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Arizona State University

2018 Local Government Operations Greenhouse Gas Emissions Inventory

A comprehensive report prepared for

City of Phoenix

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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
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 2018 Greenhouse Gas Emissions Inventory for Government Operations* is the fourth 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 2018 Greenhouse Gas Emissions Inventory for Government Operations* is the first inventory update since setting the 2025 GHG emissions reduction goal, and provides updated information for tracking progress toward the 2025 goal.

The major findings of the *City of Phoenix 2018 Greenhouse Gas Emissions Inventory for Government Operations* are listed below.

- 2018 government operations GHG emissions were 10,714 MT CO_2e (1.7%) below 2015 and 110,442 MT CO_2e (15.4%) below 2005 levels.
- GHG emissions for 2015 were revised upwards to reflect updated data from EPA on the GHG emissions intensity of the regional electricity grid. Emissions from electrical use are determined by multiplying the amount of electricity consumed by an emissions factor given in carbon dioxide emissions per megawatt-hour generated. This is determined by the EPA and is named the Emissions and Generation Resource Integrated Database (eGRID) emissions factor. It takes

into account the environmental emissions characteristics of power plants (coal, natural gas, nuclear, solar, etc.) and groups the plants by region. In 2014, EPA changed the power plant grouping methodology and three coal power plants (Navajo, Four Corners and San Juan) were moved from the Arizona New Mexico (AZNM) region to Northwest Western Power (NWPP). This resulted in an eGRID emissions factor of 879 lb. CO_2e per MWh. This value was quite low, but did not accurately reflect the sources of electricity being used by the region. In 2016, EPA placed these plants back in the AZNM region. The 2016 eGRID emissions factor was 1,049 lb. CO_2e per MWh. This updated value was then used to recalculate emissions from the 2015 GHG inventory to better reflect the emissions intensity of the regional power grid. Between 2005 and 2015, the City's GHG emissions fell by 13.9%.

- Between 2015 and 2018, the GHG intensity of the regional electricity grid fell by 2.1%. Accordingly, GHG emissions from purchased electricity fell by 18,620 MT CO_2e.
    - Buildings and Facilities GHG emissions from purchased electricity fell 16,925 MT CO_2e between 2015 and 2018.
    - GHG emissions Traffic Signals and Streetlights have decreased 10,090 MT CO_2e (22%) since 2005 and 2,556 MT CO_2e (6.6%) since 2015, with some additional reduction from retrofitting traffic signals and streetlights with LED bulbs.
    - Water Services GHG emissions from purchased electricity increased 849 MT CO_2e (0.7%) since 2015 due to a 2.8% increase in electricity consumption from 254,622,318 kWh to 261,788,472 kWh.
- GHG emissions from the City's vehicle fleet has increased 11,042 MT CO_2e since 2015 due to the addition of 2.4 million service miles by Public Transit to meet T2050 goals.
    - Specifically, Public Transit diesel fuel consumption increased by 756,631 gallons (46%) over 2015 levels to 2,392,579 gallons in 2018.
- GHG emissions from landfills fell 11,121 MT CO_2e as the City's closed landfills continue to emit less methane.
- While the 27th Avenue Compost Facility is a new source of GHG emissions, emitting 8,125 MT CO_2e in 2018, the facility will save more GHG emissions over its lifetime by reducing 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:

- Construction of the 27th Avenue Compost Facility.
- LED conversion of Traffic Lights and Streetlights that was completed in 2019.
- Continued expansion of the Valley Metro light rail system.
- Construction of PHX SkyTrain.
- The City generated 22,346,675 kWh of solar energy in 2018.

GHG emissions reductions have been achieved while population has grown by 282,292 over the same period (Figure ES-1). Accordingly, the per capita GHG intensity of the City's government operations have fallen from 0.49 to 0.36 MT CO_2e per resident between 2005 and 2018.

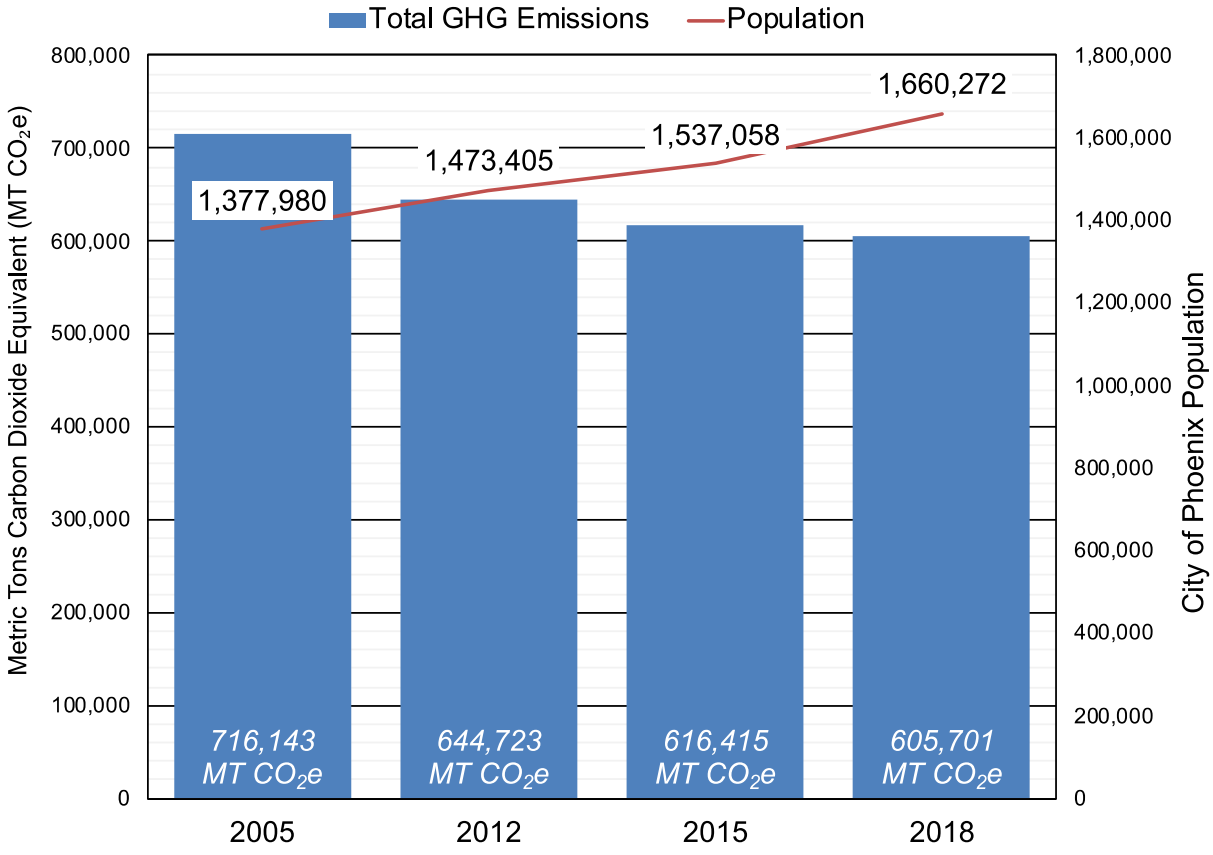

Figure ES-1. City of Phoenix Government Operations GHG Emissions and Population Between 2005 and 2018.

