhouse gas emissions in the City of Merced was the wastewater treatment sector at 30%, followed by the vehicle fleet and water delivery sectors at 25% and 22% respectively. As shown in Table 8 and Figure 6, electricity was the source with the greatest percentage of emissions at 61%, followed by diesel and gasoline (17% and 10% respectively).

Table 7: Government Operations Emissions by Sector

Sector	Metric Tons CO_2e	% of Sector Emissions
Wastewater Services	4,639	30%
Vehicle Fleet	3,807	25%
Water Delivery	3,433	22%
Buildings and Facilities	2,107	14%
Employee Commute	822	5%
Public Lighting	692	4%
Totals	**15,500**	**100%**

Figure 5: Government Operations Emissions by Sector ($MTCO_2e$)

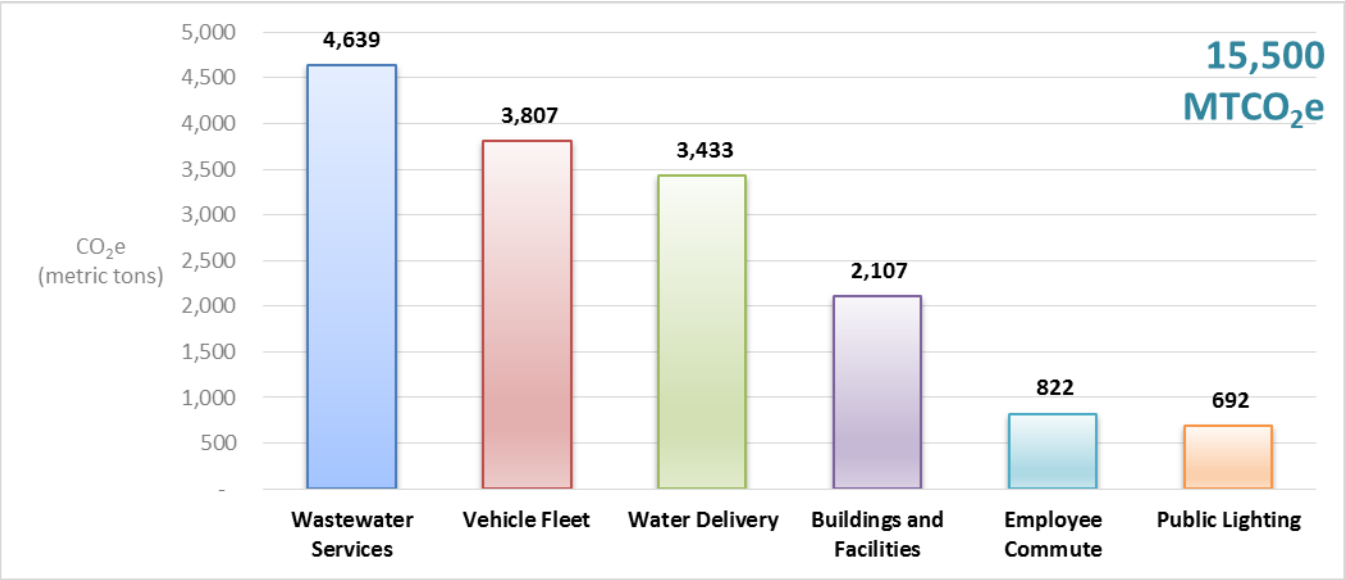
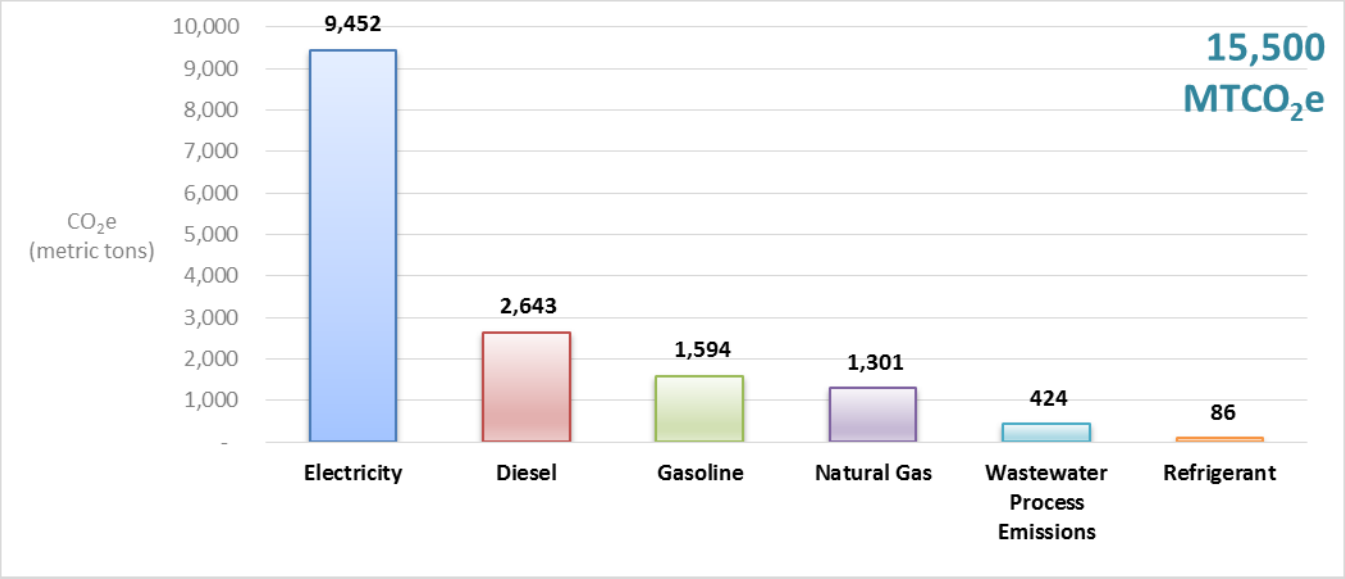


Table 8: Government Operations Emissions by Source

Source	Metric Tons CO_2e	% of Sector Emissions	Quantity
Electricity	9,452	61%	22,408,298 kWh
Diesel	2,643	17%	258,892 Gallons
Gasoline	1,594	10%	178,847 Gallons
Natural Gas	1,301	8%	4,130 MMBtu
Wastewater Process Emissions	424	3%	.05 MT CH_4 1.42 MT N_2O
Refrigerant	86	1%	132 Lbs
Totals	**15,500**	**100%**	

Figure 6: Government Operations Emissions by Source ($MTCO_2e$)



Wastewater Treatment

Wastewater collection and treatment is an essential public service provided by the City of Merced. Wastewater treatment processes require a significant amount of energy, and therefore electricity consumption is a significant source of greenhouse gas emissions from the operation of wastewater treatment facilities. In addition, as wastewater is collected, treated, and discharged, chemical processes in aerobic and anaerobic conditions lead to the creation and emission of methane and nitrous oxide. Local governments that operate wastewater treatment facilities, including treatment plants, septic systems, collection lagoons, and other facilities, must therefore account for the emission of these gases. Data relating to electricity consumption were obtained from PG&E and Merced Irrigation District (MID). Site-specific measurements were provided by the Wastewater Treatment division.

The wastewater treatment sector produced the largest amount of emissions in this LGO inventory. Overall, these facilities produced 4,639 metric tons of CO_2e (30% overall). Table 9 shows wastewater collection and treatment emissions by scope and emissions type. In the wastewater treatment sector, Scope 2 indirect emissions from purchased electricity accounted for a majority of the CO_2e emissions.

