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Arizona State University

2020 Greenhouse Gas Emissions Inventory for Government Operations

A comprehensive report prepared for

City of Phoenix

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sustainabilitysolutions.asu.edu

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Note: The data and calculations presented in this report may not be exact due to rounding errors within the GHG emissions template.

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Acronyms

AR	IPCC Assessment Report (Numbered 2 through 5)
ASU	Arizona State University
AZNM	Arizona and New Mexico eGRID Subregion
B20	A biodiesel blend consisting of 20% biodiesel and 80% diesel fuel
CARB	California Air Resources Board
CCAR	California Climate Action Registry
CEQ	President's Council on Environmental Quality
CH_4	Methane
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent Emissions
eGRID	EPA's Emissions and General Resource Integrated Database
EIA	U.S. Energy Information Administration
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FTE	Full-time equivalent
GGE	Gasoline Gallon Equivalent
GHG	Greenhouse Gas
GAC	Granular Activated Carbon
GWP	Global Warming Potential
ICLEI	International Council for Local Environmental Initiatives
IPCC	Intergovernmental Panel on Climate Change
JPA	Joint Powers Authority
LED	Light Emitting Diode
LEED	Leadership in Energy and Environmental Design
LGOP	Local Government Operations Protocol
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MT	Metric Tons
MWh	megawatt-hour
NAU	Northern Arizona University
NERC	North American Electric Reliability Corporation
N_2O	Nitrous Oxide
T&D	Transmission & Distribution
TRP	Trip Reduction Program
UNFCCC	United Nations Framework Convention on Climate Change
WWT	Wastewater Treatment
WWTP	Wastewater Treatment Plant

Executive Summary

The *City of Phoenix 2020 Greenhouse Gas Emissions Inventory for Government Operations* is the fifth update to the City of Phoenix (the City) government operations GHG emissions inventory. The initial GHG inventory of government operations covered calendar year 2005 and was published in 2009. This report provided both a baseline GHG inventory and technical support for the *City of Phoenix 2009 Climate Action Plan for Government Operations*. The climate action plan projected that GHG emissions from the City's government operations would increase by 14% over 2005 level if no actions were taken. As a result, the Phoenix City Council, in December 2008, adopted a mandate to reduce GHG emissions from government operations to 5% below the 2005 GHG emissions levels by 2015.

In 2013, the City conducted a GHG emissions inventory for calendar year 2012 to track progress toward the 2015 GHG emissions reduction goal. The *City of Phoenix 2012 Greenhouse Gas Emissions Inventory for Government Operations* found that GHG emissions from government operations had decreased 7.2%, exceeding the City's 2015 goal. Shortly thereafter, the Phoenix City Council adopted a new goal to reduce government operations GHG emissions to 15% below 2005 levels by 2015. The *City of Phoenix 2015 Greenhouse Gas Emissions Inventory for Government Operations* found that government operations GHG emissions were reduced by 15.6%, thus meeting the updated 2015 GHG emissions goal. In 2017, the City updated its government operations GHG emissions reduction goal to 40% below 2005 levels by 2025. The *City of Phoenix 2020 Greenhouse Gas Emissions Inventory for Government Operations* is the second inventory update since setting the 2025 GHG emissions reduction goal, and provides demonstrated progress towards the 2025 goal and a data-driven basis for developing climate actions to meet the 2025 goal.

The major findings of the *City of Phoenix 2020 Greenhouse Gas Emissions Inventory for Government Operations* are listed below.

- 2020 government operations GHG emissions were 68,829 MT CO_2e (11.4%) below 2018 levels and 180,467 MT CO_2e (25.2%) below 2005 levels.
- Between 2018 and 2020, the GHG intensity of the regional electricity grid fell by 17.3%. Over the same period, GHG emissions from purchased electricity fell by 23.0% (68,636 MT CO_2e), indicating additional reductions due to City actions. Through energy retrofits, energy use has declined in City buildings every year since 2016.
- Buildings and Facilities GHG emissions from purchased electricity fell 31,296 MT CO_2e between 2018 and 2020. Facilities managed by the

Public Works, Street Transportation and the Phoenix Convention Center departments, realized a 19 percent electricity use savings since 2016.

- GHG emissions from Traffic Signals and Streetlights decreased 66.8% below 2005 levels and 57.5% below 2018 levels.
- Water Services GHG emissions from purchased electricity decreased 16,550 MT CO_2e (13.6%) between 2018 and 2020 despite electricity consumption increasing by 11,725 MWh.
- GHG emissions from the City's vehicle fleet has increased 14,985 MT CO_2e since 2018. Increased Vehicle Fleet emissions is attributed to higher levels of CNG and B20 consumption.
- GHG emissions from landfills was similar between 2018 and 2020, increasing by 362 MT CO_2e.
- GHG emissions from wastewater treatment decreased 20.6% (28,949 MT CO_2e) between 2018 and 2020 and were 4.1% (345 MT CO_2e) below 2005 levels due to the capture and reuse of methane biogas at the 91st Avenue Wastewater Treatment Plant (WWTP).
- The 27th Avenue Compost Facility emitted 6,360 MT CO_2e in 2020, 21.7% decrease below 2018 levels. The facility will save GHG emissions over its lifetime by reducing green-organic waste disposal at the SR-85 landfill.

Since 2015 Phoenix has implemented, or is in the process of implementing, several projects in order to meet and surpass its original emissions reduction goal. These projects include:

- $16.9 million in the 27th Avenue Compost Facility.
- $30 million in LED Streetlight project replacing 100,000 streetlights
- $25 million in a biogas facility at the 91st Avenue WWTP
- $30 million in retrofits underway to reduce energy use in city buildings
- $530 million in transit since 2016 under the Phoenix Transportation Plan (T2050) for extended bus and paratransit operating hours, and increased local bus frequency to every 30 minutes or less citywide.

The City has achieved significant GHG emissions reductions despite growing by approximately 300,000 people since 2005 (Figure ES-1). Accordingly, the per capita GHG intensity of the City's government operations have fallen from 0.48 to 0.30 MT CO_2e per resident between 2005 and 2020. For more information on City of Phoenix actions to reduce GHG emissions, please read the City of Phoenix Climate Action Plan 2021 Edition.

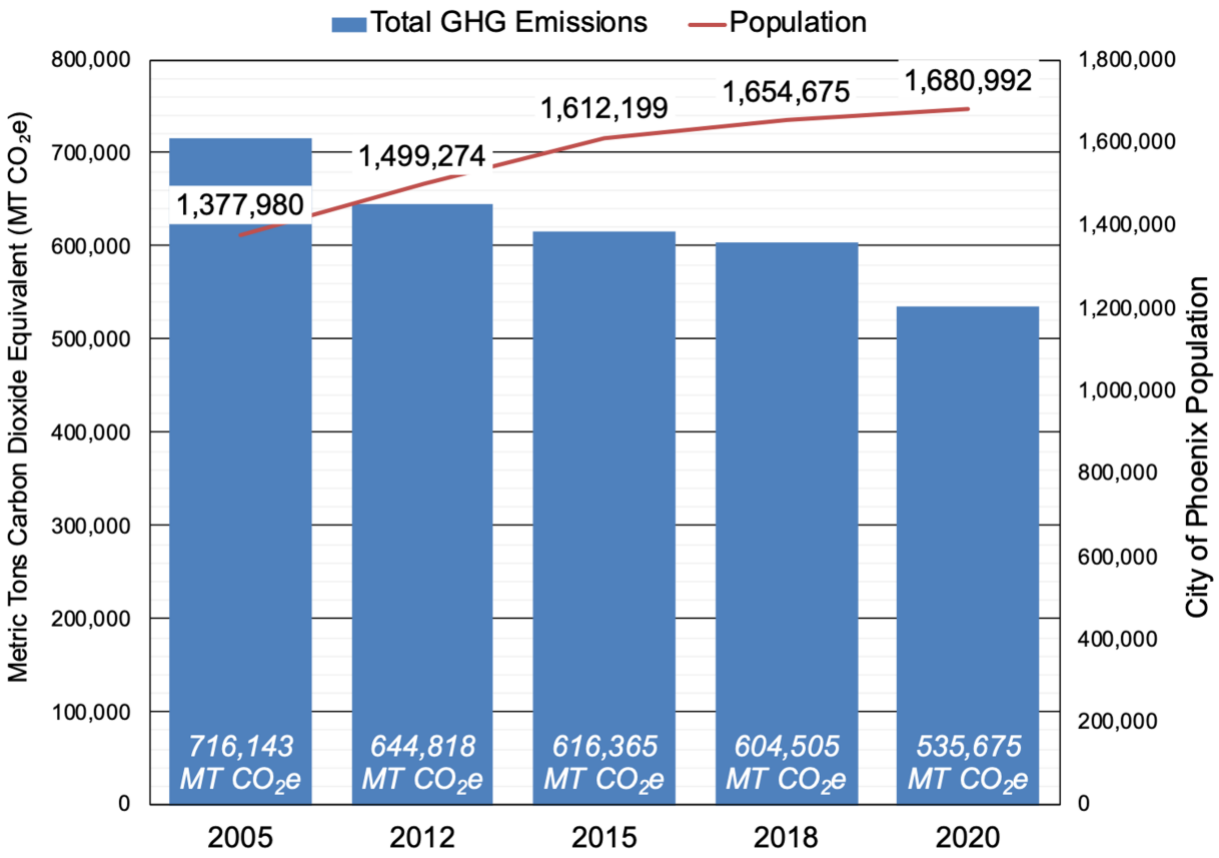


Figure ES-1. City of Phoenix Government Operations GHG Emissions and Population Between 2005 and 2020.

1 Introduction

In December 2008, the Phoenix City Council adopted a goal to reduce GHG emissions from government operations to 5% below reported 2005 levels by 2015. To achieve this goal, the City of Phoenix (City) established a baseline GHG emissions level for City operations and developed *The City of Phoenix 2009 Climate Action Plan for Government Operations*. The report forecasted a 14% increase in GHG emissions by 2015 if Phoenix maintained a business-as-usual approach and did not take efforts to curb GHG emissions.

In 2013, the City commissioned Arizona State University's Rob and Melani Walton Sustainability Solutions Service to conduct a local government operations GHG emissions inventory for 2012 to track progress toward the 2015 goal. The 2012 government operations GHG emissions inventory found that the City had already reduced GHG emissions by 7.2%, meeting the 5% reduction goal. As a result, Phoenix City Council adopted a new goal to reduce government operations GHG emissions 15% below 2005 levels by 2015. The 2015 government operations GHG emissions inventory found that the City achieved its 15% GHG emissions reduction goal. In 2017, the City updated its government operations GHG emissions reduction goal to 40% below 2005 levels by 2025.

The *City of Phoenix 2020 Greenhouse Gas Emissions Inventory for Government Operations* summarizes the City's progress toward reducing GHG emissions from government operations 40% below 2005 levels by 2025.

The report structure is as follows:

- Section 2 provides an overview of the major findings of the GHG emissions inventory of government operations.
- Section 3 describes the GHG emissions inventory boundary along with methodological background and updates for the GHG Emissions reports.
- Section 4 summarizes results by reporting sector: Buildings and Facilities, City Vehicle Fleet, Water Distribution and Wastewater Treatment Processes, Solid Waste, and Employee Commute.
- Section 5 provides internal and external benchmarks for Phoenix operations.
- Section 6 summarizes biogenic CO_2 emissions, which are non-fossil CO_2 emissions that are not included in Phoenix's total emissions.

2 Major Findings

In 2020, GHG emissions from City government operations were 535,675 MT CO_2e, which is 25.2% below 2005 levels and 11.4% below 2018 levels (Figure 1).