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 baseline GHG emissions 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. However, this report revises 2015 GHG emissions total upward to reflect updated EPA data on the GHG emissions intensity of the regional electricity grid. This updated value was then used to recalculate emissions from the 2015 GHG inventory to better reflect the emissions resulting from utilizing the regional power grid. Using updated data, 2015 GHG emissions from City government operations fell by 13.9%.

The *City of Phoenix 2018 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 2018 GHG emissions inventory of government operations.
- Section 3 describes the GHG emissions inventory boundary along with methodological background and updates for the 2018 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 2018, GHG emissions from City government operations were 605,701 MT CO_2e, which is 15.4% below 2005 levels and 1.7% below 2015 levels (Figure 1).

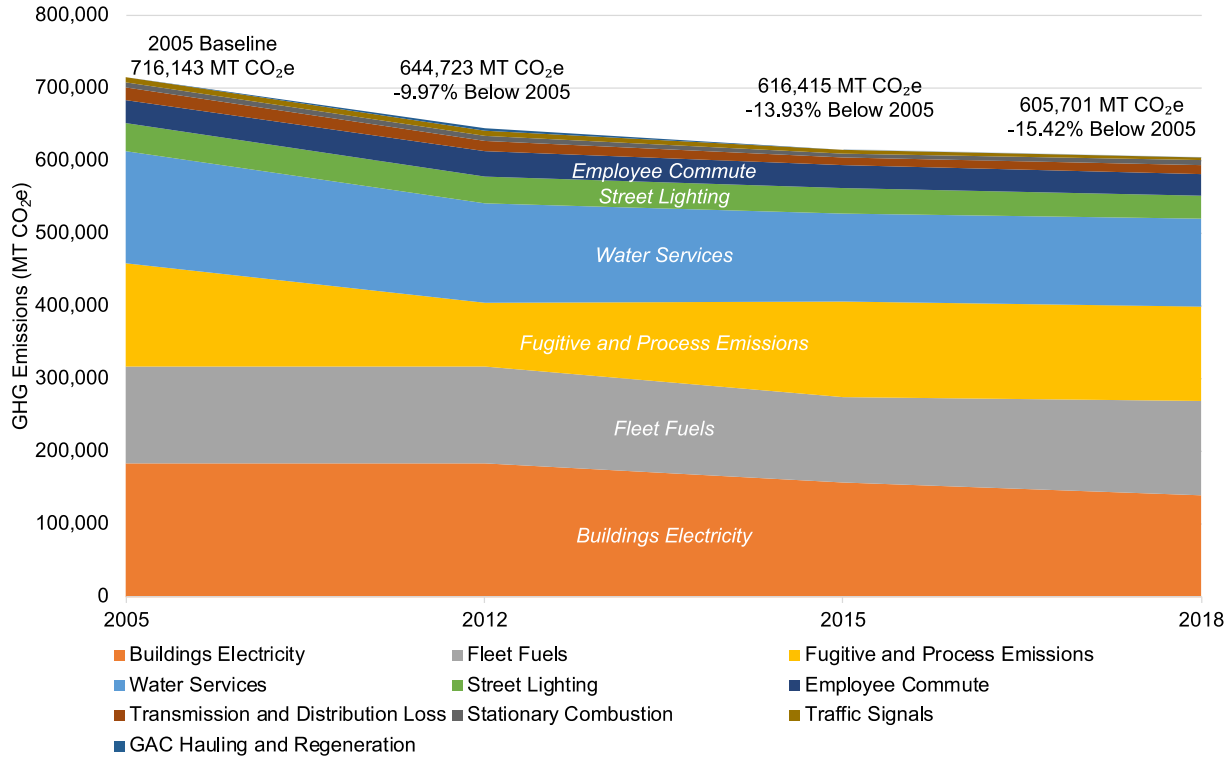

Figure 1. City of Phoenix GHG Emissions from 2005 to 2018.

Additionally, all previous GHG emissions totals were revised in order to utilize the latest IPCC GWP (AR5) for CH_4 and N_2O. Additionally, the 2015 GHG emissions total was further revised to utilize the eGRID 2016 emissions factor for electricity consumption rather than the eGRID 2014 emissions factor. Revised GHG emissions totals from City government operations are:

2005: 716,143 MT CO_2e revised upwards from 696,490 MT CO_2e;
2012: 644,723 MT CO_2e revised upwards from 629,054 MT CO_2e; and
2015: 616,415 MT CO_2e revised upwards from 588,525 MT CO_2e.

The City reduced GHG emissions through a combination of internal and external measures. Internal measures include increased waste diversion rates, city-led solar power projects, energy efficiency upgrades, the incorporation of alternative fuels into the vehicle fleet fuel portfolio, and upgrades to landfill gas capture systems.

External measures include a decrease in the EPA's Emissions & Generation Resource Integrated Database (eGRID) regional factor[1]. The carbon intensity of the AZNM subregion fell by approximately 22%, translating into an emissions factor reduction from 1,316 lb. CO_2e/MWh in the eGRID 2005 to 1,027 lb. CO_2e/MWh in the eGRID 2018 data. eGRID 2018 is the latest publication year for eGRID data, so this emissions factor is used for the 2018 calendar year. The 2015 GHG emissions were updated to use the eGRID 2016 emissions factor instead of the 2014 eGRID emission factor. The eGRID emissions factor for the AZNM subregion was anomalously low at 879 lb. CO_2e/MWh in the eGRID 2014 dataset due to EPA methodology changes. GHG-intensity of the AZNM subregion was 1,049 lb. CO_2e/MWh in the eGRID 2016 dataset. In 2014, these changes resulted in the removal of 3 coal power plants (Navajo, Four Corners and San Juan) from the Arizona New Mexico (AZNM) region to Northwest Western Power (NWPP). For each GHG inventory, the decrease in the GHG intensity of the electricity grid has been a significant contributor of emissions reductions by the City.

Between 2015 and 2018, GHG emissions from City government operations decreased in almost every subsector except Fleet Fuels and Water Services, which increased 11,042 MT CO_2e (9.3%) as shown in Table 1. Between 2015 and 2018, the increase in Fleet Fuels GHG emissions were driven by increased CNG consumption (2,911,892 GGE) and diesel fuel consumption (801,961 gallons), which resulted in 18,413 MT CO_2e and 8,915 MT CO_2e additional GHG emissions, respectively. However, over the same period, LNG consumption fell 2,985,337 gallons and B20 biodiesel consumption fell 366,741 gallons, reducing Fleet Fuel GHG emissions 13,434 MT CO_2e. and 3,000 MT CO_2e, respectively. In the Water Services sector, GHG emissions from electricity usage and natural gas combustion only increased by 1,013 MT CO_2e (0.8%) between 2015 and 2018 despite population growing by 4.8% over that same time period.

Other reductions in the City's government operations GHG emissions are due to a decrease in fugitive and process emissions – emissions from landfills, wastewater treatment, and compost operations. Increases in City solar power generation has helped to decrease emissions at city buildings and facilities. The switch to LED traffic signals and streetlights has also reduced the GHG emissions from purchased utilities.