Table 9: Wastewater Emissions by Scope and Emission Type[13]

Wastewater Treatment					
Scope	**Emission Type**	**Greenhouse Gas Emissions (metric tons)**			
SCOPE 1		CO_2e	CO_2	CH_4	N_2O
	Stationary Combustion	395	394	0.0	0.0
	Process Emissions	424	-	-	-
	Total Direct Emissions	**819**	**394**	**0.0**	**0.0**
SCOPE 2		CO_2e	CO_2	CH_4	N_2O
	Purchased Electricity	3,820	3,810	0.1	0.0

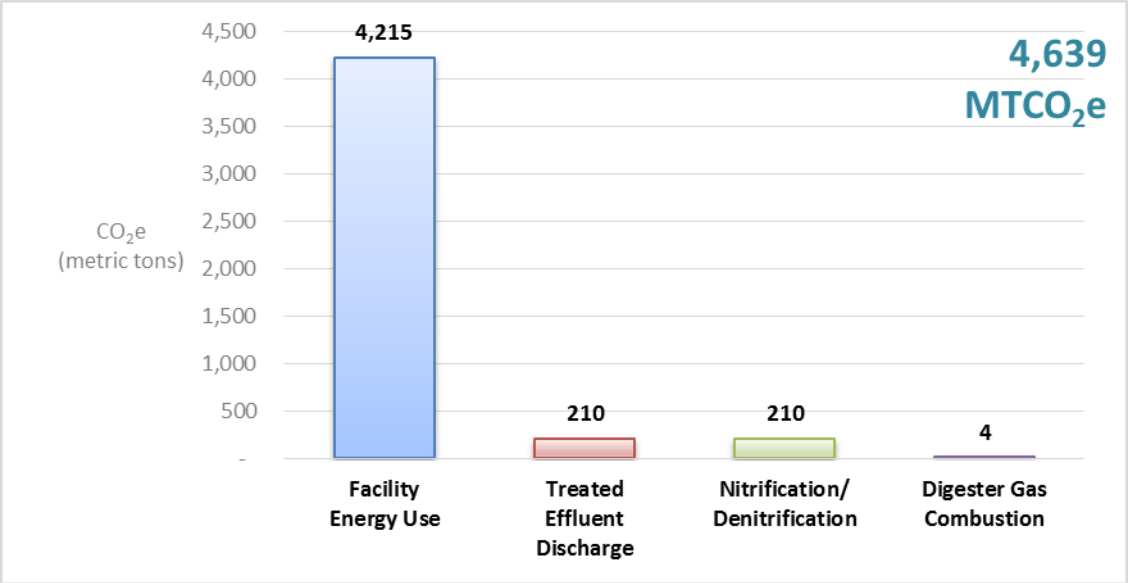
Table 10 and Figure 7 show wastewater emissions broken down by different processes within the treatment plant or collection system. The subsector producing the most greenhouse gas emissions was wastewater treatment facility energy use at 91%, followed by the discharge of treated wastewater and treatment through nitrification/denitrification, each at 5%. Wastewater collection, including energy used by sewer pumps and lift stations to transfer wastewater, could not be clearly separated from other water infrastructure within the utility records, such as stormwater and irrigation pumps. Thus, it is expected that this sector is slightly under-counted.

[13] Total emissions are reported as metric tons of each respective greenhouse gas emission type. Values less than 1 have been expanded to include one decimal point. In instances where an emission type is either not present or omitted, the category is marked " – " to signify zero emissions. Omissions and other limitations are outlined in the appendices.

Table 10: Wastewater Emissions by Equipment or Process

Subsector	Metric Tons CO_2e	% of Sector Emissions	Cost ($)
Facility Energy Use	4,215	91%	746,299
Treated Effluent Discharge	210	5%	-
Nitrification/Denitrification	210	5%	-
Digester Gas Combustion	4	0%	-
Totals	**4,639**	**100%**	**$746,299**

Figure 7: Wastewater Emissions by Equipment or Process



Vehicle Fleet

After the wastewater sector, vehicles were the next largest source of government operations emissions with 3,807 metric tons of CO_2e (25% overall). In 2011, the City of Merced operated a vehicle fleet with 514 vehicles. The City of Merced's vehicle fleet performed a number of essential services, including fire and police support, as well as street, water, wastewater and parks maintenance, among others. Table 11 shows vehicle emissions by scope and emissions type. Table 12 and Figure 8 show vehicle emissions by fuel type. Diesel and gasoline accounted for the largest share of emissions at 64% and 26% respectively.

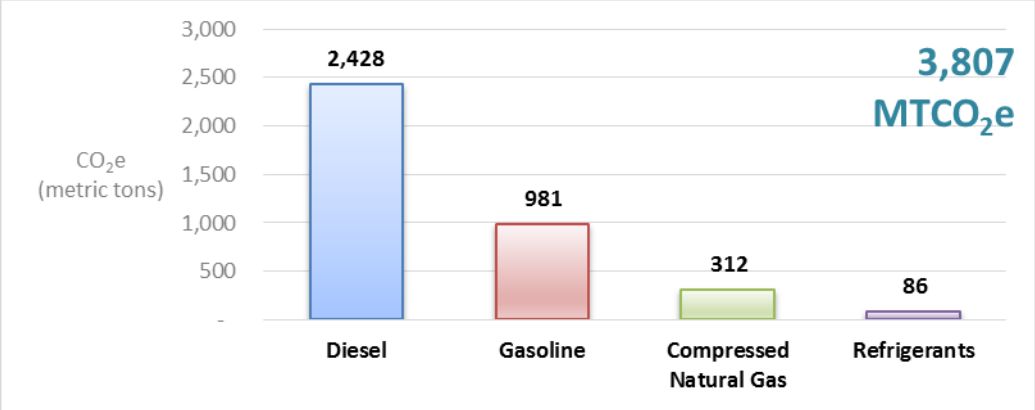
Table 11: Vehicle Emissions by Scope and Emission Type

VEHICLE FLEET						
Scope	**Emission Type**	**Greenhouse Gas Emissions (metric tons)**				
SCOPE 1		CO_2e	CO_2	CH_4	N_2O	HFC-134A
	Mobile Combustion	3,721	3,607	2	0.2	-
	Fugitive Emissions	86	-	-	-	.01
	Total Direct Emissions	**3,807**	**3,607**	**2**	**0**	**0**
INDICATORS						
	Vehicle Miles Traveled	1,364,484				

Table 12: Local Government Vehicle Fleet Emissions by Fuel Type

Source	Metric Tons CO_2e	% of Sector Emissions	Quantity
Diesel	2,428	64%	237,865 Gallons
Gasoline	981	26%	110,129 Gallons
Compressed Natural Gas	312	8%	3,924,423 SCF
Refrigerants	86	2%	132 Lbs
Totals	**3,807**	**100%**	

Figure 8: Local Government Vehicle Fleet Emissions by Fuel Type



Potable Water Delivery

Treatment and supply of potable water is another essential service provided by City of Merced and is also energy intensive. This sector includes emissions from equipment used for the distribution or transport of water, including drinking water, sprinkler systems, and irrigation. The City of Merced operates a range of water transport equipment; including water delivery pumps, irrigation/sprinkler systems, and stormwater management. Electricity consumption and the on-site combustion of fuels such as natural gas are significant sources of greenhouse gas emissions from the operation of the City of Merced's water transport equipment. Data relating to electricity consumption were obtained from PG&E and MID.

The water delivery sector produced the third-largest amount of emissions overall, with 3,433 metric tons of CO_2e (22% overall). Table 13 shows emissions from water treatment and supply by scope and emissions type. In the water delivery sector, Scope 2 indirect emissions from electricity use accounted for all CO_2e emissions.