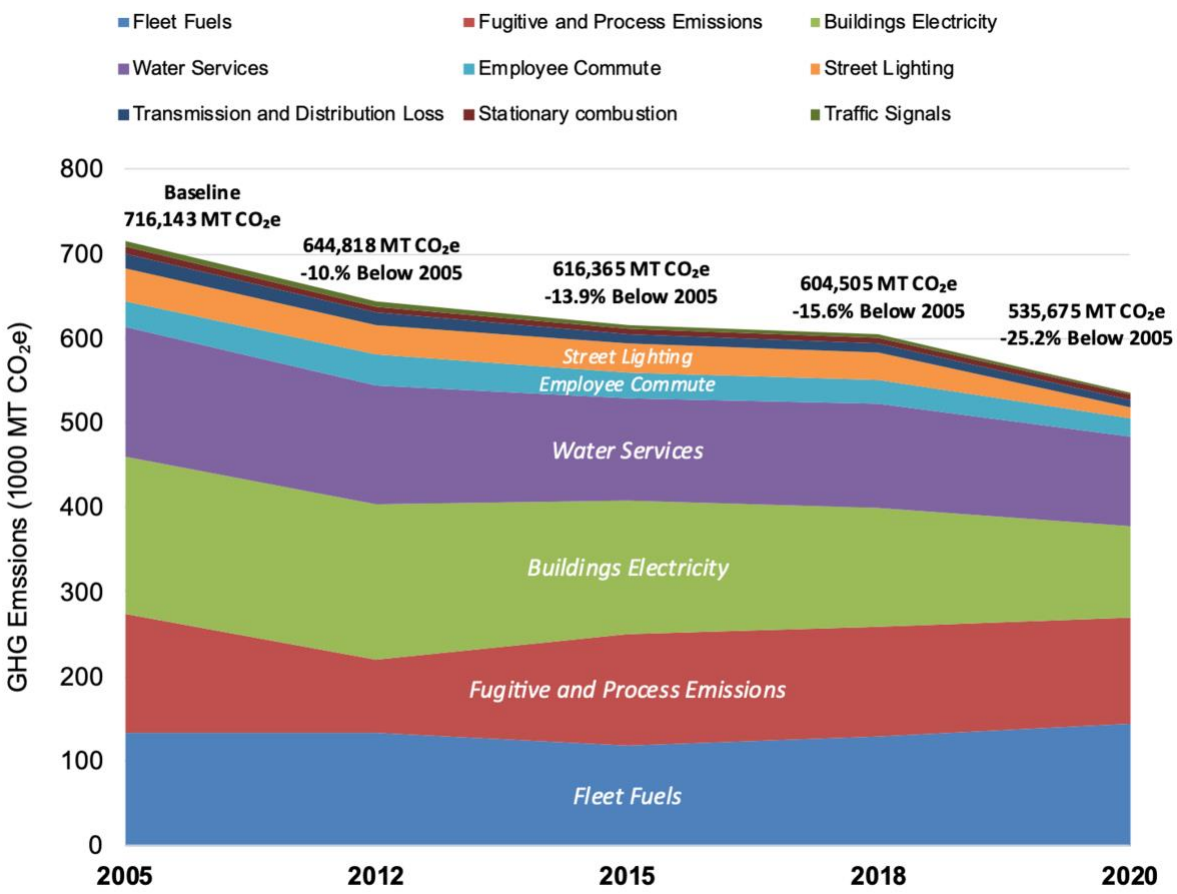


Figure 1. City of Phoenix GHG Emissions from 2005 to 2020.

The City reduced GHG emissions through a combination of internal and external measures. Internal measures include energy efficiency upgrades, the incorporation of alternative fuels into the vehicle fleet fuel portfolio, and upgrades to landfill gas capture systems. For additional internal measures, please refer to the City of Phoenix Climate Action Plan for 2021. External measures include a decrease in the EPA's Emissions & Generation Resource Integrated Database (eGRID) regional factor[1]. Between 2005 and 2020, the GHG intensity of the Arizona-New Mexico (AZNM) subregion fell by approximately 35%, from 1,316 lb. CO_2e emitted per MWh of electricity generated (lb.

[1] The Emissions & Generation Resource Integrated Database (eGRID), developed by the EPA in collaboration with the Energy Information Administration (EIA), the North American Electric Reliability Corporation (NERC), and the Federal Energy Regulatory Commission (FERC), is a comprehensive source of data on the environmental characteristics of almost all electric power generated in the United States. Detailed information can be found at http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

CO_2e/MWh) to 850 lb. CO_2e/MWh. The 2019 closure of the Navajo Generation Station, operated by Salt River Project, substantially reduced the GHG intensity of electricity in the Arizona-New Mexico subregion.

Between 2018 and 2020, GHG emissions from City government operations decreased in every subsector except Fleet Fuels, which increased 14,985 MT CO_2e (11.5%) as shown in Table 1. The increase in Fleet Fuels GHG emissions were driven by increased CNG consumption (1,404,331 GGE) and B20 fuel consumption (1,281,289 gallons), which resulted in 8,880 MT CO_2e and 10,440 MT CO_2e additional GHG emissions, respectively. However, over the same period, gasoline consumption remained relatively unchanged (3% increase) and diesel consumption decreased by 12%. In the Water Services sector, GHG emissions from electricity usage decreased by 16,650 MT CO_2e (13.6%) despite an increase in electricity consumption of 11,725 (4%). Water Services natural gas consumption increased by 25% between 2018 and 2020. GHG emissions from employee commuting decreased in 2020 most likely due to the COVID-19 pandemic as some employees were able to telework to perform their duties; the change in commuting patterns caused by the pandemic reduced commuting-related GHG emissions by 22% compared to 2018.

2.1 Revisions

Minor revisions were made to the GHG emissions totals from City government operations. These revisions are detailed below.

- 2005: No revisions were made to the 2005 inventory.
- 2012: 644,819 MT CO_2e revised upwards from 644,723 MT CO_2e.
  - Audit found incorrect Excel formula that omitted 96 MT CO_2e from liquified natural gas consumption.
- 2015: 616,351 MT CO_2e revised downwards from 616,415 MT CO_2e
  - Audit found incorrect Excel formula that overestimated N_2O emissions from the 91st Avenue wastewater treatment plant by 64 MT CO_2e.
- 2018: 604,505 MT CO_2e revised downwards from 605,701 MT CO_2e.
  - Audit found incorrect Excel formulas that overestimated emissions from Fugitive and Process Emissions by 61 MT CO_2e.
  - Updated state-level Transmission and Distribution loss data, which decreased emissions by 1,135 MT CO_2e.

Table 1 shows changes GHG emissions for City government operations and population between 2005 and 2020.

Table 1. GHG Emissions by Scope and Sector Between 2005 and 2020

Scope 1	2005	2012	2015	2018	2020	2005-2020 Change	2005-2020 % Change
Stationary Combustion	7,404	7,329	6,377	6,085	6,447	-957	-12.9%
Fleet Fuels	132,709	133,521	118,706	129,748	144,734	12,025	9.1%
Fugitive and Process Emissions	142,165	87,073	131,868	129,646	124,798	-17,187	-12.1%
Scope 1 Total Emissions	282,277	227,923	256,951	265,479	276,158	-6,119	-2.2%

Scope 2	2005	2012	2015	2018	2020	2005-2020 Change	2005-2020 % Change
Buildings Electricity	184,285	183,851	156,646	139,714	108,418	-75,867	-41.2%
Street Lighting	38,502	36,416	33,935	32,069	12,224	-26,278	-68.3%
Traffic Signals	7,733	7,157	4,755	4,075	3,130	-4,602	-59.5%
Water Services	155,368	137,793	121,158	122,002	105,452	-49,916	-32.1%
Scope 2 Total Emissions	**385,888**	**365,217**	**316,494**	**297,860**	**229,225**	**-156,664**	**-40.6%**

Scope 3	2005	2012	2015	2018	2020	2005-2020 Change	2005-2020 % Change
Employee Commute	30,272	35,042	31,350	29,518	20,799	-9,473	-31.3%
Transmission and Distribution Loss	17,705	13,640	10,810	10,766	8,548	-9,158	-51.7%
Water Services	0	2,996	760	881	946	946	-
Scope 3 Total Emissions	**47,977**	**51,679**	**42,920**	**41,165**	**30,293**	**-17,685**	**-36.9%**

GHG Inventory	2005	2012	2015	2018	2020	2005-2020 Change	2005-2020 % Change
Total Scope 1 and 2 Emissions	668,165	593,140	573,445	563,339	505,383	-162,782	-24.4%
Total Scope 1, 2, & 3 Emissions	**716,143**	**644,818**	**616,365**	**604,505**	**535,675**	**-180,467**	**-25.2%**
City of Phoenix Population	**1,377,980**	**1,499,274**	**1,612,199**	**1,654,675**	**1,680,992**	**303,012**	**22.0%**

3 Methodology

3.1 Local Government Operations Protocol

Phoenix's 2005 baseline emissions inventory was based on the Local Government Operations Protocol (LGOP), developed by the International Council for Local Environmental Initiatives (ICLEI – now officially called 'ICLEI- Local Governments for Sustainability'), the California Climate Action Registry (CCAR), the California Air Resources Board (CARB), and The Climate Registry (The Registry). The LGOP serves as a national standard for quantifying and reporting emissions associated with government operations. To ensure consistency, the ASU and NAU team has used the 2010 version (Version 1.1) of the protocol for the previous GHG emissions inventories.

The LGOP provides a methodology for the calculation of GHG emissions from numerous sources and for the development of a comprehensive inventory report. Activity data are collected from a GHG emissions source and multiplied by an emission factor (e.g., metric tons CO_2 emitted per kWh) to calculate the total emissions. Where activity data are not available, they are modeled. The LGOP provides emission factors for most calculation methodologies used in the report. Measured or calculated emissions are then converted to carbon dioxide equivalent emissions (CO_2e) using the IPCC AR5 GWP factors[2] shown in Appendix A.

3.2 Scope Classifications and Sectors

GHG emissions from government operations are categorized as Scope 1, 2, or 3 emissions. Scope categories indicate whether GHG emissions are direct or indirect in order to improve transparency and to inform different types of climate policies and goals. The Scope categories are illustrated in Figure 2.

- Scope 1: Direct emissions from City owned or controlled operations.
- Scope 2: Indirect emissions associated with the consumption of purchased or acquired electricity, steam, heating or cooling that occur at sources not owned or controlled by the City.
- Scope 3 (optional under the protocol for cities to include in their inventories): All other indirect emissions not covered in Scope 2, such as transport-related activities in vehicles not operated by Phoenix (e.g., employee commuting and business travel) and other outsourced activities. This report includes employee commuting

[2] Greenhouse Gas Protocol, 2016. Global Warming Potential Values. URL: https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

and outsourced granular activated carbon (GAC) hauling and regeneration activity as Scope 3 emissions.

This report is organized into five sectors to make it more compatible for policy making and project management teams.

- Buildings and Facilities
- City Vehicle Fleet
- Water Distribution and Wastewater Treatment
- Solid Waste
- Employee Commute

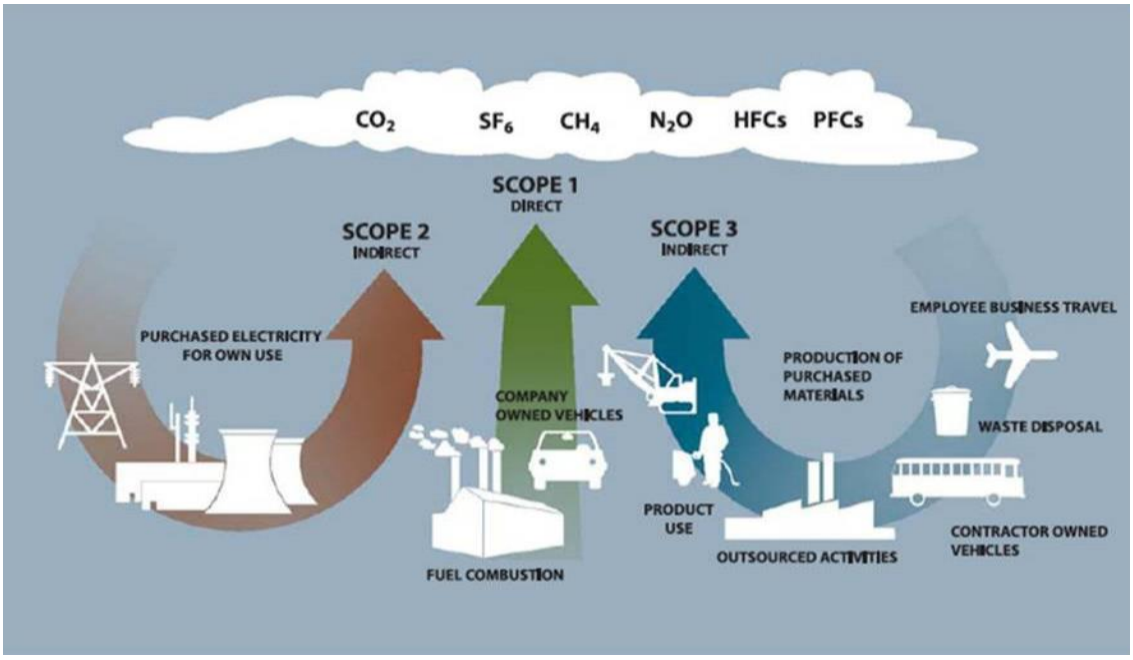


Figure 2. Overview of LGOP Scopes and Emissions Sources.[3]

3.3 City of Phoenix Government Operations Boundary

The LGOP provides two approaches for defining the boundaries of what to include in the government operations GHG inventory: the first approach is *operational control* and includes those operations in which the local government has the authority to introduce and implement operating policies; the second is *financial control* and includes those operations that are fully consolidated in financial accounts. More detail on both approaches can be found in the LGOP Version 1.1[4].

[3] Source: The City of Phoenix 2005 GHG Emissions Inventory for Government Operations (2009). Adopted from World Resources Institute GHG Protocol Corporate Accounting and Reporting Standard (Revised Edition), Chapter 4, 2004.
[4] ICLEI USA, 2020. Greenhouse Gas Protocols. URL: https://icleiusa.org/ghg-protocols/

This inventory uses the *operational control* approach as it most accurately represents GHG emissions sources within the City's control. The boundaries of the City operations GHG inventory follow the same guidelines as the 2005 baseline inventory. However, Scope 3 GHG emissions – emissions resulting granular activated carbon (GAC) hauling and regeneration and electricity transmissions and distribution (T&D) loss – and biogenic emissions were added into the 2012 inventory, and have been included in each inventory since. The 27th Avenue Compost Facility GHG emissions source was added in the 2018 inventory. A detailed description of considerations of the City's operational control boundary is located in Appendix B.