[1] The eGRID database inventories the environmental attributes of electric power generation and its effect on air emissions for every power plant in the United States. Phoenix is in the Arizona and New Mexico (AZNM) subregion. 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.

Table 1 shows GHG emissions for City government operations subsectors for 2005-2018 in comparison to population growth. All subsectors have seen a decrease in emissions since 2005, but have leveled off since 2015. Further policy actions must be taken to decrease emissions.

Table 1. GHG Emissions by Scope and Sector Between 2005 and 2018

Scope 1	2005	2012	2015	2018	2005-2018 Change	2005-2018 % Change
Stationary Combustion	7,404	7,329	6,377	6,085	-1,318	-17.8%
Fleet Fuels	132,709	133,425	118,706	129,748	-2,960	-2.2%
Fugitive and Process Emissions	142,165	87,073	131,932	129,707	-12,458	-8.8%
Scope 1 Total Emissions	**282,277**	**227,827**	**257,015**	**265,540**	**-16,080**	**-5.9%**

Scope 2	2005	2012	2015	2018	2005-2018 Change	2005-2018 % Change
Buildings Electricity	184,285	183,851	156,639	139,714	-44,571	-24.2%
Street Lighting	38,502	36,416	33,933	32,069	-6,433	-16.7%
Traffic Signals	7,733	7,157	4,755	4,075	-3,657	-47.3%
Water Services	155,368	137,793	121,153	122,002	-33,366	-21.5%
Scope 2 Total Emissions	**385,888**	**365,217**	**316,481**	**297,860**	**-88,028**	**-22.8%**

Scope 3	2005	2012	2015	2018	2005-2018 Change	2005-2018 % Change
Employee Commute	30,272	35,042	31,350	29,518	-754	-2.5%
Transmission and Distribution Loss	17,705	13,640	10,810	11,901	-5,804	-32.8
Granular Activated Carbon Hauling and Regeneration	0	2,996	760	881	881	—
Scope 3 Total Emissions	**47,977**	**51,679**	**42,919**	**42,301**	**-5,677**	**11.8%**

GHG Inventory	2005	2012	2015	2018	2005-2018 % Change	2005-2018 % Change
Total Scope 1 and 2 Emissions	668,165	593,044	573,496	563,400	-104,765	-15.7%
Total Scope 1, 2, & 3 Emissions	**716,143**	**644,723**	**616,415**	**605,701**	**-110,442**	**-15.4%**
City of Phoenix Population	**1,377,980**	**1,473,405**	**1,537,058**	**1,660,272**	**282,292**	**20.5%**

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 2005, 2012, 2015, and 2018 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: All direct emissions from operational sources owned or controlled by the City.
- 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.

[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

- 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 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

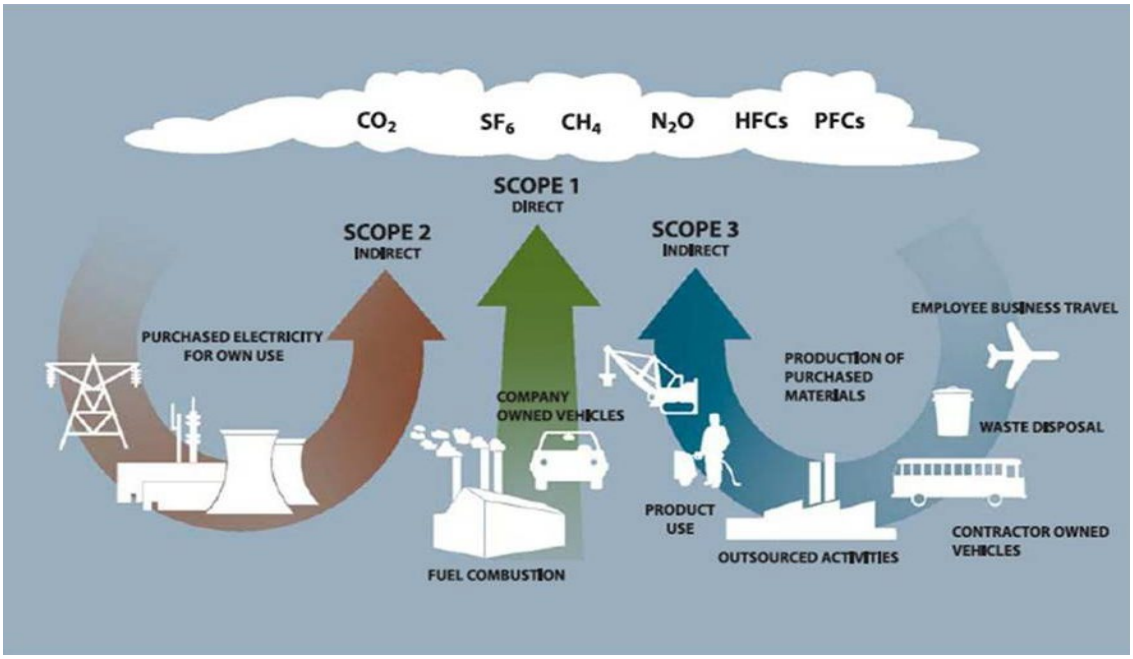

Figure 2. Overview of LGOP Scopes and Emissions Sources.[3]

[3] 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.

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].

This inventory uses the *operational control* approach as it most accurately represents GHG emissions sources within the City's control. The boundaries of the 2018 inventory generally 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 is the only new GHG emissions source 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 2018 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; and the 2018 GHG emissions inventory utilizes IPCC AR5 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:

[4] ICLEI USA, 2020. Greenhouse Gas Protocols. URL: https://icleiusa.org/ghg-protocols/
[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.

- Estes Landfill was added to all inventory years;
- Employee commuting emissions at sites with less than 50 employees added to the 2005 inventory year;
- In 2005, wastewater treatment emissions were estimated using population-based data. In 2012, 2015, 2018 site-specific data were used where applicable;
- Inventory-year specific T&D loss rates are used;
- Biogenic emissions are calculated for all inventory years;
- The 2018 inventory year utilizes eGRID 2018, which is the most up-to-date eGRID data available;
- In 2005, the City did not have any solar power, while 2018 has electricity production data from solar installations; and
- The 2018 GHG emissions inventory includes emissions from the 27th Avenue Compost Facility.

Finally, GHG emissions for 2015 were revised upwards to reflect updated data from EPA on the GHG emissions intensity of the regional electricity grid. GHG emissions from electricity consumption are calculated by multiplying the amount of electricity consumed by an emissions factor given in CO_2e emissions per MWh generated. EPA determines the emissions factor in eGRID, takes into account the environmental emissions characteristics of power plants (coal, natural gas, nuclear, solar, etc.), and groups power plants to estimate the GHG intensity of electricity production for U.S. regions. In 2014, EPA changed the power plant grouping methodology and moved three coal power plants (Navajo, Four Corners, and San Juan) from the Arizona New Mexico (AZNM) subregion, which the City is in, to the Northwest Western Power (NWPP) subregion. The methodology change resulted in an AZNM emissions factor of 879 lb. CO_2e per MWh, which was quite low, and did not accurately reflect regional electricity generation. In 2016, EPA placed the three coal power plants back in the AZNM subregion. The 2016 AZNM eGRID emissions factor was 1,049 lb. CO_2e per MWh. The 2016 AZNM eGRID value was used to recalculate electricity emissions for the 2015 GHG inventory to represent the GHG emissions intensity of the regional power grid more accurately. Between 2005 and 2015, the City's GHG emissions fell by 13.9%.