Table 13: Water Delivery Emissions by Scope and Emission Type

WATER TRANSPORT FACILITIES					
Scope	Emission Type	Greenhouse Gas Emissions (metric tons)			
SCOPE 2		CO_2e	CO_2	CH_4	N_2O
	Purchased Electricity	3,433	3,420	0.1	0.0

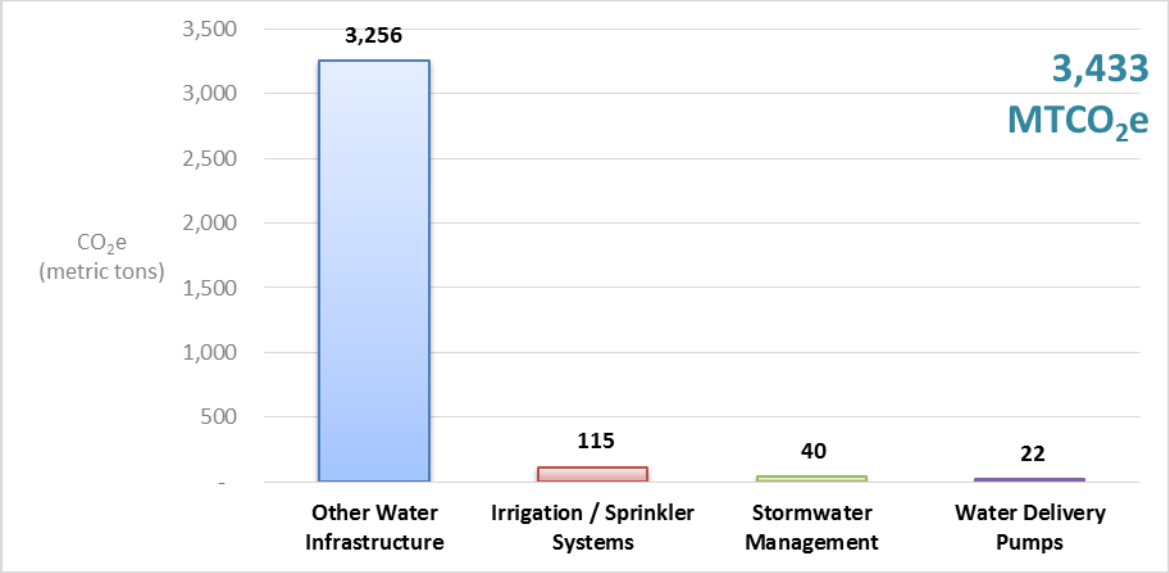
Table 14 and Figure 9 show water delivery emissions and energy costs broken down by different system components. This information may be useful in identifying opportunities for emissions reductions and cost savings within the water

supply system. As illustrated in Table 14 and Figure 9, the subsector producing the most greenhouse gas emissions in the Water Transport sector was a group of infrastructure classified as "Other" at 95%. This group includes utility records that were either previously unclassified by the utility or unclearly designated between sub-sectors. The City of Merced spent a total of $1,260,311 on water delivery for the year 2011.

Table 14: Water Delivery Emissions by Equipment Type

Subsector (Equipment Type)	Metric Tons CO_2e	% of Sector Emissions	kWh Consumption	Cost ($)
Other Water Infrastructure	3,256	95%	7,880,656	1,133,658
Irrigation / Sprinkler Systems	115	3%	438,494	83,050
Stormwater Management	40	1%	116,746	26,836
Water Delivery Pumps	22	1%	38,286	16,767
Totals	**3,433**	**100%**	**8,474,182**	**$1,260,311**

Figure 9: Water Delivery Emissions by Equipment Type



Buildings & Facilities

Facility operations contribute to greenhouse gas emissions in two major ways. First, facilities consume electricity and fuels such as natural gas. This consumption is associated with the majority of greenhouse gas emissions from facilities. The City of Merced operates facilities, ranging from general City offices to parks and museums. For the purpose of reporting emissions, these facilities were grouped by department when possible. Facilities that were minor, unknown, or previously uncategorized were included in this section of the inventory and were assigned to a category called "Unclassified Facilities." Data relating to electricity and natural gas consumption were obtained from PG&E and MID.

Buildings and facilities operated by the City of Merced produced the fourth-largest amount of emissions by sector. Overall, these facilities produced 2,107 metric tons of CO_2e (14% of total emissions). Table 15 reports emissions by scope and

emission type, as recommended by the LGO Protocol. In the buildings and facilities sector, Scope 2 indirect emissions accounted for a majority of the CO_2e emissions.

Table 15: Building and Facility Emissions by Scope and Emission Type

BUILDINGS & OTHER FACILITIES					
Scope	**Emission Type**	**Greenhouse Gas Emissions (metric tons)**			
SCOPE 1		CO_2e	CO_2	CH_4	N_2O
	Stationary Combustion	600	597	0.1	0.0
SCOPE 2		CO_2e	CO_2	CH_4	N_2O
	Purchased Electricity	1,507	1,496	0.1	0.0

Table 16 and Figure 10 show building emissions and cost by department. This information will be helpful in engaging department directors to identify strategies to reduce energy use. The City of Merced spent $766,670 on building energy use in 2011, showing that there is considerable opportunity for cost savings through building energy conservation measures. The facility group producing the most greenhouse gas emissions in the City of Merced was the Civic Center at 33%. The second and third largest contributors were unclassified facilities and the Police Department facilities at 22% and 14% respectively.

Table 16: Building and Facility Emissions and Energy Cost by Department

Department	Metric Tons CO_2e	% of Sector Emissions	Cost ($)
Civic Center	703	33%	157,929
Unclassified Facilities	472	22%	254,911
Police	301	14%	76,845
Fire	250	12%	62,954
Recreation	157	7%	61,407
Public Works	149	7%	83,076
Airport	37	2%	31,275
Parks	31	1%	31,799
Merced Visitor Center	7	0%	6,474
Totals	**2,107**	**100%**	**$766,670**

Figure 10: Building and Facility Emissions and Energy Cost by Department

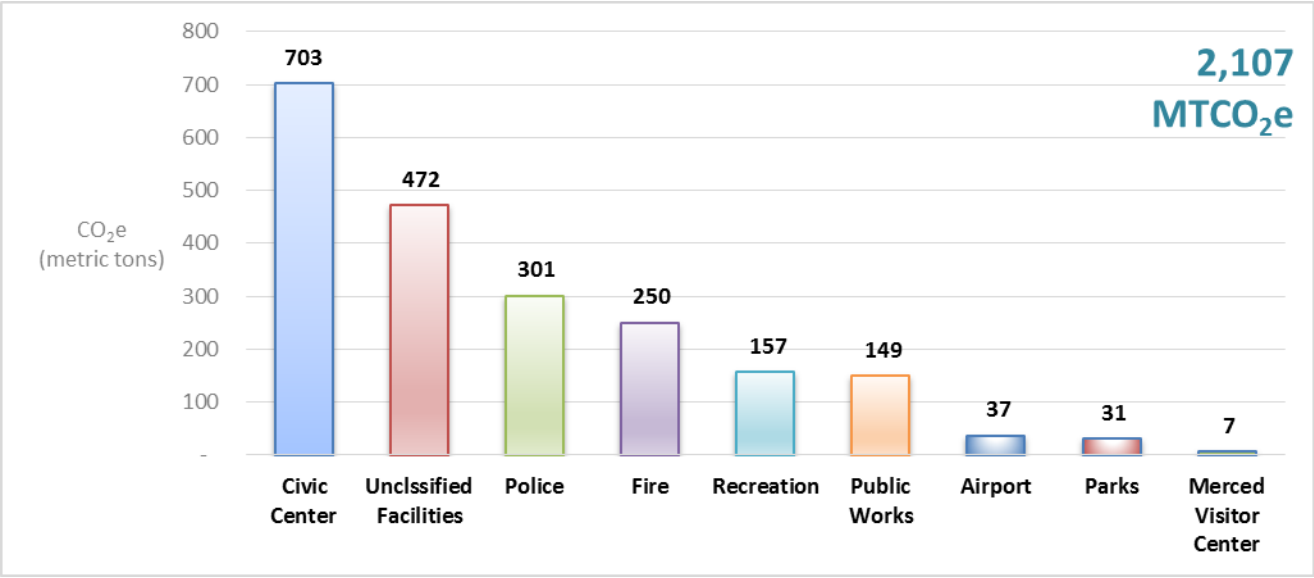
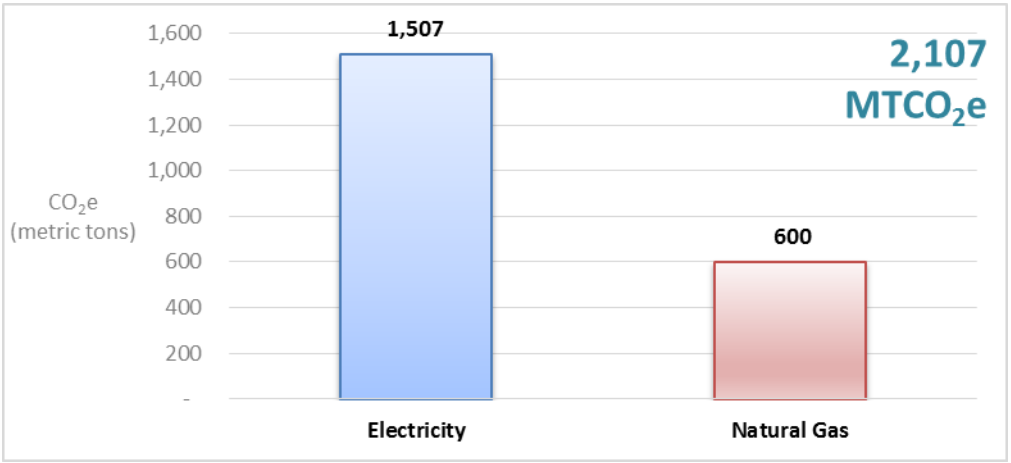