3.4 Inventory Changes Since 2005

The 2020 GHG emissions inventory methodology generally follows that of the 2005 inventory. With each emissions inventory, technical improvements are made to more accurately quantify emissions. In 2010, ICLEI and partners released the latest LGOP Version 1.1. This update included several changes to figures, methods, and other factors. Additionally, the 2005 and 2012 GHG emissions inventory utilized Intergovernmental Panel on Climate Change (IPCC) AR2 Global Warming Potential (GWP) emissions factors; the 2015 GHG emissions inventory utilized IPCC AR4 GWP emissions factors; the 2018 and 2020 GHG emissions inventory utilizes IPCC AR5 GWP; and the 2020 GHG emissions inventory utilizes IPCC AR6 GWP. This procedure of updated GWP factors, found in the EPA U.S. Greenhouse Gas Inventory Report, complies with the United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines for national inventories, requiring the use of the latest GWPs for national GHG emissions inventories[5].

The following changes have been made to the City government operations GHG emissions inventory since the baseline inventory:

- Estes Landfill was added to all inventory years;
- Employee commuting emissions at sites with more than 50 employees added to the 2005 inventory year;
- In 2005, wastewater treatment emissions were estimated using population-based data. Site-specific data were used where applicable in 2012, 2015, 2018, and 2020;
- Inventory-year specific T&D loss rates are used;
- Biogenic emissions are calculated for all inventory years;
- The 2020 inventory year utilizes eGRID 2020, which is the most up-to-date eGRID data available; and

[5] UNFCCC Secretariat, 2014. Report of the Conference of the Parties on its nineteenth session, held in Warsaw from 11 to 23 November 2013. Decision 24/CP.19, paragraph 2. URL: http://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf.

- The 2020 GHG emissions inventory includes emissions from the 27th Avenue Compost Facility.

3.4.1 Estimating Tailpipe Emissions of Methane and Nitrous Oxide

The methodology used to estimate tailpipe methane (CH_4) and nitrous oxide (N_2O) emissions changed between the 2005 and 2015 GHG emissions inventories. In 2005, the Clean Air-Cool Planet's GHG modeling software was used to estimate fleet emissions of CH_4 and N_2O. The 2020 inventory uses the Climate Registry's simple estimation method for tailpipe CH_4 and N_2O emissions based upon fuel carbon dioxide content, providing a standard estimation of these emissions across fuel and vehicle types. Using this method, CH_4 and N_2O emissions factors were developed for the previous inventories using the EPA *Inventory of U.S. Greenhouse Gas Emissions and Sinks*[6]*.* This method avoids the need to track vehicle mileage.

3.4.2 2005 Wastewater Treatment Methane and Nitrous Oxide Emissions

Wastewater treatment CH_4 and N_2O emissions for 2005 were obtained from the *City of Phoenix 2015 Greenhouse Gas Emissions Inventory for Government Operations.* Please refer to that report for an explanation for the backcasting methodology to estimate 2005 emissions levels.

3.4.3 Alternative Fuel Estimates for Employee Commuting

Employee commuting data is based on an annual survey conducted by the Maricopa County Trip Reduction Program (TRP) regarding commuting throughout the work week. Alternative fuel combustion data were obtained Energy Information Administration (EIA) *Annual Energy Outlook* to estimate alternative fuel employee commuting. It was assumed that national alternative fuel combustion levels provided a proxy for alternative fuel combustion patterns for City employees[7].

3.4.4 Estimating Compost Emissions

In 2017, the City began operating the 27th Avenue Compost Facility. While a compost operation did exist within City boundaries prior to 2018, this facility was neither owned nor operated by the City. GHG emissions from composting were calculated according to EPA methodology for estimating national-level emissions from composting in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019*[8]*.*

[6] U.S. EPA (2019). Inventory of U.S. Greenhouse Gas Emissions and Sinks. URL: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks 2.
[7] U.S. Energy Information Administration (2013). Annual Energy Outlook. URL: https://www.eia.gov/outlooks/aeo/
[8] U.S. EPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017. URL: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2017

3.4.5 Estimating Aviation GHG Emissions for 2020

The 2018 levels Jet Fuel A and Aviation Gasoline consumption for Police Department Aircraft were assumed for 2020. This assumption was made due to incomplete reporting, which showed the reduction of fuel consumption by multiple orders of magnitude, related to the consumption of these fuels. If the reported 2020 data are proven to be correct, these emissions will be revised in a future GHG emissions inventory.

4 Results

4.1 Summary

2020 Overall Findings

GHG emissions from City of Phoenix government operations have decreased 25.2% below 2005 levels.

Emissions Sources*

- Buildings and Facilities** — 129,264 MT CO_2e
- City Vehicle Fleet — 144,734 MT CO_2e
- Employee Commute — 20,799 MT CO_2e
- Solid Waste — 116,884 MT CO_2e
- Water Services — 115,447 MT CO_2e

*Above GHG emissions represent all emissions within a sector across all emissions scopes but excludes Transmission and Distribution Loss in the regional electricity grid, which was 8,458 MT CO_2e in 2020.
** Excludes Water Services.

4.1.1 2005 to 2020: What has Changed?

The 2020 GHG emissions inventory of City operations is an additional data point in support of the City's 15-year track record of reducing GHG emissions (Figure 3). Numerous projects and activities undertaken by the City since 2005 have significantly reduced the GHG intensity of City operations. Projects and activities, and how they have affected the 2020 City government operations GHG emissions, are listed below.

- The installation of advanced methane capture systems at landfills reduced fugitive methane emissions from City landfills.
- Transitioning City Fleet to B20 and CNG from diesel has reduced the GHG intensity of Public Works activities.
- Public Transit has transitioned all its diesel consumption to B20 and increased use of LNG, reducing GHG intensity, while fuel consumption has increased since 2015 in order to meet T2050 goals.
- Energy efficiency upgrades to buildings, facilities, streetlights, traffic signals, water treatment and distribution, and wastewater treatment have reduced 2020 electricity consumption 8% below 2005 and 4% below 2015 levels.

- The 27th Avenue Compost Facility diverts material from the SR-85 landfill, reducing landfill GHG emissions while producing an environmentally beneficial commercial product.

Beyond projects and activities undertaken by the City, the GHG intensity of the regional electricity grid – the Arizona-New Mexico (AZNM) eGRID subregion – has fallen 35.4% over the last fifteen years. The 2019 retirement of the Navajo Generation Station, among other factors, reduced the GHG intensity of the regional electricity grid by 11.2% between 2018 and 2020.The planned retirement of additional regional coal power plants over the next decade will further reduce the GHG intensity of the regional electricity grid.

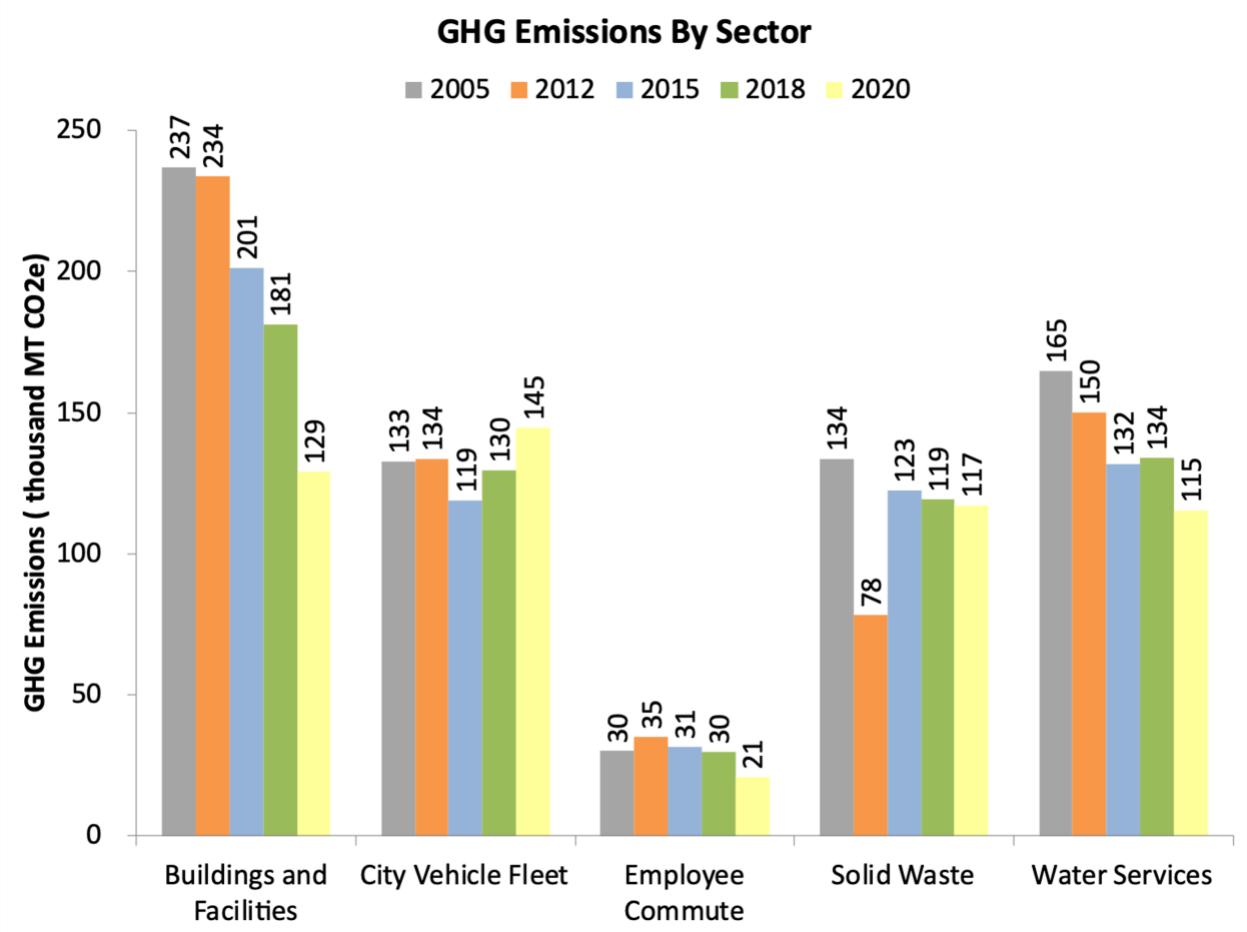


Figure 3. GHG Emissions by City Sector

Between 2005 and 2020, the City's population increased by 22% from 1,377,980[9] to 1,680,992[10] residents. While some government operations are population dependent – e.g., solid waste generation and water distribution and wastewater treatment – the City's GHG emissions are largely electricity-dependent. The significant decarbonization of the regional electricity grid has effectively decoupled population growth from GHG emissions from City government operations. Had the regional electricity grid not decarbonized, GHG emissions from City operations would have decreased by only 7.0% between 2005 and 2020. Instead, GHG emissions decreased by over 25%.

4.1.2 Emissions Sources and Distribution

City government operations GHG emissions are largely attributed to four sectors: Buildings and Facilities, Vehicle Fleet, Water Services, and Fugitive and Process Emissions. Figure 4 provides an overview of the relative magnitude of GHG emissions by Scope and Subsector.