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 2018 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 2005, 2012, 2015, and 2018 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: 1990-2017*[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

4 Results

4.1 Summary

2018 Overall Findings

City of Phoenix government operations decreased GHG emissions 15.4% below 2005 levels.

Emissions Sources*

- Buildings and Facilities** — 188,205 MT CO_2e
- City Vehicle Fleet — 129,748 MT CO_2e
- Employee Commute — 29,518 MT CO_2e
- Solid Waste — 119,508 MT CO_2e
- Water Distribution and Wastewater Treatment — 138,721 MT CO_2e

*Above GHG emissions represent all emissions within a sector across all emissions scopes.
** Excludes Water Services.

4.1.1 2005 to 2018: What has Changed?

With the 2018 GHG emissions inventory of government operations, the City is developing a dataset of how GHG emissions from government operations have evolved since 2005 (Figure 3). Numerous projects and activities undertaken by the City since 2005 have affected the GHG emissions from government operations over the last thirteen years. Projects and activities, and how they have affected the 2018 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 biodiesel and CNG from diesel have reduced public transit GHG emissions since 2005. Fuel consumption increased between 2015 and 2018 in order to meet T2050 goals.
- Energy efficiency upgrades to buildings and facilities, streetlights, traffic signals, water treatment and distribution, and wastewater treatment.

- Solar power facilities, such as the Lake Pleasant solar installation, reduce the amount of electricity the City purchases from the electricity grid.
- The construction of the Sky Train at the Phoenix Sky Harbor International Airport has reduced fossil fuel usage for ground transportation, but further study is required to accurately estimate the GHG emissions reduction from the Sky Train.
- Implementing diversion policies, such as the utilization of the 27th Avenue Compost Facility to divert material from the landfill and produce an environmentally beneficial, salable 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 by 22% from 1,316 lb. CO_2e/MWH in 2005 to 1,027 lb. CO_2e/MWH in 2018. The closing of the Navajo Generation Station in 2019, as well as other regional coal power plant closures planned for the next five years, will further reduce the GHG intensity of AZNM subregion of the electricity grid.

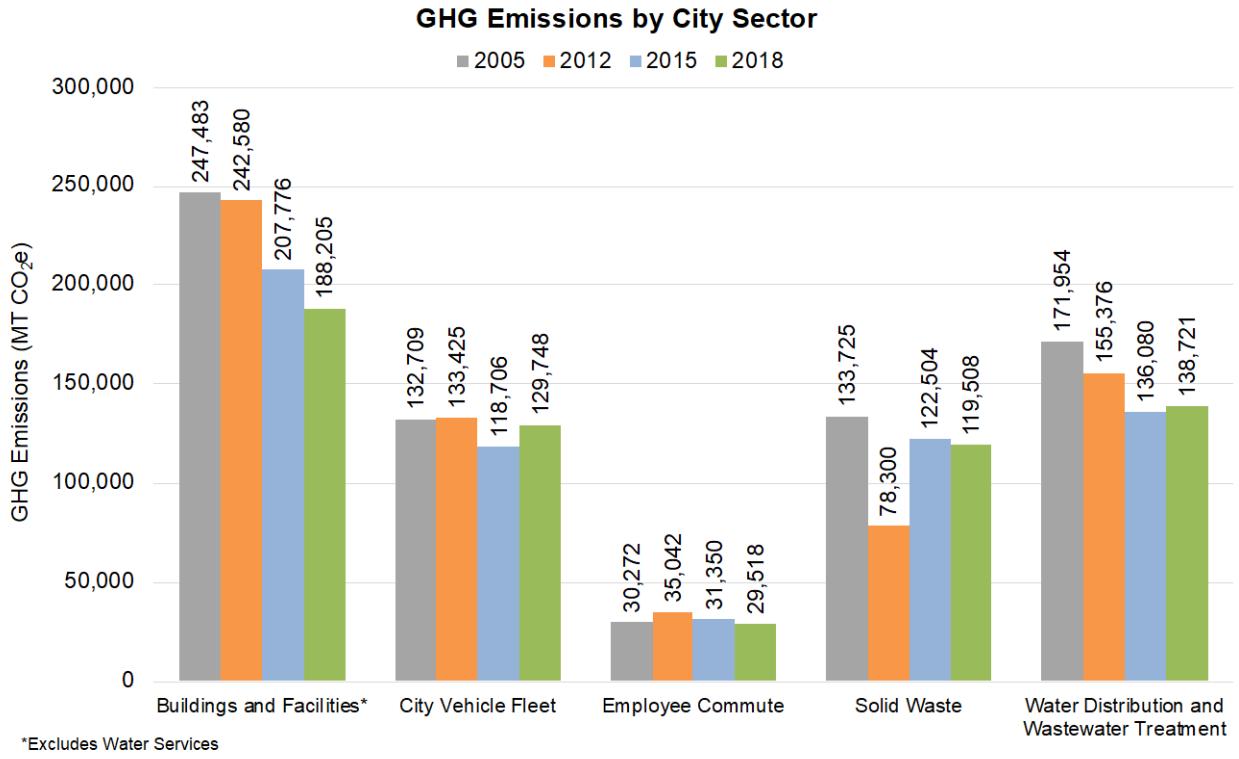

Figure 3. GHG Emissions by City Sector for 2005, 2012, 2015, and 2018

Between 2005 and 2018, the City's population increased by 20.5% from 1,377,980[9] to 1,660,272[10] residents. Some government operation GHG emissions are population dependent – e.g., aspects of solid waste disposal, wastewater treatment and discharge, and vehicle fleet emissions – the majority of the City's GHG emissions are electricity-dependent. The regional electricity grid becoming less carbon-intensive has had a stronger influence on the City government operations GHG emissions than population growth. If the reduction in the GHG intensity of the regional electricity grid had not occurred, GHG emissions from City government operations would have decreased only by 3.3% between 2005-2018 – instead GHG emissions decreased 15.6%. A less carbon-intensive regional electricity grid, which includes the solar power development undertaken by the City, has resulted in an additional 12.3% GHG emissions reduction.