Table 17 and Figure 11 show buildings sector emissions by source. Electricity use is the larger source of buildings emissions at 72%, with the remaining 28% from natural gas use.

Table 17: Buildings Emissions by Source

Source	Metric Tons CO_2e	% of Sector Emissions	Quantity	Quantity Units	Cost ($)
Electricity	1,507	72%	4,014,705	kWh	622,294
Natural Gas	600	28%	11,296	MMBtu	144,376
Totals	**2,107**	**100%**	**4,026,001**		**766,670**

Figure 11: Buildings Emissions by Source



Employee Commute

Emissions in the Employee Commute sector are due to combustion of fuels in vehicles used by government employees for commuting to work at the City of Merced. A survey conducted by the City of Merced Alternative Transportation Team in February 2011 provided the necessary data points to estimate emissions from employee commute in 2011.

The employee commute sector produced the fifth-largest amount of emissions in this inventory. Overall, this sector produced 822 metric tons of CO_2e (5% of total emissions). Table 18 reports emissions by scope and emission type, as recommended by the LGO Protocol. In the employee commute sector, all emissions are reported as Scope 3 because the activity is not directly within the local government's operational control; however, the emissions remain relevant nonetheless. Local governments may encourage employees to reduce employee commute mileage by enacting incentives or recognition programs.

Table 18: Employee Commute Emissions by Scope and Emissions Type

EMPLOYEE COMMUTE		
Scope	**Emission Type**	**Greenhouse Gas Emissions (metric tons)**
SCOPE 3		CO_2e
	Mobile Combustion	822
INDICATORS		
	Vehicle Miles Traveled	1,177,238

Public Lighting

Like most local governments, the City of Merced operates a range of public lighting including traffic signals, street lighting, and park lights. The emissions associated with the operation of this infrastructure are due to electricity consumption. Data relating to electricity consumption for public lighting were obtained from PG&E and MID.

The public lighting sector produced the sixth-largest amount of emissions of all sectors. Overall, these facilities produced 692 metric tons of CO_2e (4% of total emissions). Table 19 reports emissions by scope and emission type, as recommended by the LGO Protocol. In the public lighting sector, Scope 2 indirect emissions accounted for the majority of CO_2e emissions. Some emissions from streetlight energy consumption were classified as Scope 3 emissions because a number of streetlights are owned and operated by the utility company and are, thus, outside of the City of Merced's operational boundary.

Table 19: Public Lighting Emissions by Scope and Emission Type

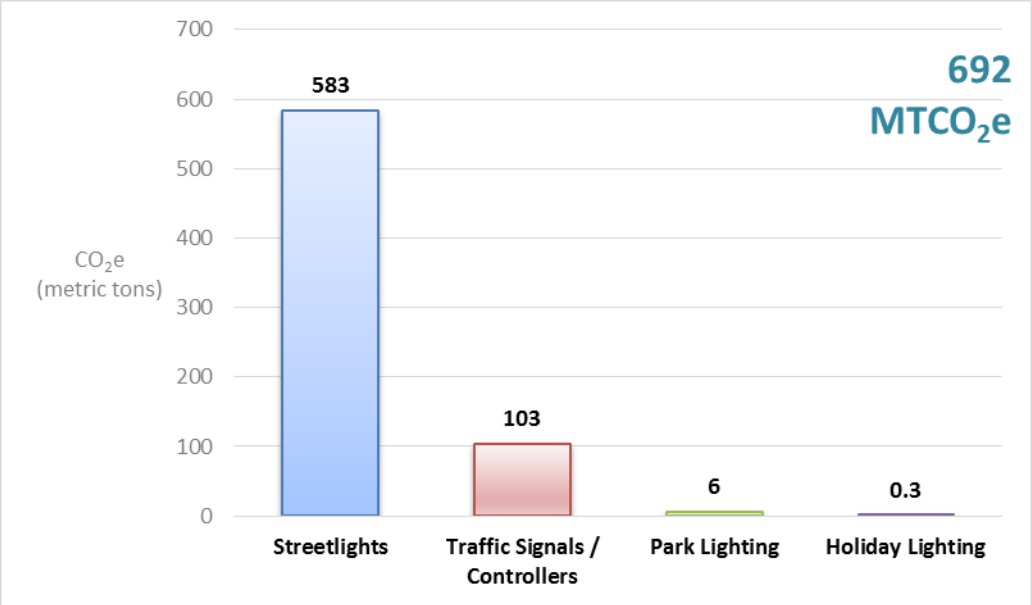
BUILDINGS & OTHER FACILITIES					
Scope	**Emission Type**	**Greenhouse Gas Emissions (metric tons)**			
SCOPE 2		CO_2e	CO_2	CH_4	N_2O
	Purchased Electricity	636	630	0.0	0.0
SCOPE 3		CO_2e			
	Utility Owned/Operated Streetlights	56			

Table 20 and Figure 12 shows public lighting emissions and energy cost by lighting type. Street lighting was the largest contributor to lighting sector emissions at 84%, followed by traffic signals and controllers at 15%. Replacing existing lights with new technologies, in particular Light Emitting Diodes or LEDs, may create an opportunity to significantly reduce energy use and offer a fast return on investment.

Table 20: Emissions by Lighting Type

Subsector (Light Type)	Metric Tons CO_2e	% of Sector Emissions	Electricity Use (kWh)	Cost ($)
Streetlights	583	84%	3,241,564	465,657
Traffic Signals / Controllers	103	15%	343,500	56,104
Park Lighting	6	1%	34,885	6,683
Holiday Lighting	0.3	0%	1,509	681
Totals	**692**	**100%**	**3,621,458**	**529,125**

Figure 12: Emissions by Lighting Type



Conclusion

This analysis found that the Merced community as a whole was responsible for emitting 505,579 metric tons of CO_2e in 2011, with emissions from the transportation sector contributing the most to this total. (See summary table in Appendix A for more detail).

The City of Merced's 2008 baseline estimated emissions at roughly 408,329 metric tons of CO_2e. While the 2011 inventory, by comparison, estimates a roughly 24% increase over the three year period, it is important to note three things:

1. The Merced Climate Action Plan was not implemented until October 1, 2012, meaning there was not a concentrated, community-wide effort in place during this time to mitigate emissions;
2. The 2008 and 2011 inventories were conducted by different parties, using different methods. While both inventories were conducted using ICLEI tools and guidance, the 2011 report was conducted using a newer, relatively more accurate method of data collection and emissions calculation, integrating the IPCC's newest global warming potential revisions;
3. Regardless of whether or not mitigation measures are in place in a community, many other factors can be responsible for changes in GHG emissions over time. Certain external factors, such as temperature and water scarcity, may naturally cause direct or upstream emissions increases. When conducting an emissions reassessment, it is prudent to acknowledge these uncontrollable factors alongside controllable mitigation measures.
    a. For instance, in 2011 there were 16% more heating degree days (HDD) than in 2008; while the cooling degree days (CDD) were 24% less in 2011, the increase in HDD may have had a larger net impact on energy demand due to the energy intensity of air conditioning.