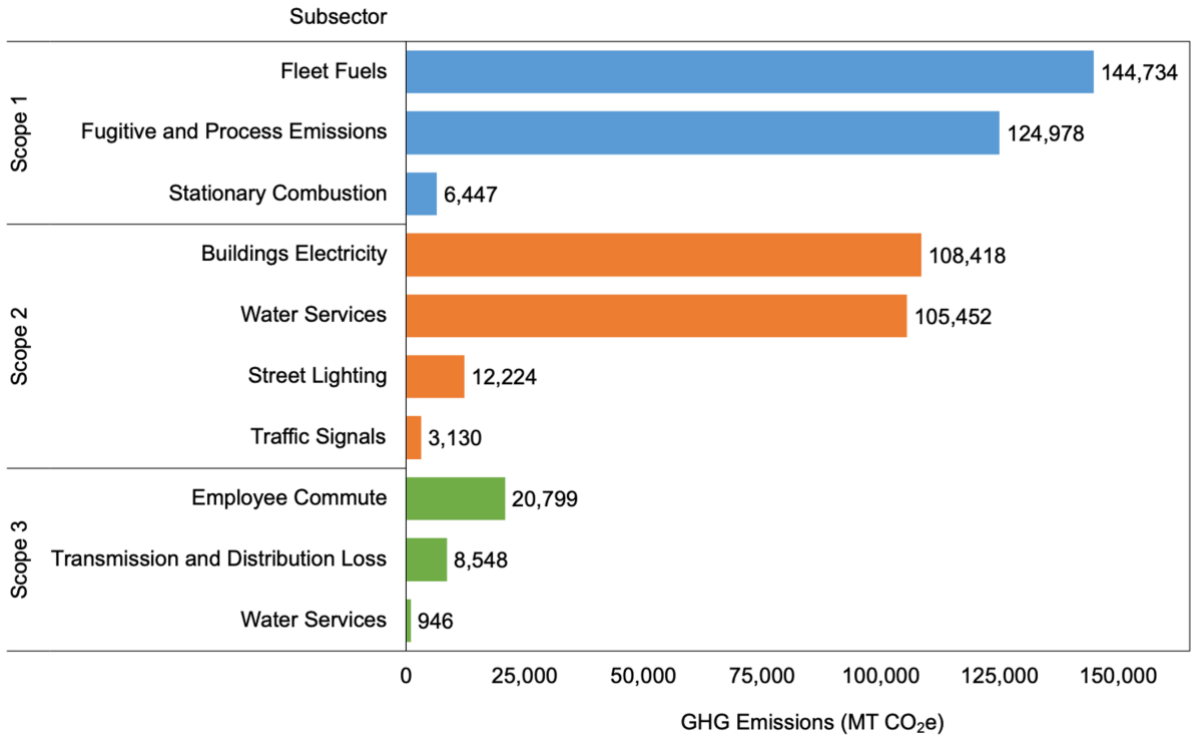


Figure 4. Total Emissions by Scope and Subsector

[9] U.S. Census Bureau (2005). American Community Survey. URL: https://factfinder.census.gov/bkmk/table/1.0/en/ACS/05_EST/S0101/1600000US0455000
[10] U.S. Census (2022). City and Town Population Totals: 2010-2019. URL: https://www.census.gov/data/tables/time-series/demo/popest/2010s-total-cities-and-towns.html

Scope 1 and Scope 2 GHG emissions account for 94% of GHG emissions from City government operations. Scope 1 emissions account for more than 50% of City government operations GHG emissions (Figure 5) and, more specifically, Fleet Fuels and Fugitive and Process Emissions represents 27.0% and 23.3% of total GHG emissions, respectively. Scope 2 GHG emissions from Buildings Electricity and Water Services each account for approximately 20% of total GHG emissions. Combined, these four sectors comprise over 90% of GHG emissions from City government operations. As the regional electricity grid becomes less GHG-intensive, Scope 2 GHG emissions will comprise a smaller proportion of the City government operations GHG emissions inventory.

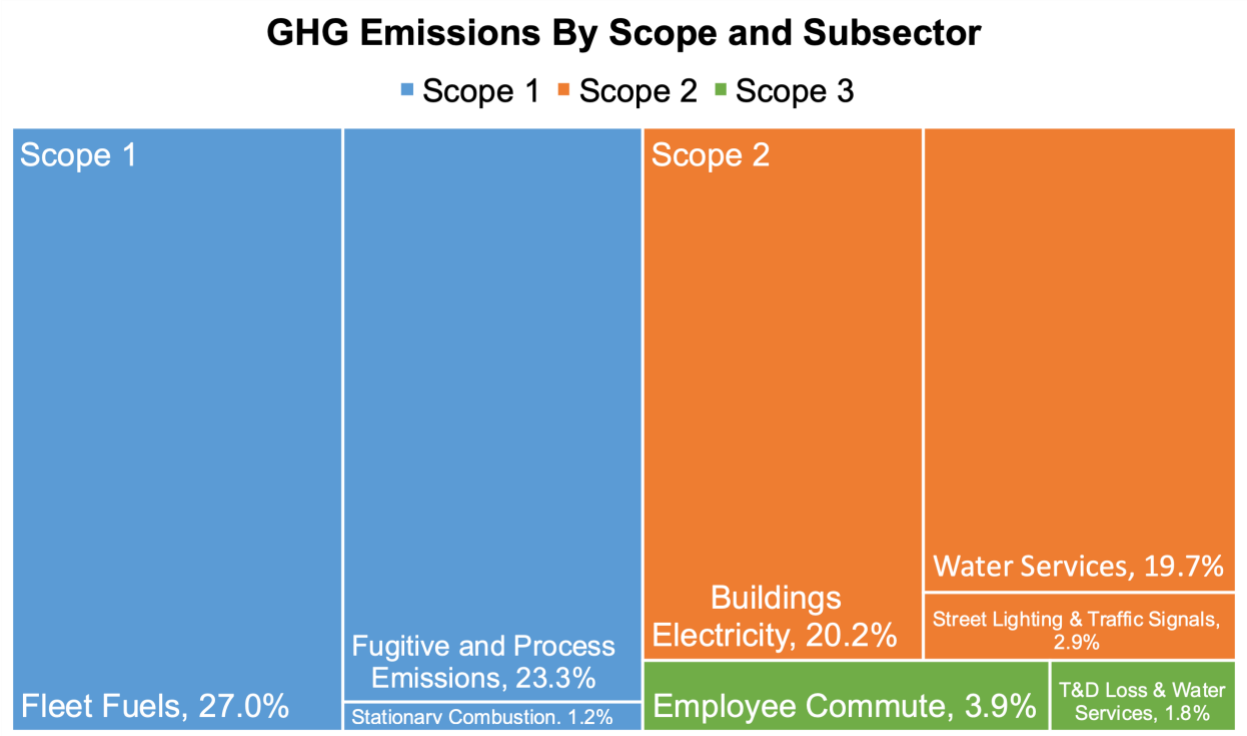


Figure 5. Percent of Total Emissions by Scope and Subsector

4.1.3 GHG Emissions Reductions Since 2005

Each GHG emissions subsectors have decreased emissions since 2005, except Fleet Fuels, which increased due to increased service needs (Figure 6).

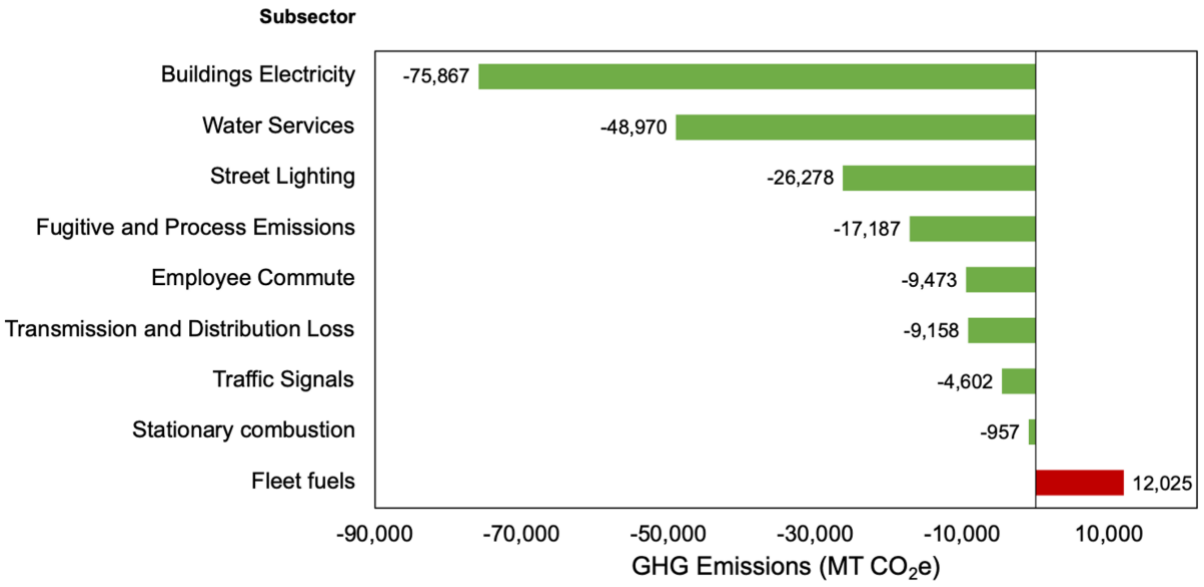


Figure 6. Emissions Changes between 2005 and 2020.

The Buildings Electricity and Water Services subsectors and have had the largest observed decreases in GHG emissions between 2005 and 2020; GHG emissions from Buildings Electricity fell by 41% and Water Services by 32%. The observed GHG emissions reductions in these subsectors were driven by several factors. First, the regional electricity grid became less GHG intensive. A less GHG intensive regional electricity grid has led to the reduction of 156,664 MT CO_2e below 2005 levels. Finally, energy efficiency projects have led to GHG emissions reductions, but exact emissions reductions are difficult to quantify.

Additional factors that contribute to the observed GHG emissions reduction include:

- Decreased emissions from closed City landfills;
- Capturing generated biogas at the 91st Avenue Wastewater Treatment Plant;
- A change in commuting patterns (increased teleworking) compared to previous inventory years.

5 Findings by Sector for 2020

5.1 Buildings and Facilities

Building and Facilities Findings

Total Emissions: 235,671 MT CO_2e
44.0% of government operations emissions
40.1% decrease from 2005 levels

Emissions Sources

- Building Electricity Consumption
- Building Natural Gas Consumption
- Streetlights Electricity Consumption
- Traffic Signals Electricity Consumption
- Water Services Electricity and Natural Gas Consumption*

City Action Highlights

- To date, the City has installed:
  - 94,875 LED Street Lights
  - 63,324 LED Signal Indications
  - 9,320 LED Pedestrian Indications

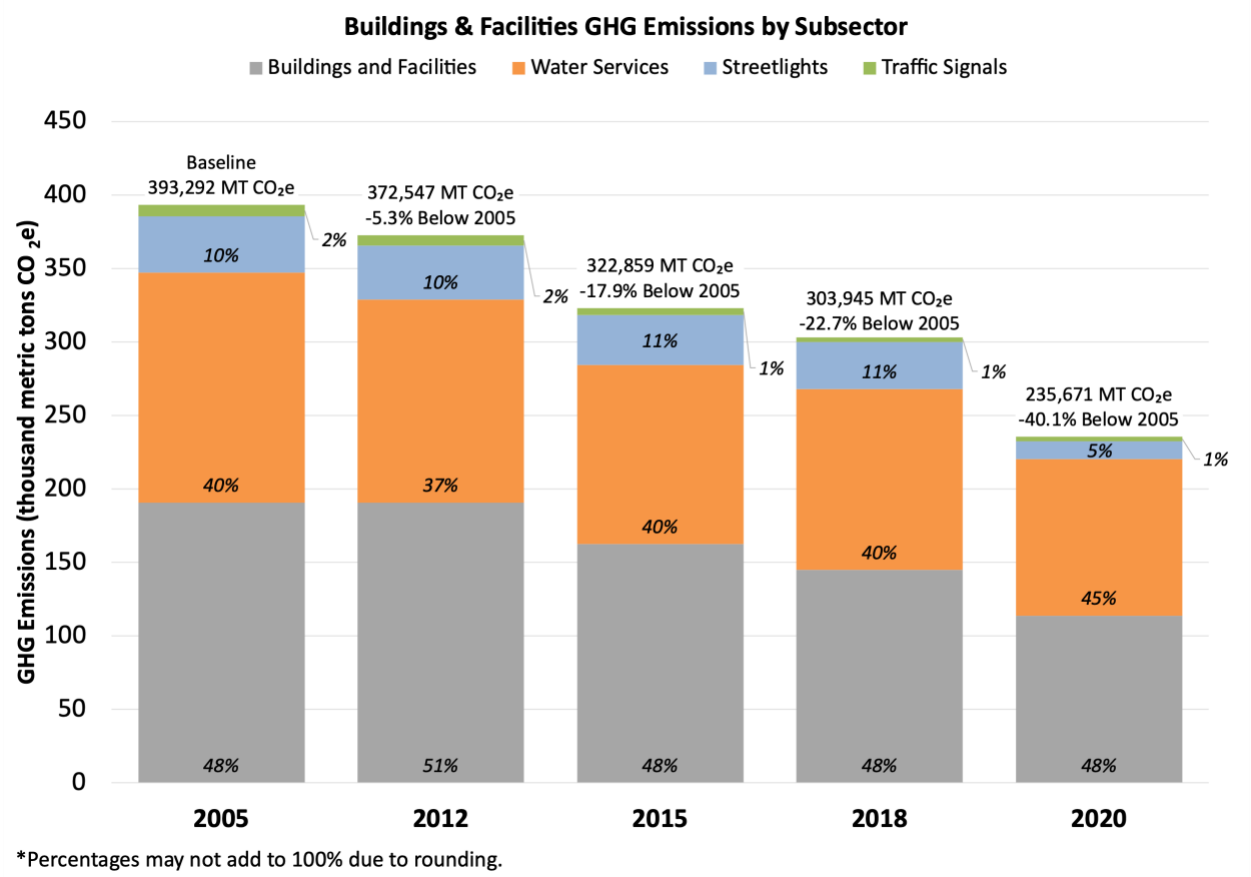
*Water Services electricity and natural gas consumption are included because this section describes trends for all electricity and natural gas consumption.

5.1.1 2005 to 2020: What has Changed?