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 from solid waste disposal and wastewater treatment. Figure 4 provides an overview of the relative magnitude of GHG 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 (2020). Quick Facts: Phoenix city, Arizona. URL: https://www.census.gov/quickfacts/phoenixcityarizona

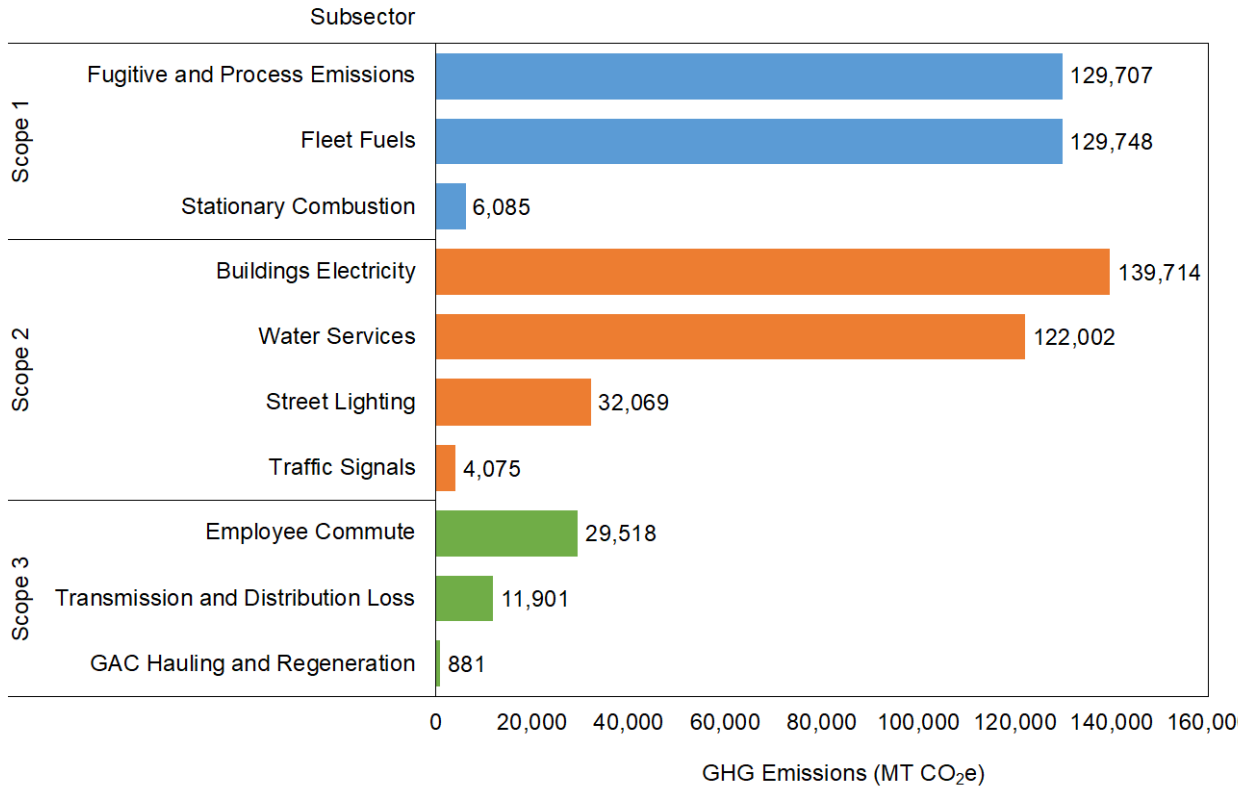

Figure 4. 2018 Emissions by Scope and Subsector

Scope 1 and Scope 2 GHG emissions account for 94% of GHG emissions from City government operations. Purchased electricity (Scope 2 emissions) accounts for 50% of City government operations GHG emissions (Table 2) and, more specifically, Buildings and Water Services represents 23% and 20% of total GHG emissions, respectively. Scope 1 GHG emissions from Fleet Fuels and Fugitive and Process Emissions each account for approximately 21% of total GHG emissions. Combined, these four sectors comprise 85% of City government operations GHG emissions. 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.

Table 2. 2018 GHG Emissions by Scope and Subsector

	Scope 1		Scope 2		Scope 3	
Sector	**GHG Emissions (MT CO_2e)**	**% of Total Emissions**	**GHG Emissions (MT CO_2e)**	**% of Total Emissions**	**GHG Emissions (MT CO_2e)**	**% of Total Emissions**
Stationary Combustion	6,085	1%				
Fleet Fuels	129,748	21%				
Fugitive and Process Emissions	129,707	21%				
Buildings Electricity			139,714	23%		
Street Lighting			32,069	5%		
Traffic Signals			4,075	1%		
Water Services			122,002	20%		
Employee Commute					29,518	5%
Transmission and Distribution					11,901	2%
GAC Hauling and Regeneration					881	0%
Total	**265,540**	**44%**	**297,860**	**49%**	**42,301**	**7%**

4.1.3 GHG Emissions Reductions Since 2005

Total emissions fell from the 716,143 MT CO_2e in 2005, to 605,701 MT CO_2e in 2018. Scope 1 and 2 GHG emissions have decreased in all emissions sectors. All GHG emissions subsectors have decreased emissions since 2005 (Figure 5).

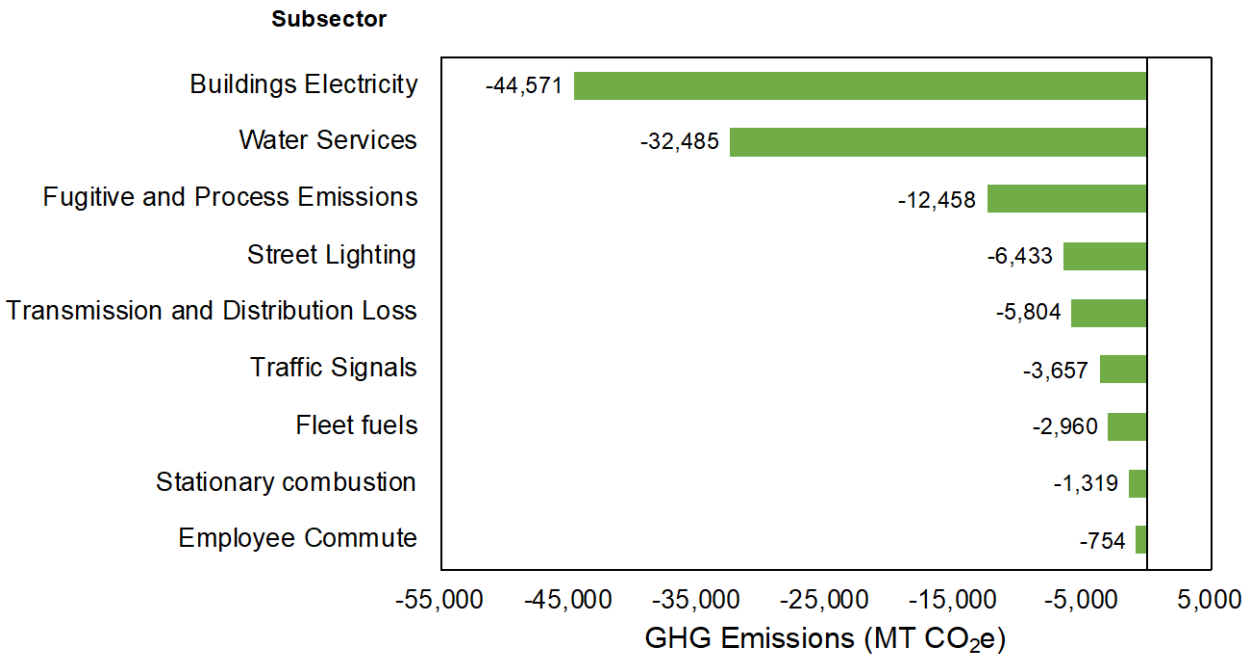

Figure 5. Emissions Changes between 2005 and 2018.