As the City of Merced moves forward with implementing emission reduction strategies through a Programmatic Climate Action Plan, the City will identify and quantify the emission reduction benefits of climate and sustainability strategies that could be implemented in the future including: enhancing mobility, ensuring sustainable community design, improving air resources, water conservation, renewable energy, building energy conservation, waste reduction and public outreach. Through these efforts and others the City of Merced can achieve additional benefits beyond reducing emissions, including saving money, improving the City of Merced's economic vitality and improving the quality of life in the community. It is recommended that City staff continue to update this inventory as additional data become available.

Project Resources

Tools are available for the City of Merced to use to assist with monitoring emissions. These tools are designed to work in conjunction with the Community Protocol, which is the primary reference document for conducting an emissions inventory. The following tools should be saved as resources and supplemental information to this report:

- The "Master Data Workbook" that contains most or all of the raw data, conditioned data, data sources, emissions calculations and notes on inclusions and exclusions
- The Statewide Energy Efficiency Collaborative (SEEC) Climate and Energy Management Suite (CEMS) is a web-based system available to local government staff which provides emissions calculation tools, forecasting tools, and monitoring/evaluation tools. City of Merced staff may register for access to the system in order to conduct future inventories, or to generate additional data reports beyond this report.
- The Scoping and Reporting Tool (see Appendix A-1) is a grid of all emissions activities and sources included within the CWP. The tool was used in this inventory to concisely identify all emissions to be included and how to be reported. It is recommended that City staff, if utilizing this narrative report template and applying the CWP in the future, utilize the Scoping and Reporting Tool to frame future community emissions analyses.

Appendix A: Community Inventory Details

Section A-1 provides a summary of the emissions sources and activities that are included in the community inventory, as well as those potential sources that are excluded.

Section A-1: Summary of Included and Excluded Community Emissions

Key:

SI – Local Government Significant Influence framework.
CA – Community Activities reporting framework.
HC – Household Consumption is another reporting framework, which was not utilized in this inventory.
IE – Included Elsewhere: emissions for this activity are estimated and presented in another category of the inventory.
NA – Not Applicable: the activity occurs, but does not cause emissions.
NO – Not Occurring: the source or activity does not occur or exist within the community.
NE – Not Estimated: emissions occur but have not been estimated or reported.

Emissions Type		Source or Activity?	Required Activities	Included under reporting frameworks:			Excluded (IE, NA, NO, or NE)	Explanatory Notes	Emissions ($MTCO_2e$)
				SI	CA	HC			
Built Environment									
Use of fuel in residential and commercial stationary combustion equipment		Source AND Activity	·	·	·				91,732
Industrial stationary combustion sources		Source					NE	Included in commercial activity	
Electricity	Power generation in the community	Source					NO	No municipally-owned utility	
	Use of electricity by the community	Activity	·	·	·				177,383
District Heating/ Cooling	District heating/cooling facilities in the community	Source					NE	Not a significant source	
	Use of district heating/cooling by the community	Activity					NE	Not a significant source	
Industrial process emissions in the community		Source					NE	Not a significant source	
Refrigerant leakage in the community		Source					NE	Not a significant source	
Transportation and Other Mobile Sources									

On-road Passenger Vehicles	On-road passenger vehicles operating within the community boundary	Source	·	·				VMT approach encompasses both passenger and freight vehicles	211,675
	On-road passenger vehicle travel associated with community land uses	Activity					NE		
On-road Freight Vehicles	On-road freight and service vehicles operating within the community boundary	Source					NE		
	On-road freight and service vehicle travel associated with community land uses	Activity					NE		
On-road transit vehicles operating within the community boundary		Source					NE		
Transit Rail	Transit rail vehicles operating within the community boundary	Source					NE		
	Use of transit rail travel by the community	Activity					NE		
Inter-city passenger rail vehicles operating within the community boundary		Source					NE		
Freight rail vehicles operating within the community boundary		Source					NE		
Marine	Marine vessels operating within the community boundary	Source					NE		
	Use of ferries by the community	Activity					NE		
Off-road surface vehicles and other mobile equipment operating within the community boundary		Source					NE		
Use of air travel by the community		Activity					NE		
Solid Waste									
Solid Waste	Operation of solid waste disposal facilities in the community	Source					NO	Not within city boundaries	
	Generation and disposal of solid waste by the community	Activity	·	·	·				24,365
Water and Wastewater									
Potable Water - Energy Use	Operation of water delivery facilities in the community	Source					NE	Included in row below	
	Use of energy associated with use of potable water by the community	Activity	·	·	·				4,209
Use of energy associated with generation of wastewater by the community		Activity	·	·	·				3,256
Centralized Wastewater Systems - Process Emissions	Process emissions from operation of wastewater treatment facilities located in the community	Source					NE	Included in row below	
	Process emissions associated with generation of wastewater by the community	Activity	·	·	·				424
Use of septic systems in the community		Source AND activity					NE	No data available	
Agriculture									
Domesticated animal production		Source					NE	Not a significant	

							source within city boundaries	
Manure decomposition and treatment	Source					NE	Not a significant source within city boundaries	
Upstream Impacts of Community-Wide Activities								
Upstream impacts of fuels used in stationary applications by the community	Activity					NE		
Upstream and transmission and distribution (T&D) impacts of purchased electricity used by the community	Activity					NE		
Upstream impacts of fuels used for transportation in trips associated with the community	Activity					NE		
Upstream impacts of fuels used by water and wastewater facilities for water used and wastewater generated within the community boundary	Activity					NE		
Upstream impacts of select materials (concrete, food, paper, carpets, etc.) used by the whole community	Activity					NE		

Section A-2 provides details on calculation methods and data sources for each included activity and source.

Section A-2: Community Inventory Calculation Method and Data Source Details

Residential and Commercial Use of Electricity	Activity data		Emissions factors			Method
	Value	Unit	Value	Unit	Source	
			393	CO_2 lbs/MWh	PG&E	**Method A**
Residential	167,894,694	kWh PG&E	30	CH_4 lbs/MWh	PG&E	
	27,813,185	kWh MID	10	N_2O lbs/MWh	PG&E	
Commercial	92,253,892	kWh PG&E	1336	CO_2 lbs/MWh	MID	
	187,091,917	kWh MID	31	CH_4 lbs/MWh	MID	
			9	N_2O lbs/MWh	MID	

Method A:
PG&E portion of consumed kWh in 2011 (provided by PG&E) multiplied by 2011 PG&E emission factors (provided by PG&E). MID portion of consumed kWh in 2011 (provided by MID) multiplied by 2011 MID emission factors (provided by MID).
Data Source Notes:
PG&E did not provide Industrial data. MID provided industrial, commercial and agricultural rate data, but these categories were joined together as "Commercial/Industrial" to ensure the two utility data sets would be compatible with each other.
Method:
Electricity and natural gas greenhouse gas emissions were calculated by multiplying the applicable emission factors by the consumed kWh of electricity and the consumed MMBtu of natural gas. Both the activity data and the emissions factors specific to this inventory were entered into the CEMS tool.

Residential and Commercial Use of Natural Gas	Activity data		Emissions factors			Method
	Value	Unit	Value	Unit	Source	
			0.0053020	CO_2 MT/MMBtu	CWP	**Method B**
Residential	1,084,569.4	MMBtu	$5x10^{-6}$	CH_4 MT/MMBtu	CWP	
Commercial	6,390,217	MMBtu	$1x10^{-7}$	N_2O MT/MMBtu	CWP	

Method B:
PG&E portion of consumed MMBtu in 2005 (provided by PG&E) multiplied by standard natural gas emission factors (provided in CWP).
Method:
See narrative in "Residential and Commercial Use of Electricity" table above.