- Between 2005 and 2020, the GHG emissions intensity of the AZNM subregion of the U.S. electricity grid fell by 35%.

5.1.2 Emissions Sources and Distribution

GHG emissions in the Buildings and Facilities sector occur directly from the combustion of natural gas purchased from a natural gas utility and indirectly from the purchase of electricity (Figure 7).



*Percentages may not add to 100% due to rounding.

Figure 7. Buildings and Facilities GHG Emissions Between 2005 and 2020

GHG emissions from natural gas combustion fell by 14% between 2005 and 2020 and 4.9% between 2018 and 2020. Additionally, GHG purchased electricity emissions decreased 40.6% below 2005 levels and 27.6% below 2018 levels. Table 2 shows 2020 summary data. The steep decline in Buildings and Facilities GHG emissions is primarily due to a significant reduction in the GHG intensity of the regional electricity grid. City efforts to build and purchase solar power are located Appendix C. Further development of the city's renewable energy portfolio is necessary to continue to decrease emissions from Buildings and Facilities.

Streetlights electricity consumption peaked in 2015 at 71,316,538 kWh and has since fallen 46% to 31,705,340 kWh. In 2020, Traffic Signals electricity consumption was 27% lower than reported consumption in 2005 and 7% lower than 2018. The decrease in electricity consumption has occurred over a period during which the City has invested heavily in LED retrofits of Streetlights and Traffics Signals. Energy efficiency upgrades, along with a less GHG intensive electricity grid, have reduced GHG emissions from traffic signals and streetlights by 62%.

Table 2. 2020 Buildings and Facilities Emissions by Subsector

Subsector	Electricity Consumption (kWh)	Natural Gas Consumption (therms)	GHG Emissions (MT CO_2e)
Buildings and Facilities	281,207,257	1,033,173	113,910
Street Lighting	31,705,340	--	12,224
Traffic Signals	8,119,517	--	3,130
Water Services	273,513,529	179,591	106,407
Total	**594,545,642**	**1,212,764**	**235,671**

5.1.3 GHG Metrics: Buildings and Facilities

Table 3 provides a list GHG metrics for City buildings and facilities.

Table 3. Buildings and Facilities Emissions Indicators

Indicator	2005	2012	2015	2018	2020
Building Space (sq. ft.)	25,948,884	30,624,893	12,599,324	11,495,864	15,047,461
Building Space GHG Emissions Intensity (kg CO_2e per sq. ft)	7.35	6.22	12.89	12.62	7.57
Per Capita GHG Emissions Intensity (kg CO_2e per resident)	138.4	127.1	100.7	87.7	67.8
Electricity GHG Emissions per CDD (kg CO_2e per CDD)	39.1	36.3	30.9	28.3	19.3
FTE GHG Emissions Intensity (kg CO_2e per FTE)	13.00	12.64	11.08	9.92	9.92

5.2 City Vehicle Fleet

City Vehicle Fleet Findings

Total Emissions: 144,734 MT CO_2e
27% of government operations emissions
9.1% increase from 2005 levels

Emissions Sources

- Gasoline
- Diesel
- Compressed Natural Gas (CNG)
- Biodiesel
- Liquefied Natural Gas (LNG)
- Liquefied Petroleum Gas (LPG)
- Ethanol
- Aviation gasoline (Police Department Aircraft)
- Jet Fuel A (Police Department Aircraft)

City Action Highlights

- Biodiesel alternative fuel program
- Ethanol alternative fuel program
- Adoption of CNG in Public Transit

5.2.1 2005 to 2020: What has Changed?

- The size of Public Works fleet peaked in 2015 with 7,389 vehicles and has since dropped to 7,340 vehicles.
- Public Works and Aviation have converted the majority of the diesel vehicle fleet to B20 and CNG. However, Ultra Low Sulfur diesel fuel continues to be used in specific situations, such as emergency generators and fueling sites with low throughput. Aviation has plans to convert to electric-powered ground equipment.
- The completion of the PHX SkyTrain in 2021 will decrease emissions as the CNG-powered passenger fleet is used less frequently.
- GHG emissions from B20 and CNG have increased since 2018 due to added service miles as part of the City's Transportation 2050 (T2050) Plan to increase local bus frequency, build out the existing city bus network, increase service hours of bus operations, and introduce new bus routes.

5.2.2 Emissions Sources and Distribution

CNG, gasoline, B20 vehicles were the largest source Vehicle Fleet GHG emissions in 2020, respectively. CNG and B20 consumption has increased as diesel consumption has decreased; 2020 diesel consumption was 41% of the 2005 levels. However, diesel consumption has increased since 2015 due to an increase in public transit service miles to meet T2050 goals. GHG emissions from gasoline and E85 ethanol has remained largely flat since 2012. Jet Fuel A and Aviation GHG emissions Gasoline, a small percentage of Vehicle Fleet emissions, have also remained flat. Jet Fuel A and Aviation Gas consumption levels were carried over from the 2018 inventory to account for incomplete reporting. Figure 8 shows Vehicle Fleet GHG emissions by fuel type. Only the fossil fuel component of biofuel GHG emissions – 80% of each gallon of B20 and 15% of each gallon of E85 ethanol – is counted towards the GHG emissions.

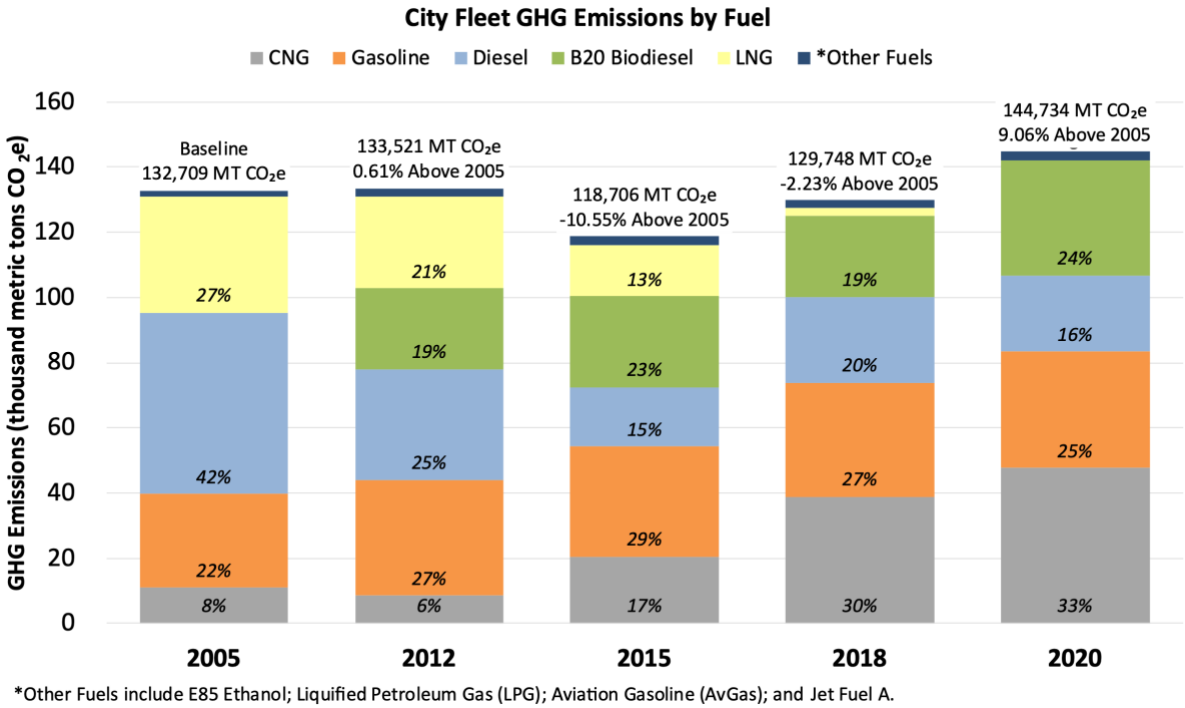


Figure 8. Vehicle Fleet Emissions by Fuel Between 2005 and 2020

Table 4 shows fuel consumption levels by fuel type and inventory year. The major changes to the levels of CNG, B20, and LNG fuel consumption is driven by Public Transit vehicle fleet and service levels. The City began replacing LNG buses with more efficient CNG busses in 2013; all LNG buses are retired. The LNG that is used by the Public Transit vehicle fleet is converted to CNG. No other major changes in fuel consumption were observed between 2015 and 2020.

Table 4. City Fleet Fuel Consumption By Type By Year

Fuel Type	Unit	2005	2012	2015	2018	2020
Gasoline	gallon	3,172,441	3,976,124	3,813,990	3,936,224	4,064,327
Diesel	gallon	5,452,613	3,324,829	1,777,341	2,579,301	2,282,301
B20	gallon	0	3,034,345	3,394,710	3,027,969	4,309,358
Compressed Natural Gas (CNG)	GGE*	1,744,813	1,349,993	3,239,129	6,151,022	7,555,353
Liquefied Natural Gas (LNG)	gallon	7,917,008	6,222,272	3,528,633	543,296	38,866
E85 Ethanol	gallon	0	287,438	340,753	311,460	335,145
Liquified Petroleum Gas (LPG)^	gallon	14,392	0	0	0	0
Aviation Gasoline (AvGas) ^	gallon	2,401	5,975	4,961	4,875	4,875
Jet Fuel A^	gallon	163,160	222,283	202,119	192,739	192,739

* GGE – Gasoline Gallon Equivalent
^ Jet Fuel A and Aviation Gas consumption levels were carried over from the 2018 inventory to account for incomplete reporting

5.2.3 GHG Metrics: Vehicle Fleet

Emissions per vehicle maintained by Public Works fell from approximately 9.2 to 6.7 MT CO_2e per vehicle, despite an increase to the number of vehicles (Table 5). The data shown in Table 5 are for Public Works vehicles only.

Table 5. City Fleet Indicators Change

Indicator	2005	2012	2015	2018	2020
Number of Vehicles	6,090	7,387	7,389	7,340	7,548
MT CO_2e per Vehicle	9.2	7.1	6.6	6.7	6.3

5.3 Water Services

Water Services Findings

Total Emissions: 115,447 MT CO_2e
21.6% of government operations emissions
25% decrease from 2005 levels

Emissions Sources

- Water distribution stationary & process emissions
- 23rd Avenue and 91st Avenue wastewater treatment plants stationary & process emissions
- Granular activated carbon (GAC) hauling and regeneration
- Electricity and natural gas use

City Action Highlights

- The onsite harvesting of biogas at the 91St Avenue Wastewater Treatment plant has reduced GHG emissions from wastewater treatment.

5.3.1 2005 to 2020: What has Changed?

- The Cave Creek Water Reclamation Plant was taken offline in January 2010 as an efficiency measure due to wastewater flows into the plant being at only half of the plant capacity. Future wastewater flows will be reviewed to determine if there is a need to return the plant to service.
- In January 2007, the Lake Pleasant Water Treatment Plant (WTP) came online. The Verde WTP was closed in December 2011 and the lease with the Salt River Pima Maricopa Indian Community for the use of the site was extended.
- In 2018, the Water Services department treated 102.6 billion gallons of water and 41.1 billion gallons of wastewater. The volume of water treated has increased 4% since 2005 while the volume of wastewater treated has decreased 6%.
- The emissions from the hauling and regeneration of granular activated carbon (GAC) for water treatment did not occur in 2005, but have been included in the GHG inventory since 2012.

5.3.2 Emissions Sources and Distribution

GHG emissions can occur from natural gas combustion, electricity consumption, CH_4 generation during wastewater treatment, and N_2O emissions from wastewater effluent discharge. Scope 3 GHG emissions also occur during GAC filter regeneration. Between

2005 and 2020, Water Services GHG emissions have decreased 30% (Figure 9). The overwhelming majority of Water Services GHG emissions occur from electricity consumption, and benefit from the decarbonization of the regional electricity grid. Most wastewater treatment GHG emissions – methane flaring and wastewater discharge – are population-driven. Projected population increases over the next decade will potentially increase GHG emissions in this sector unless further mitigation efforts are undertaken. However, the capture and reuse of methane generated during wastewater treatment (biogas) will substantially reduce GHG emission from methane flaring.