The Buildings Electricity and Water Services subsectors and have had the largest observed decreases in GHG emissions between 2005 and 2018 – 24% (Buildings Electricity) and 21% (Water Services). 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 83,745 MT CO_2e. City efforts to build and purchase solar power has led to a reduction of 10,414 MT CO_2e, of which 9,116 MT CO_2e resulted from solar power projects developed by the Water Services Department. 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:

- Solar power generation reduced emissions by 10,414 MT CO_2e in 2018.
- The aging of closed landfills that emit less methane over time; and
- Transitioning city buses to CNG from LNG and diesel.

5 Findings by Sector for 2018

5.1 Buildings and Facilities

Building and Facilities Findings

Total Emissions: 303,945 MT CO_2e
50% of government operations emissions
22.7% 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

- Solar Power Generation totaled 22,346,675 kWh
- To date, the City has installed:
  - 94,865 LED Street Lights
  - 63,090 LED Signal Indications
  - 9,308 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 2018: What has Changed?

- Between 2005 and 2018, the GHG emissions intensity of the AZNM subregion of the U.S. electricity grid fell by 22%.
- The City began to generate its own solar power and now generates 3.3% of all electricity consumed by government operations.
- These two factors are the largest drivers of the decrease in GHG emissions trends.

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 6).

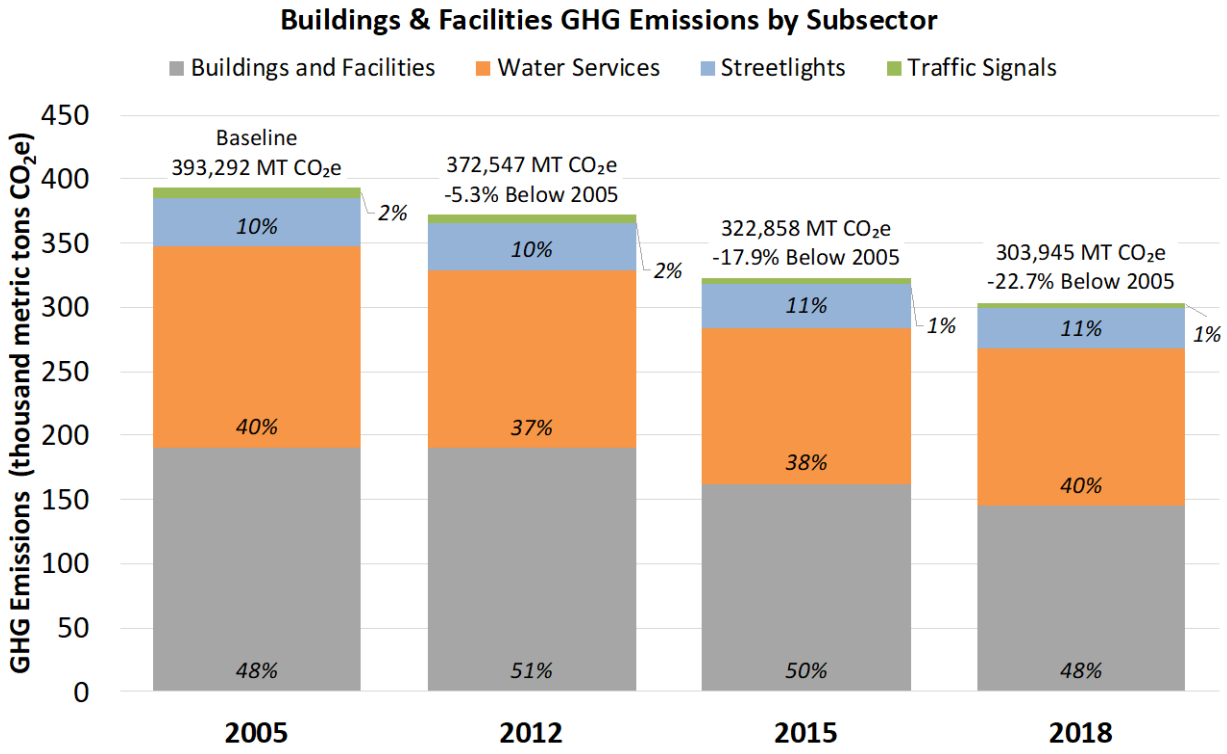

Figure 6. Buildings and Facilities GHG Emissions Between 2005 and 2018

GHG emissions from the combustion of purchased natural gas fell by 17.8% between 2005 and 2018,with 4.6% between 2015 and 2018. Additionally, GHG emissions from purchased electricity decreased 22.8% below 2005 levels and by 5.9% below 2015 levels. The steep decline in Buildings and Facilities GHG has occurred due to multiple City actions. A less GHG intensive regional electricity grid has led to the reduction of 83,745 MT CO_2e. City efforts to build and purchase solar power has led to a reduction of 10,414 MT CO_2e, of which 9,116 MT CO_2e resulted from solar power projects developed by the Water Services Department. Refer to Appendix C & D for a list of City solar projects. Finally, energy efficiency projects have led to GHG emissions reductions, but exact emissions reductions are difficult to quantify.

Electricity consumption by Streetlights and Traffic Signals have shown marked decreases. Streetlights electricity consumption peaked in 2015 at 71,316,538 kWh and has since fallen 4% to 68,812,574 kWh, which is only 7% above 2005 levels. Traffic Signals electricity consumption in 2018 were 30% lower than reported consumption in 2005 and 2012. The observed decrease in electricity consumption has occurred over a period during which the City has invested heavily in LED retrofits of Streetlights and Traffics Signals. These energy efficiency upgrades, along with a less GHG intensive electricity grid, have resulted in 47% fewer GHG emissions from traffic signals between 2005 and 2018 and a reduction of 14% since 2015.

Table 3. 2018 Buildings and Facilities Emissions by Subsector

Subsector	Electricity Consumption (kWh)	Solar Power Generation (kWh)	Natural Gas Consumption (therms)	GHG Emissions (MT CO_2e)
Buildings and Facilities	299,794,866	2,785,675	1,000,901	145,035
Street Lighting	8,744,680	--	--	32,069
Traffic Signals	68,812,574	--	--	4,075
Water Services	261,788,472	19,561,000	143,807	122,766
Total	**639,140,592**	**22,346,675**	**1,144,708**	**303,945**

Solar power generation has had a significant role in the reduction of emissions for Buildings and Facilities. Between 2005 and 2018, Phoenix has continued its commitment towards its goal of obtaining 15% of electricity from renewable sources. Solar projects offset 3.3% of Buildings and Facilities electricity demand. Table 4 shows the breakdown of onsite solar power generation by department. The Aviation and Water Services Departments generated the most solar power – 2,270,760 and 19,561,000 kWh, respectively – and Water Services Department has the highest proportion of its electricity demand met by solar power (7%). Overall, the City was able to avoid 10,633 MT CO_2e. Further renewable energy policies and projects must be developed to continue to decrease emissions from Buildings and Facilities.