Residential Use of Stationary Combustion Equipment	Activity data		Emissions factors			Method
	Value	Unit	Value	Unit	Source	
LPG	1,258.7	MMBtu	0.062980	CO_2 MT/MMBtu	CWP	**Method C**
			0.000010870	CH_4 MT/MMBtu	CWP	
			0.0000010870	N_2O MT/MMBtu	CWP	
Wood	6,648.2	MMBtu	1335.997	CO_2 MT/MMBtu	CWP	
			31	CH_4 MT/MMBtu	CWP	
			9	N_2O MT/MMBtu	CWP	

Method C:
Per household consumption of fuel in 2011 = CT4 (2006 values)/ HC.1.11 (2011 values)
Fuel consumed in community = 2005 through 2009 American Community Survey 5 year estimate B25040 line items * per household consumption of fuel in 2011

Data Source Notes:

In some cases, the year 2009 was used as proxy for the inventory year, 2011.

Table CT4: "Residential Sector Energy Consumption Estimates, Selected Years, 1960-2011, California." U.S. Energy Information Administration.

Table HC.1.11: "Fuels Used and End Uses in Homes in West Region, Divisions, and States, 2009" U.S. Energy Information Administration.

Table B25040: "HOUSE HEATING FUEL 2005-2009 American Community Survey 5-Year Estimates"

Method:

Greenhouse gas emissions from residential stationary combustion of non-utility fuels, Liquefied Petroleum Gas (LPG) and wood, were calculated using state averages. Per household consumption of fuel in 2011 was calculated by dividing values in Table CT4 "Residential Sector Energy Consumption Estimates, Selected Years, 1960-2011, California," a dataset indicating total consumptions by types of fuel, by the values in table HC.1.11 "Fuels Used and End Uses in Homes in West Region, Divisions, and States, 2009," a dataset indicating the amount of households that use a specific type of fuel. This division gave us the statewide average for per household consumption of a particular fuel. Per household consumption of a fuel was multiplied by values in table B25040 "House Heating Fuel Universe: Occupied housing units more information 2005-2009 American Community Survey 5-Year Estimates," a dataset that indicates the amount of households using a specific type of fuel by city, by the previously calculated state average consumption of fuel. Residential use of wood resulted in emissions of 280 MT of biogenic CO_2e and residential use of LPG resulted in emissions of 282 MT CO_2e. Other common fuel types, such as kerosene and fuel oil, could not be quantified due to data limitations.

On-road Passenger Vehicle Travel	Activity Data		Emissions Factor			Method
	Value	Unit	Value	Unit	Source	
Gasoline	352,014,982.8	Annual VMT	455.9	g CO_2 / Mile	EMFAC	**Method B**
Diesel	26,850,716.27	Annual VMT	1,784.1	g CO_2 / Mile	EMFAC	

Data sources:

2011 Highway Performance Monitoring Service (HPMS) Report

2011 EMFAC Emissions Inventory for the year 2011 issued by the California Air Resources Board

California County and City Boundaries Shapefiles from CalTrans

Method:

The method used is a modified version of TR.1.B and is dependent on three data sources: annual vehicle miles traveled (VMT), the proportion of VMT attributed to gasoline and diesel vehicles, and emissions factors dependent on fuel type. Because HPMS only reports daily city VMT for local roads and maintained freeway miles for the entire county, QGIS was implemented to determine freeway miles within city boundaries. Using county and city shapefiles, US highways within cities, local roads within cities, and California highway road miles within cities were determined. The county-wide VMT per highway mile was applied to each city's in-bound highway mileage. The summation of reported local miles from HPMS and highway miles derived using QGIS allowed estimation of total daily VMT for the city. An EMFAC gas to diesel ratio was then applied to estimate how much of the daily VMT was resulting from gasoline engines versus diesel engines. Emissions factors for each fuel type, derived from EMFAC data, were then applied.

Generation of Solid Waste by the Community	Activity data		Emissions factor			Method
	Value	Unit	Value	Unit	Source	
Capture system	51,474	Wet short ton	.043	$MTCH_4$/Wet short ton waste newspaper	WARM	**Equation SW.4.1**
Non-capture system	11,653	Wet short ton	.203	$MTCH_4$/Wet short ton waste office paper	WARM	
			.120	$MTCH_4$/Wet short ton waste corrugated containers	WARM	
			.049	$MTCH_4$/Wet short ton waste magazines/third-class mail	WARM	
			.078	$MTCH_4$/Wet short ton waste food scraps	WARM	
			.038	$MTCH_4$/Wet short ton waste grass	WARM	
			.013	$MTCH_4$/Wet short ton waste leaves	WARM	
			.062	$MTCH_4$/Wet short ton waste branches	WARM	
			.062	$MTCH_4$/Wet short ton waste dimensional lumber	WARM	

Method: Equation SW.4.1 Solid Waste Community Protocol using CEMS Waste Generation calculator.

Data source notes:

Data provided by Merced County Regional Waste Management Authority's (RWMA) Financial Services Manager Nadia Gonzalez.
California 2008 Statewide Waste Characterization Study Table ES-3 "Composition of California's Overall Disposed Waste Stream by Material Type"
WARM – Waste Reduction Model
Solid Waste Community Protocol Table SW.5 CH_4 Yield for Solid Waste Components

Activity Data:

The methodology used for the solid waste inventory of the City of Merced began with documenting the instate tonnage generated by the City in 2011, which was provided by RWMA Financial Services Manager, Nadia Gonzalez. Since the solid waste generated within Merced County are reported in aggregate from RWMA to the California Department of Resources Recycling and Recovery (CalRecycle), the specific tonnage of waste generated by the City and sent to various disposal facilities within and outside Merced County could not be determined. In lieu of figures specific to the City of Merced, the CalRecycle "Jurisdiction Disposal by Facility" database (available at www.calrecycle.org) was used to determine total waste sent from Merced County jurisdictions to specific destinations. The proportion of aggregate waste sent to each destination was applied to the total tonnage reported for the City of Merced by RWMA.

In order to estimate total CO_2e emissions from waste sent to different landfills, an investigation of the landfills with and without landfill gas capture systems in place during the inventory year was completed. This was necessary because landfill gas capture systems, when paired with landfill gas flaring, significantly mitigate the amount of methane each landfill emits. The total tonnage sent to landfills with capture systems was combined, as was the total for those without. The two totals were entered into ICLEI's CEMS tool, where an emissions factor based on capture system presence and waste characterization was applied.

Emissions Factors:

The solid waste characterization percentages were provided by the California 2008 Statewide Waste Characterization Study. Emissions factors for each waste type were provided by WARM, as defined in Appendix E (Solid Waste Emission Activities and Sources) of the Community Protocol. After these factor sets were entered into CEMS, the tool calculated the methane (CH_4) emissions based on activity data. The calculator then converted total CH_4 produced by all landfills into CO_2e.

Emissions from Incineration of Solid Waste	Activity data		Emissions factor			Method
	Value	Unit	Value	Unit	Source	
Biogenic-origin	410.3	Wet short ton	0.902465	MT CO_2/wet short ton	Covanta Energy	**Local Government Operations Protocol Equations 8.2 – 8.4**
Anthropogenic-origin	220.9	Wet short ton	$4.2x10^{-5}$	MT N_2O/wet short ton	Covanta Energy	
			0.000318	MT CH_4/wet short ton	Covanta Energy	

Data source notes:

CO_2, N_2O, CH_4 outputs obtained from Karen Wilhem at Covanta Energy to derive emissions factors based on waste characterization. Tons sent to Covanta were estimated from information obtained from Nadia Gonzalez at the Merced County Regional Waste Management Authority and CalRecycle county-wide reports. See "Generation of Solid Waste by the Community" above for detail.