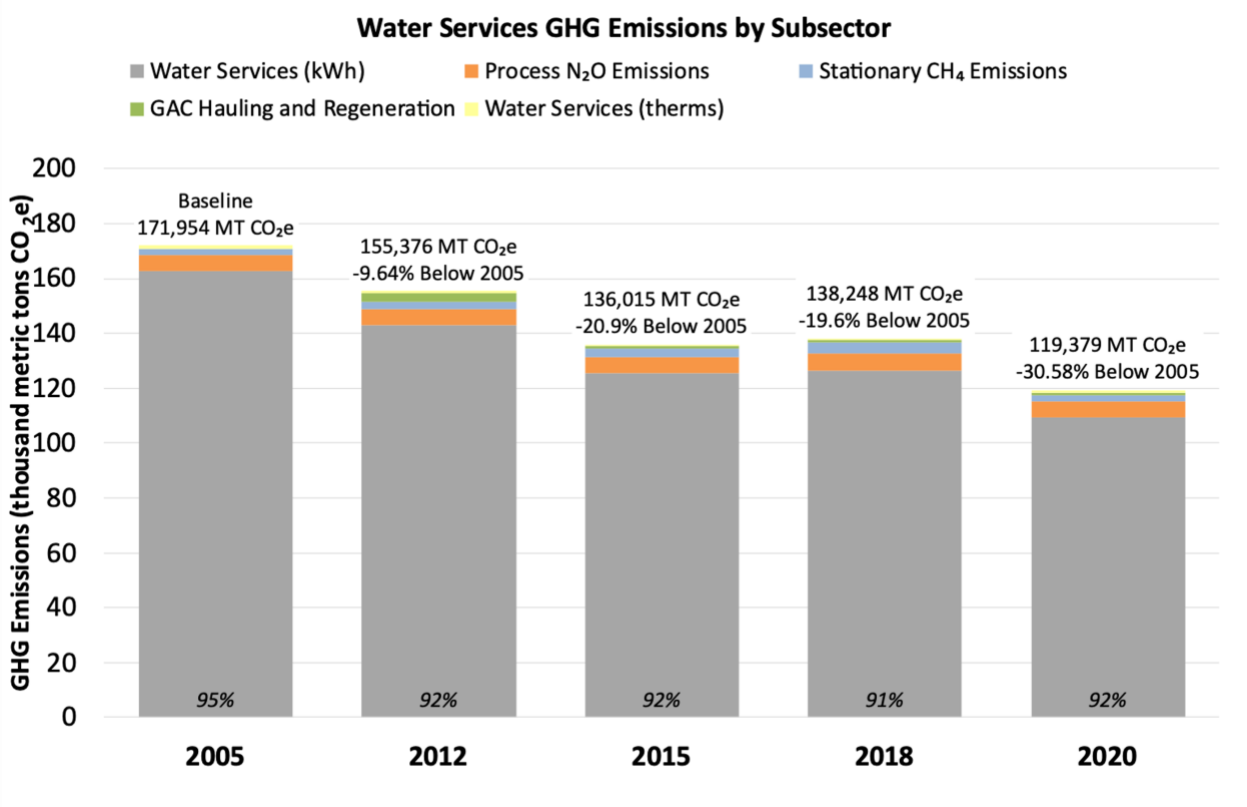


Figure 9. Water Services Emissions Changes Between 2005 and 2020

The changes in the GHG emissions observed at the 23rd Avenue and 91st Avenue WWTPs are due to a combination of population change as well as the changes in operation at the WWTPs, such as biogas capture. Wastewater treatment GHG are shown in Figure 10.

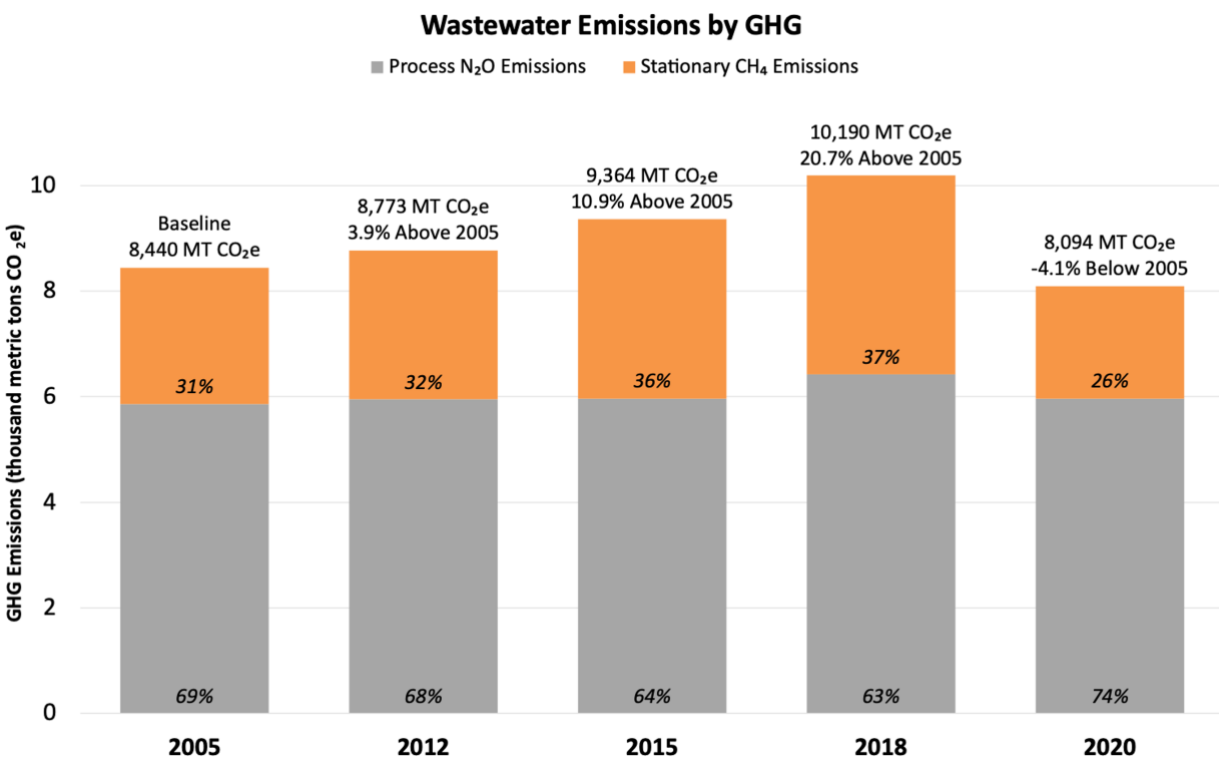


Figure 10. Wastewater Treatment GHG Emissions Between 2005 and 2020

GHG emissions at the 23rd Avenue and 91st Avenue WWTPS are shown in Table 6. During 2020, the 91st Avenue WWTP, which is the larger of the two WWTPs, emitted roughly the same amount of GHGs as the 23rd Avenue WWTP. The 91st Avenue WWTP accepts wastewater from Glendale, Mesa, Scottsdale, and Tempe. In previous inventory years, the 91st Avenue WWTP emitted more than double the 23rd Avenue WWTP. The reduction in GHG emissions at the 91s Avenue WWTP observed in 2020 occurred because of the reuse of captured methane emissions (biogas). Currently, the City accounts for all GHG emissions at the 91st Avenue WWTP because the plant is under the City's operational control.

Table 6. GHG emissions at the 23rd Avenue and 91st Avenue WWTPs

Wastewater GHG Emissions Source		Wastewater Treatment Plant		Total
		23rd Avenue	91st Avenue	
Stationary CH_4 Emissions	Incomplete Digester Gas Combustion	1,933	194	2,126
Process N_2O Emissions	Effluent Discharge	386	1,341	1,726
	Nitrification/Denitrification	1,083	3,159	4,242
Total		**3,322**	**3,402**	**4,693**

5.3.3 GHG Metrics: Water Services

Water Services indicators in Table 7 below shows that the GHG intensity of drinking water served by the City has consistently decreased since 2005.

Table 7. Water Services Emissions Indicators

Indicator	2005	2012	2015	2018	2020
Gallons of Drinking Water Treated (billion gallons)	105.9	98.9	95.4	99.2	102.6
MT CO_2e per Billion Gallons Treated	1,624	1,571	1,426	1,394	1,164
Water Treatment Plants	6	5	5	5	5
MT CO_2e per WTP	28,659	31,075	27,203	27,650	23,876
Million Gallons of Wastewater Treated	69.5	42.2	40.3	40.8	41.1
MT CO_2e per Million Gallons Wastewater Treated	2,473	3,682	3,375	3,388	2,905

5.4 Solid Waste

Solid Waste Findings

Total Emissions: 116,884 MT CO_2e
21.8% of government operations emissions
13% decrease from 2005 levels

Emissions Sources

- City landfills emitted 110,523 MT CO_2e
- The 27th Avenue Compost Facility emitted 6,360 MT CO_2e

City Action Highlights

- 27th Avenue Compost Facility will help avoid future GHG emissions

5.4.1 2005 to 2020: What has Changed?

- In 2006, the State Route 85 (SR-85) landfill was opened and features an ongoing installation of a landfill gas collection system, which includes horizontal wells that can capture gas while waste is still being placed in the landfill.
- In 2017, the City opened the 27th Avenue Compost Facility. This facility will reduce long-term GHG emissions associated with the hauling and disposal of green & organic solid waste at the SR-85 Landfill.

5.4.2 Emissions Sources and Distribution

The SR-85 landfill, which opened in 2006, is the only operational landfill managed by the City. The SR-85 landfill has an active landfill gas collection system which has a 65% collection efficiency. Collection efficiencies at City landfills ranged from 50-85%. The Del Rio Landfill is the only City landfill that does not have a landfill gas collection system. Methane emissions are expected to increase at the SR-85 landfill as it is the only active landfill in the City, while methane emissions from the other City landfills will decrease as they are now closed (Figure 11).

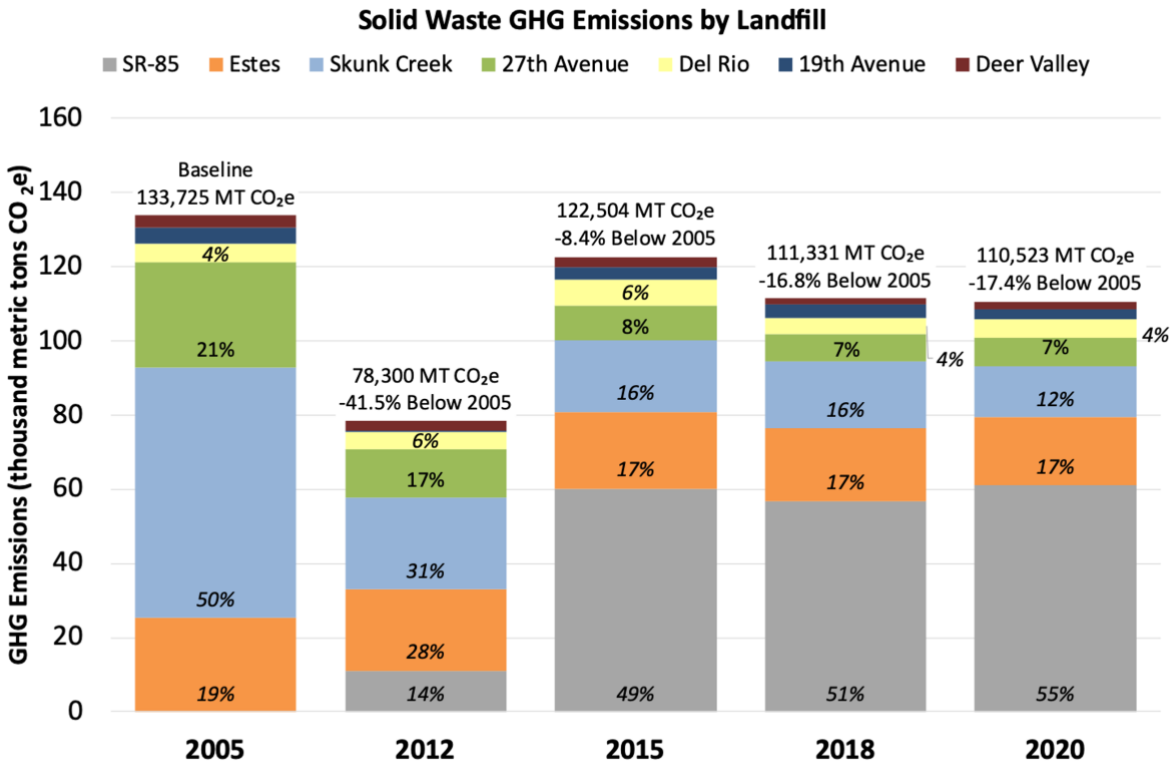


Figure 11. Phoenix Landfills Emissions Changes between 2005 and 2020

Table 8 provides an overview of the amount of methane (CH_4) collected and flared, the resulting methane released after flaring, and the MT CO_2e emissions produced from the released methane at each facility.

Table 8. 2020 Solid Waste Emissions by Landfill

Facility	2005	2012	2015	2018	2020
Skunk Creek	67,375	24,589	19,400	18,047	13,803
27th Avenue	28,476	13,013	9,257	7,403	7,643
Del Rio	4,902	4,760	6,986	4,367	4,859
Deer Valley	3,394	2,548	2,641	1,664	2,241
19th Avenue	4,377	429	3,468	3,598	2,676
Estes	25,200	21,896	20,636	19,432	18,284
SR-85	0	11,064	60,116	56,820	61,016
Total	**133,725**	**78,300**	**122,504**	**111,331**	**110,523**

Landfill GHG emissions in this report will differ from data reported to the EPA Greenhouse Gas Reporting Program. The City operations GHG emissions inventory utilizes landfill methane flaring formulas contained in the LGOP methodology, while EPA

utilizes a different methodology for both GHG emissions and estimated gas collection system capture rates. EPA specifies use of a capture rate formula which relies on cover type and area, this GHG update estimates capture rates at city landfills using operational indicators, such as status of ongoing gas well installation at SR-85, which includes horizontal wells, surface monitoring, flare data, and landfill cover maintenance.