Table 4. Departmental Energy Consumption and Solar Power Generation

Department*	2018 Usage (kWh)	2018 Solar Power Generation (kWh)	% Departmental Electricity Demand Met by Solar	Avoided GHG Emissions (MT CO_2e)
Aviation	146,025,156	2,270,760	2%	1,058
Convention Center	27,653,971	0	0%	0
Fire	14,441,510	15,635	0%	7.29
Human Services	1,599,797	62,683	4%	29
PRLD - Recreation	32,070,516	57,394	0%	27
Public Transit	1,145,577	32,623	3%	15
Public Works	35,968,380	346,580	1%	162
Water Services	261,788,472	19,561,000	7%	9,116
Total	**537,372,239**	**22,346,675**	**4%**	**10,414**

*Departments without solar power generation are not included in the table.

5.1.3 GHG Metrics: Buildings and Facilities

Table 5 provides a list GHG metrics for City buildings and facilities. Since 2005, the per capita GHG emissions intensity for government operations has fallen 37% and the per FTE GHG emissions intensity city operations has fallen 24%.

Table 5. Buildings and Facilities Emissions Indicators and Percent of Change

Indicator	2005	2012	2015	2018
Building Space (sq. ft.)	25,948,884	30,624,893	12,599,324	11,495,864
Building Space GHG Emissions Intensity (kg CO_2e per sq. ft)	7.35	6.22	12.89	12.62
Per Capita GHG Emissions Intensity (kg CO_2e per resident)	138.4	129.3	105.7	87.4
Electricity GHG Emissions per CDD (kg CO_2e per CDD)	39.1	36.3	30.9	28.3
FTE GHG Emissions Intensity (kg CO_2e per FTE)	13.00	12.64	11.08	9.92

5.2 City Vehicle Fleet

City Vehicle Fleet Findings

Total Emissions: 129,748 MT CO_2e
21.4% of government operations emissions
2.2% decrease 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 2018: What has Changed?

- The size of Public Works fleet peaked in 2015 with 7,389 vehicles and has since dropped to 7,340 vehicles.
- The majority of the diesel fleet vehicles operated by Public Works and Aviation have converted to B20 biodiesel 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 will be retired.
- At 2018 consumption-levels, the adoption of CNG and B20 biodiesel in lieu of diesel consumption avoids the emission of 56,067 MT CO_2e. Transitioning diesel

fleet to CNG vehicles has reduced 31,709 MT CO_2e of GHG emissions, while the adoption of B20 biodiesel has saved 24,358 MT CO_2e.

- GHG emissions from diesel and CNG have increased since 2015 due to the addition of 2.4 million service miles as part of the City's Transportation 2050 Plan to increase local bus frequency by building out the existing city bus network, increasing service hours of bus operations, and introducing new bus routes, which includes the introduction of bus rapid transit corridors.

5.2.2 Emissions Sources and Distribution

In 2018, CNG vehicles were the largest source Vehicle GHG emissions followed by gasoline vehicles. The increase in CNG vehicle emissions has resulted from the shift away from diesel vehicles. GHG emissions from diesel vehicles were highest in 2005 and decreased 53% by 2018. GHG emissions from diesel vehicles increased by 8,195 MT CO_2e between 2015 and 2018 due to an increase in public transit service miles to meet T2050 goals. GHG emissions from gasoline, B20 biodiesel, and E85 ethanol vehicles have remained largely flat since 2012. Additionally, aviation-based emissions from Jet Fuel A and Aviation Gasoline, which are a small percentage of Vehicle Fleet GHG emissions, have also remained flat.

Figure 7 shows Vehicle Fleet GHG emissions by fuel type and have slightly decreased by 2.2% since 2018, largely due to the inclusion of alternative fuels. GHG emissions for B20 biodiesel and E85 ethanol are shown. Only the fossil fuel component of biofuel GHG emissions – 80% of each gallon of B20 biodiesel and 15% of each gallon of E85 ethanol – is counted toward GHG emission totals plotted in Figure 7.

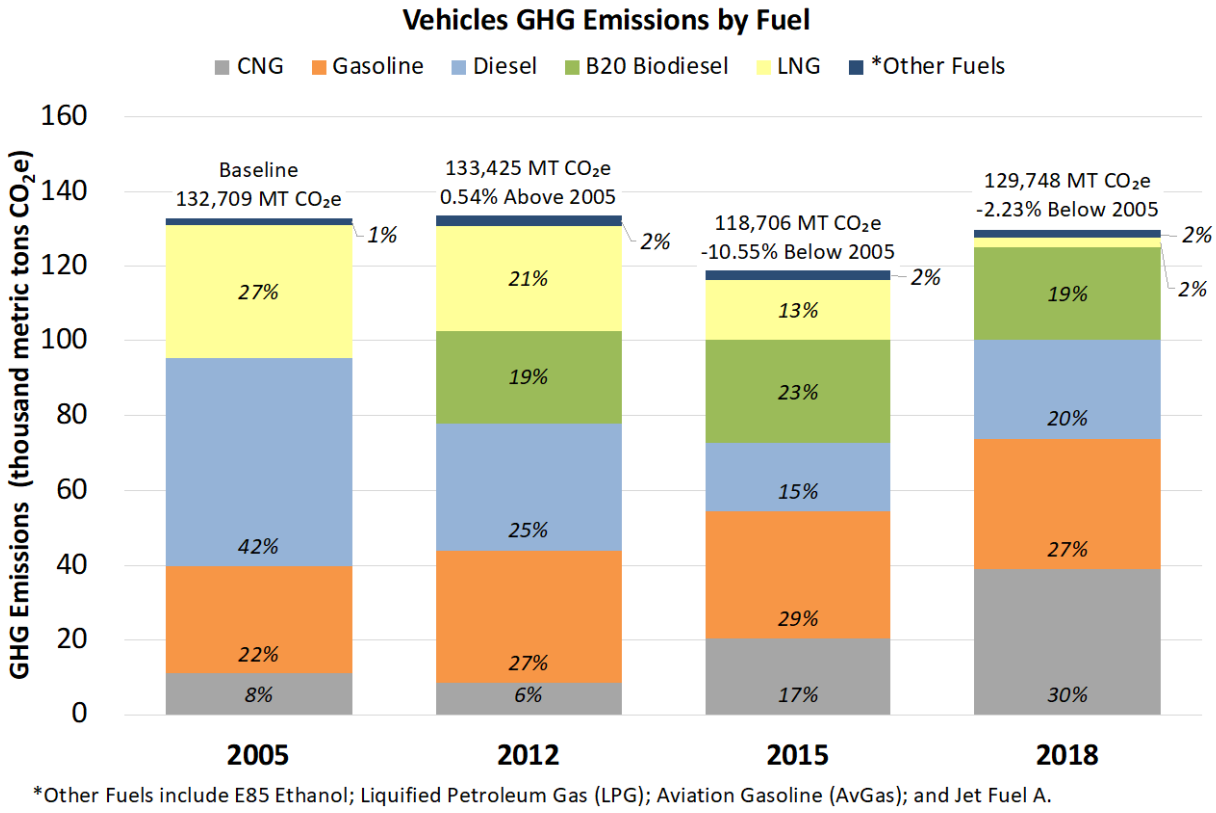

Figure 7. Vehicle Fleet Emissions by Fuel Between 2005 and 2018

As shown in Table 6, CNG fuel consumption has increased 89% between 2015 and 2018. The CNG fuel consumption increase occurred along with an increase in diesel fuel consumption by 45% and a decrease in LNG consumption by 85% between 2015 and 2018. The major changes to the levels of CNG, diesel, and LNG fuel consumption was driven by Public Transit, which increased CNG fuel consumption by 147%, increased diesel fuel consumption by 46%, and decreased LNG consumption by 85%. Fuel increases were due to Public Transit increasing service miles by 2.4 million miles. The City began replacing LNG buses with more efficient CNG busses in 2013; all LNG buses will be retired by the end of FY 2020. No other major changes in fuel consumption were observed between 2015 and 2018.