Method:

The estimate of the City of Merced's waste sent to Covanta in 2011 (631 tons) was designated either biogenic-origin or anthropogenic-origin by applying Covanta's 2005 waste characterization of 65% and 35%, respectively. Emissions factors for each waste type were applied to determine: CO_2 emissions from anthropogenic based waste; N_2O from biogenic and anthropogenic based waste; CH_4 from biogenic and anthropogenic based waste; and CO_2 from biogenic waste, which is counted as an information item. For this reason, CO_2 emissions from biogenic waste are not counted in the final CO_2e emissions value. The remaining values were then entered into CEMS, where they were given a CO_2e value.

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Emissions from Wastewater Treatment: Emissions from Nitrification/ Denitrification	Activity data		Source	Method
	Value	Unit		
Population Served	80,542	People	CA Department of Finance; Merced Municipal Service Review	**Local Government Operations Protocol Equation 10.7**
Industrial Multiplier	1.25	-	LGOP, EPA	

Data source notes:

Annual N_2O emissions (metric tons CO_2e) = ((P_{total} x $F_{ind\text{-}com}$) x EF nit/denit x 10^{-6}) x GWP

Where:

TERM		DESCRIPTION	VALUE
P_{total}	=	total population that is served by the centralized WWTP adjusted for industrial discharge, if applicable [person]	user input
$F_{ind\text{-}com}$	=	factor for industrial and commercial co-discharge waste into the sewer system	1.25
EF nit/denit	=	emission factor for a WWTP with nitrification/denitrification [g N_2O/person/year]	7
10^{-6}	=	conversion from g to metric ton [metric ton/g]	10^{-6}
GWP	=	N_2O Global Warming Potential	310

Source: LGOP and EPA *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007*, Chapter 8, 8-13 (2009). LGOP Equation 10.4 provides a default industrial multiplier value of 1.25.

Method:

This equation calculates default population-based estimates of N2O production from wastewater treatment facilities employing nitrification/denitrification. Based on feedback from the City's Wastewater Treatment division, the following site-specific information was documented and entered into the CEMS calculator: the facility employs nitrification/denitrification, the system served 80,542 people in 2011 (verified against Municipal Service Review), and the system serves industrial customers.

Emissions from Wastewater Treatment: Emissions from Effluent Discharge	Activity data		Source	Method
	Value	Unit		
N Load	245.86	kg N/day	City of Merced	**Local Government Operations Protocol Equations 10.9**
Population Served	80,542	People	CA Department of Finance; Merced Municipal Service Review	
Industrial Multiplier	1.25	-	LGOP, EPA	

Data source notes:

Annual N_2O emissions (metric tons CO_2e) = (N Load x EF effluent x 365.25 x 10^{-3} x 44/28) x GWP

Where:

TERM		DESCRIPTION	VALUE
N Load	=	measured average total nitrogen discharged [kg N/day]	user input
EF effluent	=	emission factor [kg N_2O-N/kg sewage-N produced]	0.005
365.25	=	conversion factor [day/year]	365.25
10^{-3}	=	conversion from kg to metric ton [metric ton/kg]	10^{-3}
44/28	=	molecular weight ratio of N_2O to N_2	1.57
GWP	=	Global Warming Potential	310

Source: LGOP and EPA *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007*, Chapter 8, 8-13 (2009). LGOP Equation 10.4 provides a default industrial multiplier value of 1.25.

Method:
The City of Merced Wastewater Treatment division provided reports of the following information: total monthly influent flow, average daily influent flow, and nitrogen concentration. First, the daily averages for each month were averaged to determine average daily influent flow and average nitrogen concentration. The average nitrogen content was received in units of milligrams per liter of wastewater (mg/L). To determine the units of kilograms per day (kg/day), the concentration was converted from units of mg/L to kg/L, and multiplied by the average daily influent flow (converted from gallons to liters). The final figures of nitrogen (kg/day) was entered into CEMS, along with the population served by the system (verified against Municipal Service Review records), and an industrial multiplier to account for industrial discharge. Finally, based on feedback from the City's Wastewater Treatment division, the following site-specific information was selected to finish the formula: aerobic conditions are present, and the facility employs nitrification/denitrification.

Emissions from Wastewater Treatment: Incomplete Combustion of Digester Gas	Activity data		Source	Method
	Value	Unit		
Digester Gas Production	59,507.54	scf/day	City of Merced	**Local Government Operations Protocol Equations 10.1**
Gas Composition	65%	Percent CH_4	City of Merced	

Data source notes:
Annual CH_4 emissions (metric tons CO_2e) = (Digester Gas x F_{CH_4} x $\rho(CH_4)$ x (1-DE) x 0.0283 x 365.25 x 10^{-6}) x GWP

Where:

ITEM		DESCRIPTION	VALUE
Digester Gas	=	measured standard cubic feet of digester gas produced per day [ft^3/day]	user input
F CH_4	=	measured fraction of CH_4 in biogas	user input
p(CH_4)	=	density of methane at standard conditions [g/m^3]	662.00
DE	=	CH_4 Destruction Efficiency	.99
0.0283	=	conversion from ft^3 to m^3 [m^3/ft^3]	0.0283
365.25	=	conversion factor [day/year]	365.25
10^{-6}	=	conversion from g to metric ton [metric ton/g]	10^{-6}
GWP	=	Global Warming Potential	21

Source: LGOP and EPA *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007*, Chapter 8, 8-7 (2009).

Method:
The City of Merced Wastewater Treatment division provided reports of the anaerobic digester, including total gas production and the concentration of methane in the digester gas. These values were entered into the CEMS digester gas module where two outputs were generated. The first, CH_4 from incomplete combustion of digester gas, assumes that there will inevitably be an inefficiency in the deconstruction of methane through the flaring process, which allows relatively small quantities of methane to be emitted into the atmosphere. The second, biogenic CO_2, represents the amount of CO_2 emitted into the atmosphere as a result of converting CH_4 into CO_2 through the flaring process. Since the organic material in the wastewater would naturally have decayed and emitted CO_2 without human involvement, the conversion of CH_4 to CO_2 is considered a biogenic process, and is not added to the total emissions produced by the City of Merced in 2011.

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Use of energy associated with the use of potable water and collection & treatment of wastewater	Water	Wastewater
Activity Data:	7,880,656 kWh 10,531,429,597 Gallons 78,986 Population	6,297,953 kWh 73,095 therms 2,261,596,300 Gallons 78,986 Population
Data Sources:	• kWh from 2011 LGO inventory, provided by PG&E and MID. • Gallons adjusted by population from 2005 baseline used in 2009 Merced County Supply and Demand Study • Population from table e-4, California Department of Finance.	• kWh and therms from 2011 LGO inventory, provided by PG&E and MID. • Gallons from 2013 City of Merced MSR, no rate adjustment. • Population, table e-4, California Department of Finance.

Emissions Factors:

393	CO_2 lbs/MWh	2011 emission factor provided by PG&E
30	CH_4 lbs/MWh	2011 emission factor provided by PG&E
10	N_2O lbs/MWh	2011 emission factor provided by PG&E
1,336	CO_2 lbs/MWh	2011 emission factor provided by MID
31	CH_4 lbs/MWh	2011 emission factor provided by MID
9	N_2O lbs/MWh	2011 emission factor provided by MID

Methods:

City of Merced water sector emissions were based on information taken from both the 2011 Local Government Operations (LGO) inventory completed by the Great Valley Center and the 2009 Merced County General Plan Update's Qualitative Comparison of Water Supply and Demand. The 2011 LGO inventory provided a kWh value, acquired from both PG&E and MID, and the 2009 Merced County study provided estimated city water consumption in 2005, which was then adjusted by population change to estimate 2011 consumption. In total, 7,880,656 kWh, 3,583,656 kWh from PG&E and 4,297,000 kWh from MID, and an estimated 10,531,429,597 gallons were consumed for potable water demand in the year 2011. These values were entered into CEMS, where emissions factors provided by PG&E and MID were applied to give a final CO_2e equivalent of 3,256 MT for water sector emissions. PG&E electricity use accounts for 645 MT CO_2e of total emissions, while MID electricity use accounts for 2,611 MT CO_2e.