5.4.3 27th Avenue Compost Facility

In 2017, the City opened the 27th Avenue Compost Facility. The facility processed 33,213 tons of compost in CY 2020, resulting in the emission of 133 MT CH_4 and 10 MT N_2O. Total GHG emissions from the compost facility were 6,360 MT CO_2e.

Over its lifetime, the 27th Avenue Compost Facility will have a net negative effect on GHG emissions from City government operations. Though the facility does emit GHG emissions, composting green organic solid waste will emit fewer GHG emissions than disposal at the SR-85 Landfill. Since methane is the primary GHG emitted from composting and landfilling, any GHG reduction will have a multiplier effect (Table A1). Additionally, composting at the 27th Avenue Compost Facility reduces the number of trips necessary to haul waste to the SR-85 Landfill, which in turn reduces Vehicle Fleet emissions. For these reasons, GHG emissions reductions from the 27th Avenue Compost Facility will be tangible and measurable in the future.

5.4.4 GHG Metrics: Solid Waste

Table 9 shows Solid Waste sector GHG indicators for the City.

Table 9. GHG Emissions Indicators for Solid Waste

Indicator	2005	2012	2015	2018	2020
Amount of Waste in Place (short tons)	44,030,052	50,257,923	52,405,666	54,666,679	56,335,520
Kg CO_2e Per Ton of Solid Waste in Landfills	3.04	1.56	2.34	2.19	2.07
Compost Processed (short tons)	—	—	—	46,768	33,213

5.5 Employee Commute

Employee Commute Findings

Total Emissions: 20,799 MT CO_2e
3.9% of government operations emissions
31.3% decrease from 2005 levels

Emissions Sources

- Gasoline
- Compressed Natural Gas (CNG)
- Electric and Hybrid Electric Vehicles
- Liquefied Petroleum Gas (LPG)
- Ethanol – E85

City Action Highlights

- Construction of light rail
- Employee Rideshare Program

5.5.1 2005 to 2020: What has Changed?

- City employees fill out surveys as part of the Trip Reduction Program (TRP) overseen by Maricopa County Air Quality Department.
- Employee commuting from 2005 did not include miles by bus or light rail as this data was not available. Bus and light rail commuting data were available for the previous GHG emissions inventories.
- Employee commuting using city vehicles is counted in the City Vehicle Fleet sector to avoid double counting.
- The ongoing SARS-CoV2 (COVID-19) pandemic facilitated the City's development and implementation of the City's Telework Program, which reduced the 2020 Employee Commuting GHG emissions.

5.5.2 Emissions Sources and Distribution

Employee commuting GHG emissions occur from the fuel use for personal vehicles, vanpools, bus transit, and light rail is used to account for commuting emissions (Table 10). Alternative fuel use was estimated using annual transportation fuel usage data EIA Annual Energy Outlook. Emissions from bus commuting are reported in the Public Transit sector. Instances of employees commuting in city vehicles are counted as City Vehicle Fleet emissions. The employee commuting data show that there was an increase in hybrid-electric and plug-in electric vehicle employee commuting miles.

Table 10. Employee Commute Emissions by Fuel Type/Mode

Year	Commuting Miles	GHG Emissions (MT CO_2e)
2005	84,325,745	30,272
2012	99,937,270	35,042
2015	88,496,426	31,350
2018	87,386,610	29,518
2020	60,556,831	20,799

5.5.3 City Action Highlights

The Phoenix Light Rail opened in 2008, providing city employees another opportunity to commute by public transit. The City also continued its employee rideshare program, providing carpool-parking subsidies, free bus/light rail passes for employees, emergency ride home cab vouchers, telecommuting, flex-work schedules, bicycle facilities and other incentives. However, given the structure of the current commuting data it is difficult to estimate GHG emissions from commuting alternatives. Nonetheless, the City can encourage employees to seek alternative modes of travel to commute to work. In addition, unnecessary travel should be avoided, when possible, potentially by increasing telecommuting opportunities.

6 City of Phoenix GHG Metrics

Table 11 details GHG Indicators for City of Phoenix government operations.

Table 11. Internal Government operations Indicators

Government Operations Indicators	2005	2012	2015	2018	2020	Unit
Population	1,377,980	1,473,405	1,537,058	1,660,272	1,680,992	People
Employees	14,667	12,849	14,664	14,615	14,261	Employees
Building Area	25,948,884	30,624,893	12,599,324	11,495,864	15,047,761	Sq. ft.
Cooling Degree Day (CDD)	4,709	5,065	5,065	4,943	5,618	CDD
Building Area GHG Intensity	7.35	6.22	12.89	12.62	7.57	kg CO_2e per sq. ft
Per Capita GHG Intensity	138.4	129.3	105.7	87.4	67.8	kg CO_2e per resident
CDD Electricity GHG Intensity	39.1	36.3	30.9	28.3	19.3	kg CO_2e per CDD
FTE GHG Intensity	13.00	12.64	11.08	9.92	9.92	kg CO_2e per FTE
Drinking Water Treated	105.9	98.9	95.4	99.2	102.6	billion gallons
Drinking Water GHG Intensity	1,624	1,571	1,426	1,394	1,164	MT CO_2e per billion gallons
Water Treatment Plants (WTP)	6	5	5	5	5	number
WTP GHG Intensity	28,659	31,075	27,203	27,650	23,876	MT CO_2e per WTP
Wastewater Treated	69.5	42.2	40.3	40.8	41.1	million gallons
Wastewater GHG Intensity	2,473	3,682	3,375	3,388	2,905	MT CO_2e per million gallons
Solid Waste in Place (WIP)	44,030,052	50,257,923	52,405,666	54,666,679	56,335,520	tons
Solid Waste GHG Intensity	3.04	1.56	2.34	2.19	2.07	kg CO_2e per Ton WIP
Fleet Size	6,090	7,387	7,389	7,340	7,548	Number of Vehicles
Fleet Vehicle GHG Intensity	9.2	7.1	6.6	6.7	6.3	MT CO_2e per Fleet Vehicle
Vehicle Miles Traveled (VMT)	52,825,683	48,022,781	—	35,990,125	29,238,298	VMT
VMT GHG Intensity	1.06	1.09	—	1.36	1.62	kg CO_2e per VMT
Gasoline Consumption	3,172,441	3,976,124	3,813,990	3,936,224	4,064,327	gallons
Diesel Consumption	5,452,613	3,324,829	1,777,341	2,579,301	2,282,301	gallons
Diesel + B20 Consumption	5,452,613	6,359,174	5,172,051	5,607,270	6,591,659	gallons
CNG Consumption	1,744,813	1,349,993	3,239,129	6,151,022	7,555,353	GGE
Commuting Gasoline Miles Traveled	80,555,678	93,917,068	83,504,307	82,130,508	57,275,929	miles
Commuting Gasoline Miles Per Employee	5,576	7,167	5,711	5,772	4,045	mile per FTE
% Single Occupancy Vehicle	73.8%	74.1%	75.8%	72.1%	67.88%	%
Alternative Fuel Vehicle Miles	891,044	1,140,705	1,402,897	3,354,038	3,013,192	mile

Appendix A: Greenhouse Gas Equivalents

Table A1. IPCC AR2, AR4, and AR5 Global Warming Potential (GWP) Values

Greenhouse Gas*	AR2 GWP Values[1]	AR4 GWP Values[2]	AR5 GWP Values[3]
Carbon Dioxide (CO_2)	1	1	1
Methane (CH_4)	21	25	28
Nitrous Oxide (N_2O)	310	298	265

*Only carbon dioxide, methane and nitrous oxide were included in the 2005 and 2015 inventories

[1]GWP values used in the previous City of Phoenix 2005 and 2012 local government operations GHG emissions inventories.

[2]GWP values used in the City of Phoenix 2015 local government operations GHG emissions inventories.

[3]GWP values used in *2018 and 2020 City of Phoenix GHG Emissions from Government Operations*.

Appendix B: City of Phoenix's Government Operations Boundary

Wastewater Facilities

For the 2012 government operations GHG emissions inventory, the City considered whether the 91st Avenue wastewater treatment plant (WWTP) emissions and if they should be part of the inventory. This plant accepts wastewater from several other cities and is operated under a formal Joint Powers Authority (JPA) agreement. Although the LGOP accounting system recommends that JPA's be excluded from the inventory, the full emissions from this facility have been included, as the City operates the facility and is listed as the responsible party on the facility's air and water permits. Inclusion of the plant's full emissions has continued in the current GHG emissions inventory of government operations.

Solid Waste Facilities

The 2020 inventory includes estimated emissions from the 27th Avenue Compost Facility. As this facility was opened in 2017, the 2018 inventory is the first inventory where city-owned compost operations are included.

Biogenic CO_2 Emissions

Biogenic CO_2 emissions are emissions from non-fossil carbon sources—such as biodiesel and ethanol in blended biofuels—and the conversion of methane to carbon dioxide resulting from methane flaring. According to LGOP, biogenic CO_2 emissions do not add carbon into the atmosphere as these sources of CO_2 are part of the natural carbon cycle and do not count toward local government operations GHG emissions total. The City can shift fossil CO_2 emissions to biogenic CO_2 emissions through the continued conversion of diesel fleet vehicles to biodiesel blends in addition to the development of biomass-based sources of electricity.

Leased Facilities

The City also reviewed options for including the facilities that are owned by Phoenix but leased to other entities. Consistent with the operational control in the protocol, the inventory would generally not include energy used at city-owned leased facilities. However, a unique circumstance occurs at Phoenix Sky Harbor International Airport. The airport could have excluded facilities that are leased to tenants (airlines, restaurants, gift shops, etc. which account for 1/3 of the terminal areas and 1/3 of common use areas) on a proportional basis because the costs of the energy used at those airport facilities are allocated to tenants based on the size of revenue-generating

area. The City chose to include emissions from the entirety of the airport-owned facilities as the airport runs the building energy systems and pays the energy bills.

Scope 3 Emissions

The City has chosen to report Employee Commute and GAC hauling and regeneration emissions because it does not maintain direct operational control and therefore is not required to report these emissions. However, because Phoenix has influence over its employees commuting habits through various rideshare incentives and telecommuting, it chose to include these emissions in the inventory as Scope 3 emissions (Scope classifications are explained below). It also chose to report emissions from outsourced GAC hauling and regeneration as Scope 3 emissions in the Water Services sector because the city holds financial control and considers it an area over which it has influence. Both sludge and solid waste hauling were included as Scope 1 emissions as those contracts are considered more integral to government operations and control.

Appendix C: Solar Projects & Partnerships

Table C1. Completed Solar Projects and Partnerships

Solar Projects/Partnerships			
Description	**Completed**	**kW**	**Projected kWh/year**
Aviation HQ	2020	580	917,126
SRP Solar Sleeve	2020	10,700	18,350,500

Appendix D: Findings by Scope

Appendix C presents City government operations GHG emissions by GHG emissions scope (Scope). GHG emissions by Scope are shown in Figures D1 and D2.

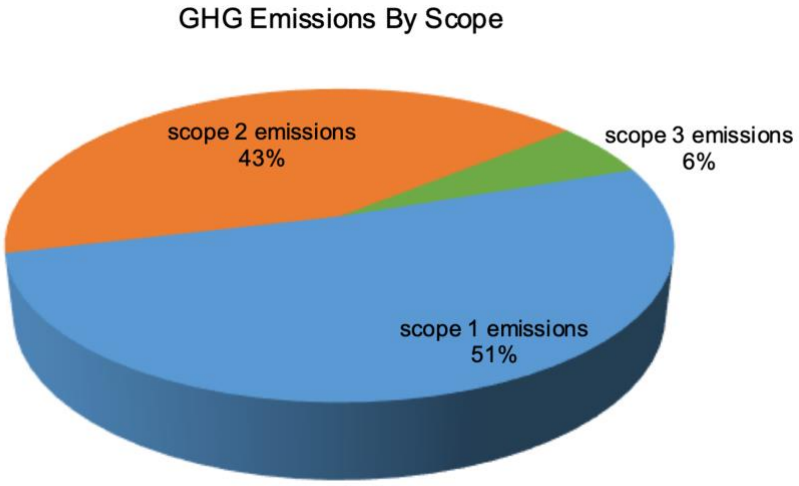


Figure D1. GHG Emissions by Scope

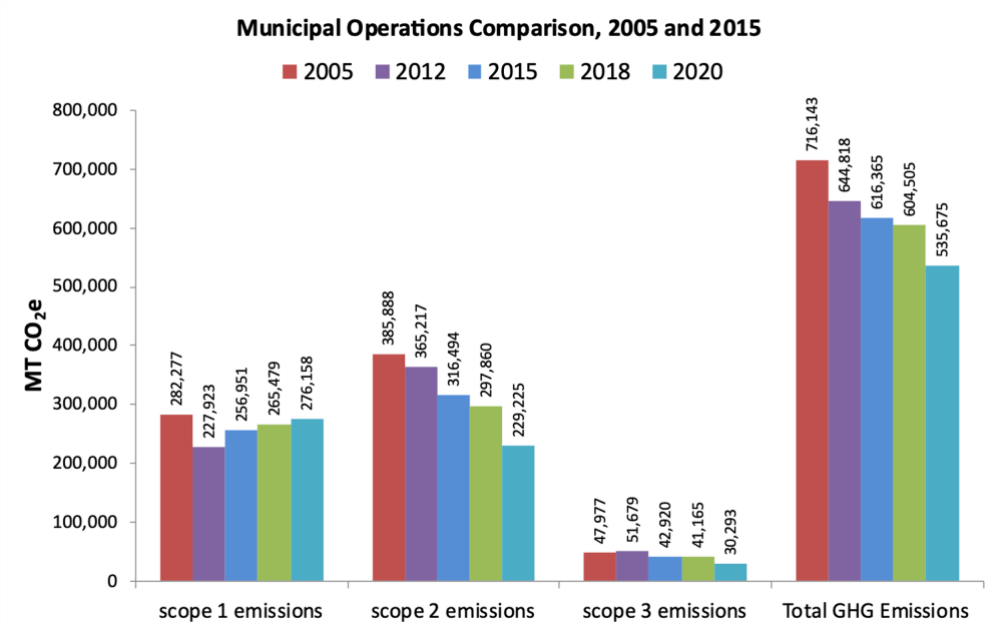


Figure D2. Government operations comparison, 2005 through 2020

Scope 1

Scope 1 emissions contribute 51% of the city's total emissions accounting for 276,158 MT CO_2e. From 2005 to 2020, Scope 1 emissions decreased 2.2%. Scope 1 is comprised of stationary combustion, fleet fuels, and fugitive and process emissions from landfills and wastewater treatment plants (Figure D3). The combustion of natural gas in buildings, and the resulting emissions, decreased 12.9% between 2005 and 2020, while natural gas combustion for water distribution treatment decreased 25%. The City's fugitive and process GHG emissions decreased 12.1% between 2005 and 2020. Fugitive methane emissions from landfills were reduced by 17%. Fugitive and process emissions from wastewater treatment decreased by 4.1% because of the capture and reuse of flared methane at the 91st Avenue WWTP. The 27th Avenue Compost Facility was a new source of fugitive and process emissions in 2018.

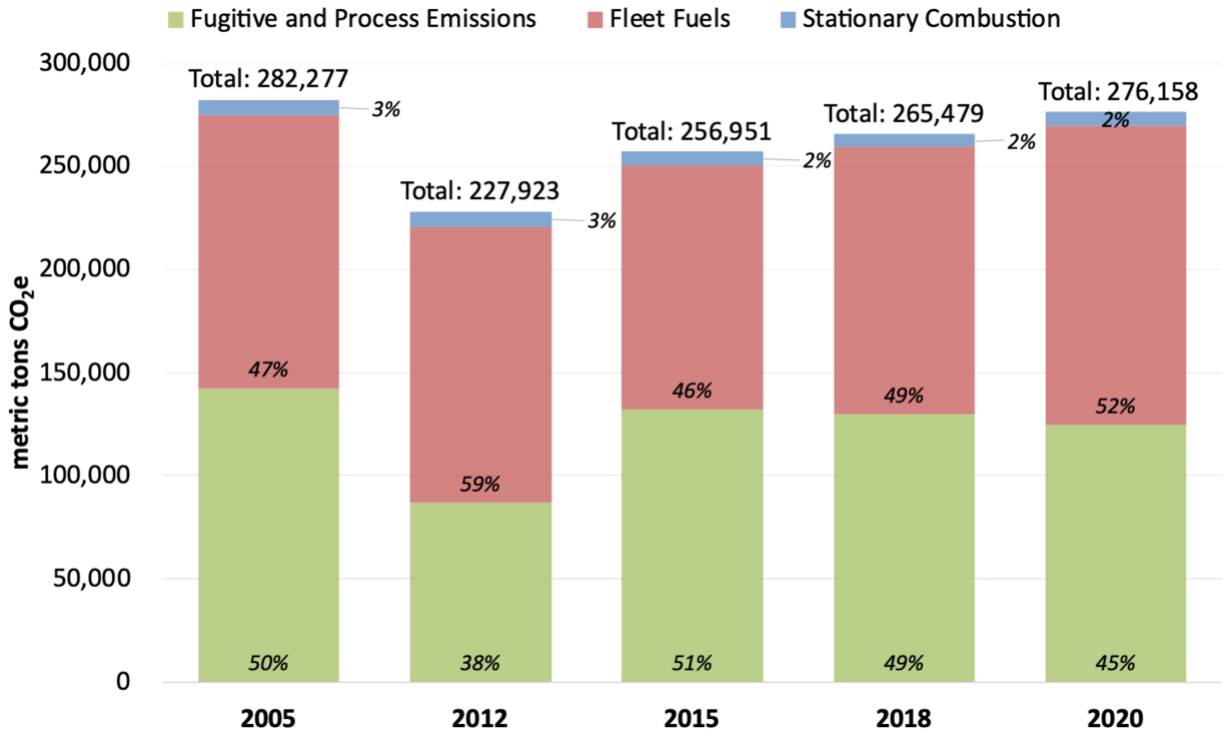


Figure D3. Breakdown of 2020 Scope 1 Emissions

The City's fuel portfolio has changed dramatically between 2005 and 2020 with the addition of B20 vehicles, CNG, and E85 flex fuel vehicles; B20 vehicles are primarily used in Public Transit. However, an increase in service miles has caused an increase in Fleet Fules (Public Transity) emissions between 2015 and 2020.

Scope 2

Scope 2 GHG emissions are indirect GHG emissions from the off-site generation of electricity used in municipal buildings, street lighting, traffic signals and wastewater treatment. Scope 2 emissions from electricity generation are calculated from billed electricity. On-site generation of electricity from solar energy projects are not incorporated into the GHG inventory total and buildings may consume more electricity (both solar and grid-based generated) than what is billed (grid-based only).

Scope 2 emissions account for 43% of the City's total emissions and totaled 229,225 MT CO_2e in 2020. Between 2005 to 2020, Scope 2 GHG emissions decreased 40.6% (Figure D4) while purchased electricity decreased only 8%. Between 2005 and 2020, the carbon intensity of purchased electricity in Arizona decreased 35.4% due to increased natural gas generation and decreased coal generation in the region electricity grid in combination with increased renewable energy genration.

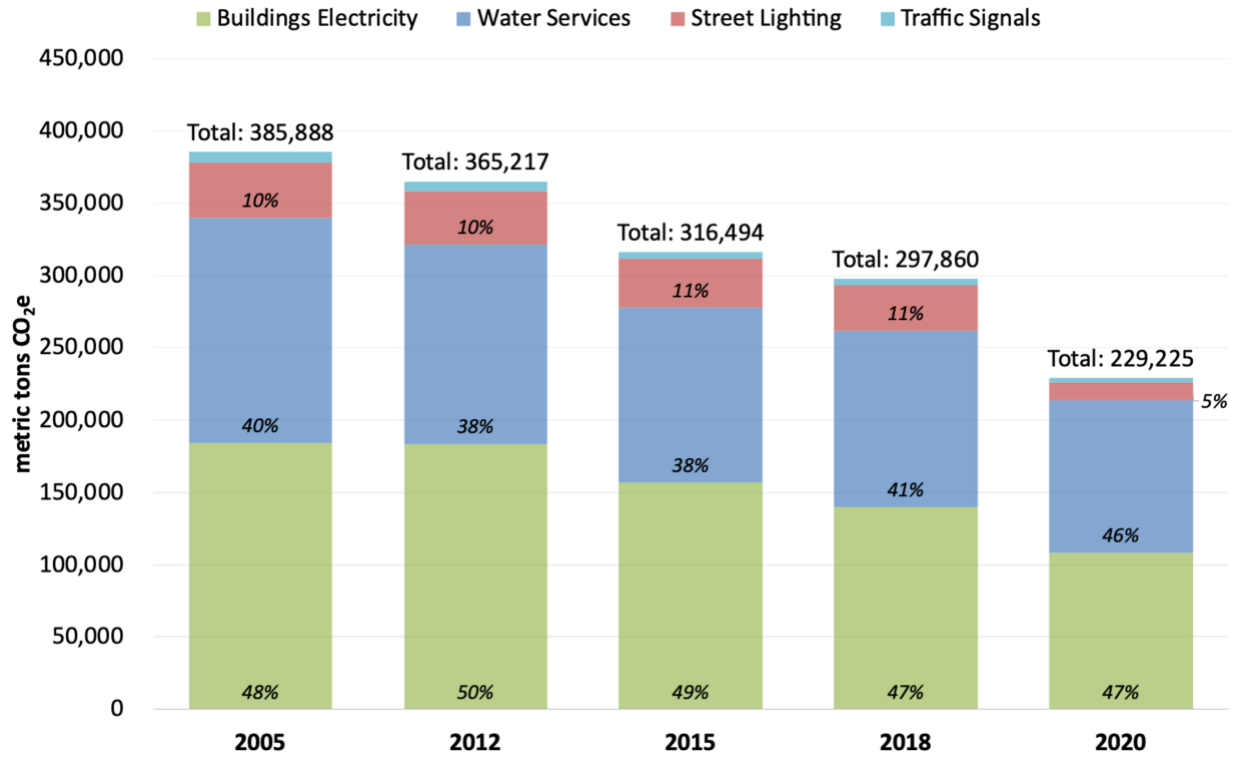


Figure D4. Breakdown of 2020 Scope 2 Emissions

Scope 3

Scope 3 is comprised of fuel emissions from employee commute, GAC Hauling and Regeneration, and the total T&D loss in the electricity grid associated with electricity purchased by the city. Although the city does not operationally control Scope 3 emissions, the LGOP encourages the reporting of activities relevant to a city's GHG programs and goals. The City chose to report emissions from these sectors because it has some ability to impact those activities through various policies, programs, and contracts.

Scope 3 emissions account for 6% of the City's total emissions with a total of 42,301 MT CO_2e. From 2005 to 2020, emissions from Scope 3 decreased 37%. GHG emissions from employee commuting are the largest component (69%) of Scope 3 emissions (Figure D5).

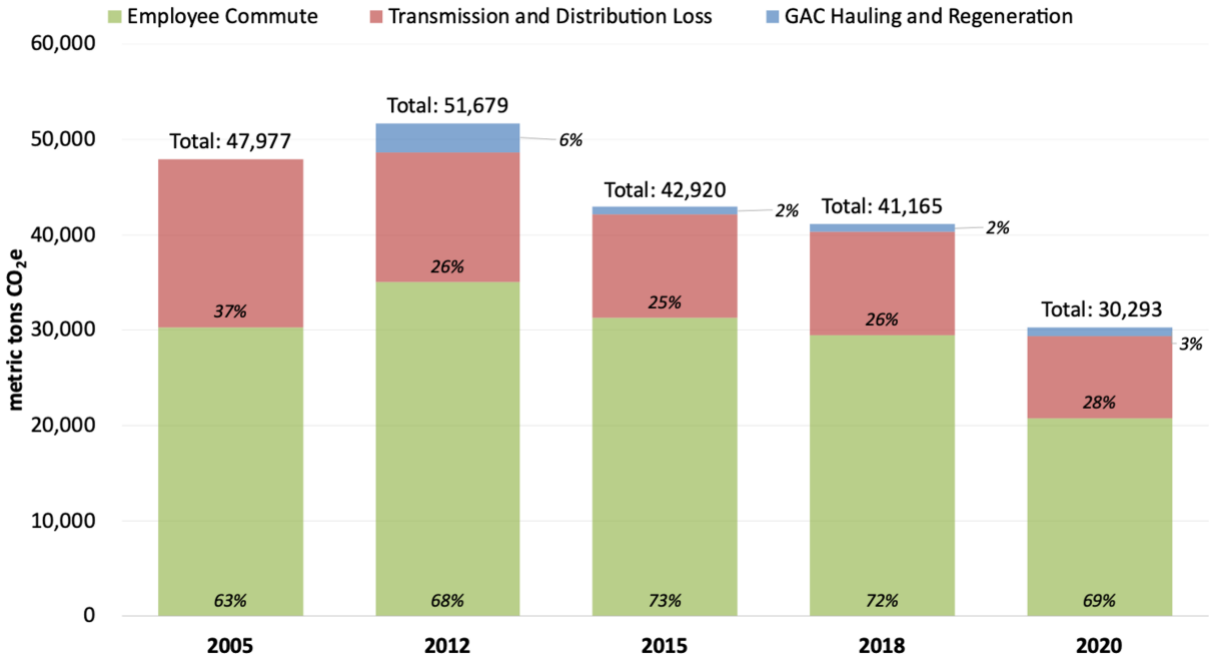


Figure D5. Breakdown of 2020 Scope 3 Emissions