Wastewater sector emissions were based on information from the 2011 LGO inventory and the 2013 City of Merced Municipal Service Review (MSR). The 2011 LGO inventory provided a kWh value and the 2013 MSR provided a total influent flow for the year 2011. In total, 6,297,953 kWh and 73,095 therms were consumed for an estimated 2,261,596,300 gallons of wastewater. PG&E provided 16,348 kWh and 73,095 therms while MID provided 621,605 kWh. These values were entered into CEMS, where emissions factors provided by PG&E and MID were applied to give a final CO_2e equivalent of 4,209 MT for wastewater sector emissions based on energy use. PG&E energy use accounted for 392 MT CO_2e while MID energy use accounted for 3,817 MT CO_2e.

Appendix B: Government Operations Inventory Details

Section B-1 provides details on calculation methods and data sources for each included emissions sector.

Section B-1: Government Operations Inventory Calculation Method and Data Source Details

Electricity	Activity data		Emissions factors			Method
	Value	Unit	Value	Unit	Source	
Buildings and Facilities (PG&E)	2,485,761	kWh	393	CO_2 lbs/MWh	PG&E	**LGOP Equations 6.10 – 6.11**
Public Lighting (PG&E)	3,526,455	kWh	30	CH_4 lbs/GWh	PG&E	
Water Delivery (PG&E)	4,012,262	kWh	10	N_2O lbs/GWh	PG&E	
Wastewater Treatment Facilities (PG&E)	16,348	kWh				
Buildings and Facilities (MID)	1,528,944	kWh	1336	CO_2 lbs/MWh	MID	
Public Lighting (MID)	95,003	kWh	31	CH_4 lbs/GWh	MID	
Water Delivery (MID)	4,461,920	kWh	9	N_2O lbs/GWh	MID	
Wastewater Treatment Facilities (MID)	6,281,605	kWh				

Equation:
PG&E portion of consumed kWh in 2011 (provided by PG&E) multiplied by 2011 PG&E emission factors (provided by PG&E). MID portion of consumed kWh in 2011 (provided by MID) multiplied by 2011 MID emission factors (provided by MID).

Data Source Notes:
Detailed municipal utility records were provided by PG&E and MID. Any facilities that were minor, unknown or previously uncategorized in 2005 were included in the facility section of the inventory and were named "Unclassified Facilities."

Method:
According to the LGOP, the recommended method for reporting emissions related to electricity consumption and natural gas combustion is summing the total number of kWh or therms (Activity Data) and multiplying the Activity Data by a corresponding emission factor. Emission factors were reported by PG&E and MID. The utility records were analyzed and categorized by sector (e.g. buildings vs. lighting), then further categorized by operation type (e.g. traffic signal vs. streetlight) or by department/division as applicable. For each classification, separate records were maintained for PG&E electricity, MID electricity and PG&E natural gas, as each has its own distinct emissions factor.

Natural Gas	Activity data		Emissions factors			Method
	Value	Unit	Value	Unit	Source	
Buildings and Facilities	111,935	MMBTU	0.0053020	CO_2 MT/MMBtu	CWP	**LGOP Equations 6.2 – 6.7**
Wastewater Treatment Facilities	73,095	MMBTU	$5x10^{-6}$	CH_4 MT/MMBtu	CWP	
			$1x10^{-7}$	N_2O MT/MMBtu	CWP	

Equation:
PG&E portion of consumed therms in 2011 (provided by PG&E) multiplied by standard natural gas emission factors (provided by CWP).

Method:
See narrative in "Electricity" above.

Vehicle Fleet	Activity data		Emissions factor		Source	Method
	Value	Unit	Value	Unit		
Gasoline	209,036	Gallons	Varies by vehicle type; fuel type		Public Works	**LGOP Equations 7.2, 7.6, 7.7 and 7.8**
Diesel	109,697	Gallons				
Compressed Natural Gas	3,924,423	SCF				
Refrigerant (HFC-134A)	132	Lbs	HFC-134A is an actual GHG emission			

Equation:
For each fuel type and vehicle class, multiply fuel consumption (obtained from fuel invoices) by emissions factors for CO_2 (obtained from CWP).
For each fuel type and vehicle class, multiply mileage (obtained from fuel invoices) by emissions factors for CH_4 and N_2O (obtained from CWP); convert CH_4 and N_2O into CO_2e using global warming potential.
Convert HFC-134a to CO_2e using global warming potential.
Add values together.

Data Source Notes:
Emissions factors were not readily available for vehicle model years prior to 2000 and post 2009. Any City vehicles model year 2000 or earlier were categorized as 2000, and vehicles model year 2009 or newer were categorized as 2009 for the purpose of applying the nearest obtainable emissions factor.
The Vehicle Fleet sector of the inventory reports emission from two main sources: fuel combustion and fuel economy. The recommended method for reporting vehicle related emission varies according to the emission source. For fuel, the recommended method requires individual vehicle fuel data in order to build a detailed fuel consumption record. For VMT, the recommended method involves gathering individual vehicle miles and fuel economy, or individual operating hours and fuel economy to create a detailed record. In this inventory, only fuel consumption was obtained for stationary and off-road equipment because individual fuel economy could not be determined for each equipment type. However, the stationary and off-road equipment did not account for a majority of fuel consumption. Incomplete combustion based on VMT was included for the majority of on-road vehicles.

Method:
The City Public Works Department provided detailed fueling records from the inventory year, which include the quantity of fuel consumed by each vehicle, the vehicle type (model, make, year and vehicle class), and odometer readings. Each of these values is an important part of the calculation of vehicle emissions. A spreadsheet of all vehicles in operation during the inventory year was compiled with each of the necessary data points. A pivot table was then generated, summarizing the total fuel consumption and VMT by fuel type, vehicle type, and vehicle year. The many values generated by the pivot table were entered into the CEMS system, with applicable emissions factors assigned to each entry.

Emissions from Wastewater Treatment Processes	**See community-wide emissions methods in Section A-2.**

Employee Commute	Activity data		Emissions factor		Source	Method
	Value	Unit	Value	Unit		
Total VMT	1,177,238.43	Miles	Varies by vehicle type; fuel type		Survey	**LGOP Equations 7.2, 7.6, 7.7 and 7.8**

Equation:
For each fuel type and vehicle class, multiply fuel consumption (obtained from fuel invoices) by emissions factors for CO_2 (obtained from CWP).
For each fuel type and vehicle class, multiply mileage (obtained from fuel invoices) by emissions factors for CH_4 and N_2O (obtained from CWP); convert CH_4 and N_2O into CO_2e using global warming potential.
Add values together.

Data Source Notes:
For a full understanding of the metrics used to calculate the employee commute emissions, see the spreadsheet titled "Employee Commute Workbook_FINAL_121013"

Method:
The City provided a survey conducted by the City of Merced Alternative Transportation Team in February 2011, which provided the necessary data points to estimate emissions from employee commute in 2011. The survey results were analyzed and estimates of total employee commute vehicle mileage were generated. A county-wide vehicle characterization of VMT by vehicle type and fuel type was applied (EMFAC). Each of these values is an important part of the calculation of vehicle emissions. These values entered into the CEMS system, with applicable emissions factors assigned to each entry.

Reporting Inconsistencies and Limitations:

This report is not intended to represent fully the emissions being generated in Merced. In some cases emissions could not be calculated due to data limitations or feasibility. The following potential sources of emissions were omitted from the LGO inventory for the following reasons:

Emission Type	Reason Omitted
Scope 1 fugitive emissions from the leakage of refrigerants from stationary heating, air conditioning, and refrigeration units	Not a significant source of emissions. Within any local government's operations there will be emission sources that fall within Scope 1 and Scope 2 that are minimal in magnitude and difficult to accurately measure.
Scope 1 fugitive emissions from the leakage of fire suppressants	
Scope 3 CH_4 from the generation of solid waste by government facilities	These values were inseparable
Scope 3 CO_2, CH_4 and N_2O emissions from combustion of fuels by employees for business-related travel	Emissions are minimal in magnitude and difficult to accurately measure.