Table 6. Changes in Total City Fleet Fuel Consumption

Fuel Type	Unit	2005	2012	2015	2018
Gasoline	gallon	3,172,441	3,976,124	3,813,990	3,936,224
Diesel	gallon	5,452,613	3,324,829	1,777,341	2,579,301
B20 Biodiesel	gallon	0	3,034,345	3,394,710	3,027,969
Compressed Natural Gas (CNG)	GGE*	1,744,813	1,349,993	3,239,129	6,151,022
Liquefied Natural Gas (LNG)	gallon	7,917,008	6,200,897	3,528,633	543,296
E85 Ethanol	gallon	0	287,438	340,753	311,460
Liquified Petroleum Gas (LPG)	gallon	14,392	0	0	0
Aviation Gasoline (AvGas)	gallon	2,401	5,975	4,961	4,875
Jet Fuel A	gallon	163,160	222,283	202,119	192,739

*GGE – Gasoline Gallon Equivalent

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 7). The data shown in Table 7 are for Public Works vehicles only.

Table 7. City Fleet Indicators Change

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

5.3 Water Services

Water Services Findings

Total Emissions: 138,721 MT CO_2e
22.9% of government operations emissions
19.3% 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

- Water Service Department's Lake Pleasant solar facility generates 19.56 million kWh
- Water conservation and less volumes at WTPs and WWTPs have reduced pumping and treatment energy requirements

5.3.1 2005 to 2018: 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 Servicers department treated 110.5 billion gallons of water and 65.6 billion gallons of waste water. The volume of water treated has increased 4% since 2005 while the volume of wastewater treated has decreased 6%.
- The Water Services department finished construction of a 7.5 MW solar power facility at the Lake Pleasant WTP in 2013. The overall reduction of GHG emissions was largely due to the onsite solar power generation by Water Services.
- 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

Water Services sector GHG emissions are generated by a variety of sources. GHG emissions can occur from the combustion of purchased natural gas, the consumption of purchased electricity, methane generation during water treatment, and N_2O emissions from wastewater effluent. GHG emissions also occur during the hauling and regeneration of GAC filters used in the treatment process to remove disinfection byproducts.

GHG emissions from Water Services decreased 18.8% between 2005 and 2018, but have increased 2.8% since 2015. The emissions decreases since 2005 have occurred due to energy efficiency measures, like plant closures, and onsite solar power generation. While there are a variety of potential Water Services GHG emissions sources, only one activity makes up the vast majority of GHG emissions from this sector. Electricity consumption by Water Services has comprised over 90% of GHG emissions from this sector (Figure 8). These emissions can be offset by renewable energy credits in addition to further on-site renewable energy development and battery storage projects. Some Water Services emissions from the treatment of wastewater – methane flaring and wastewater discharge –are largely population-driven. Projected population increases over the next decade will potentially increase GHG emissions in this sector unless further mitigation efforts are undertaken.

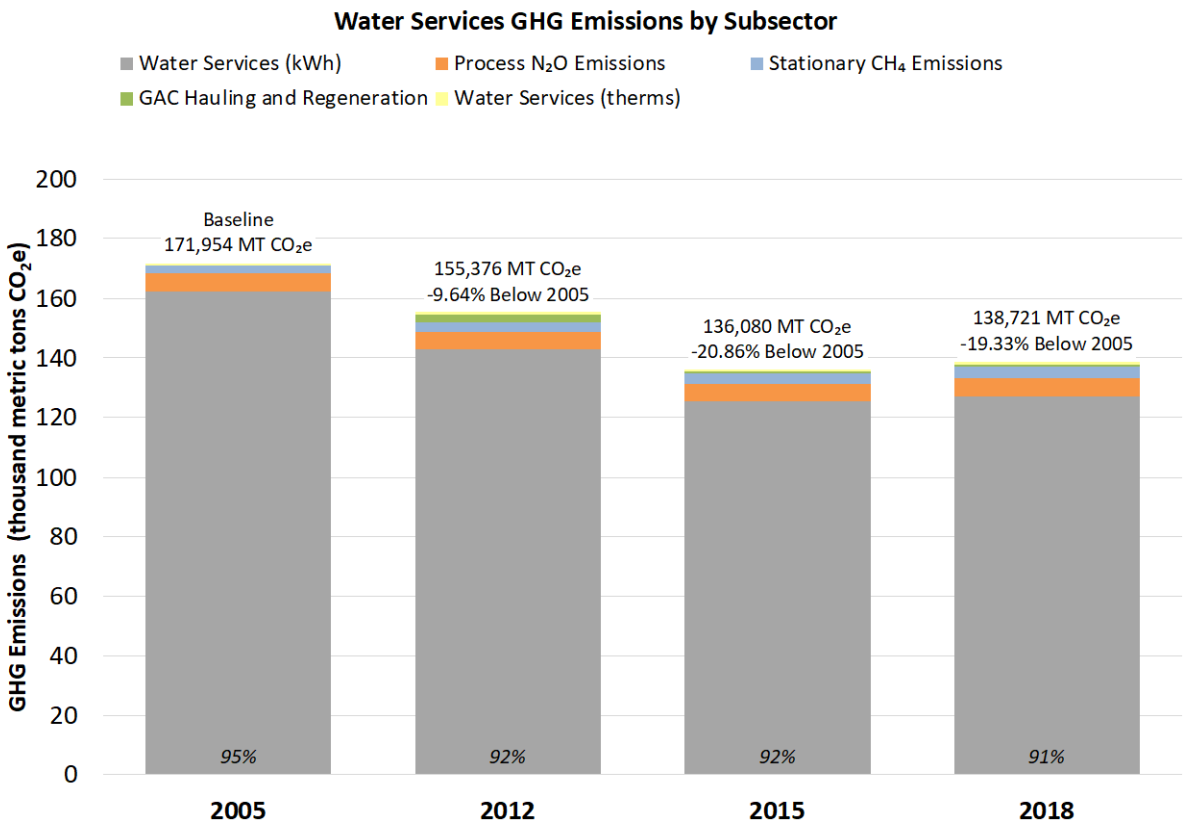

Figure 8. Water Services Emissions Changes Between 2005 and 2018

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. Therefore, these emissions Changes in emissions for each Water Services subsector are shown in Figure 9.

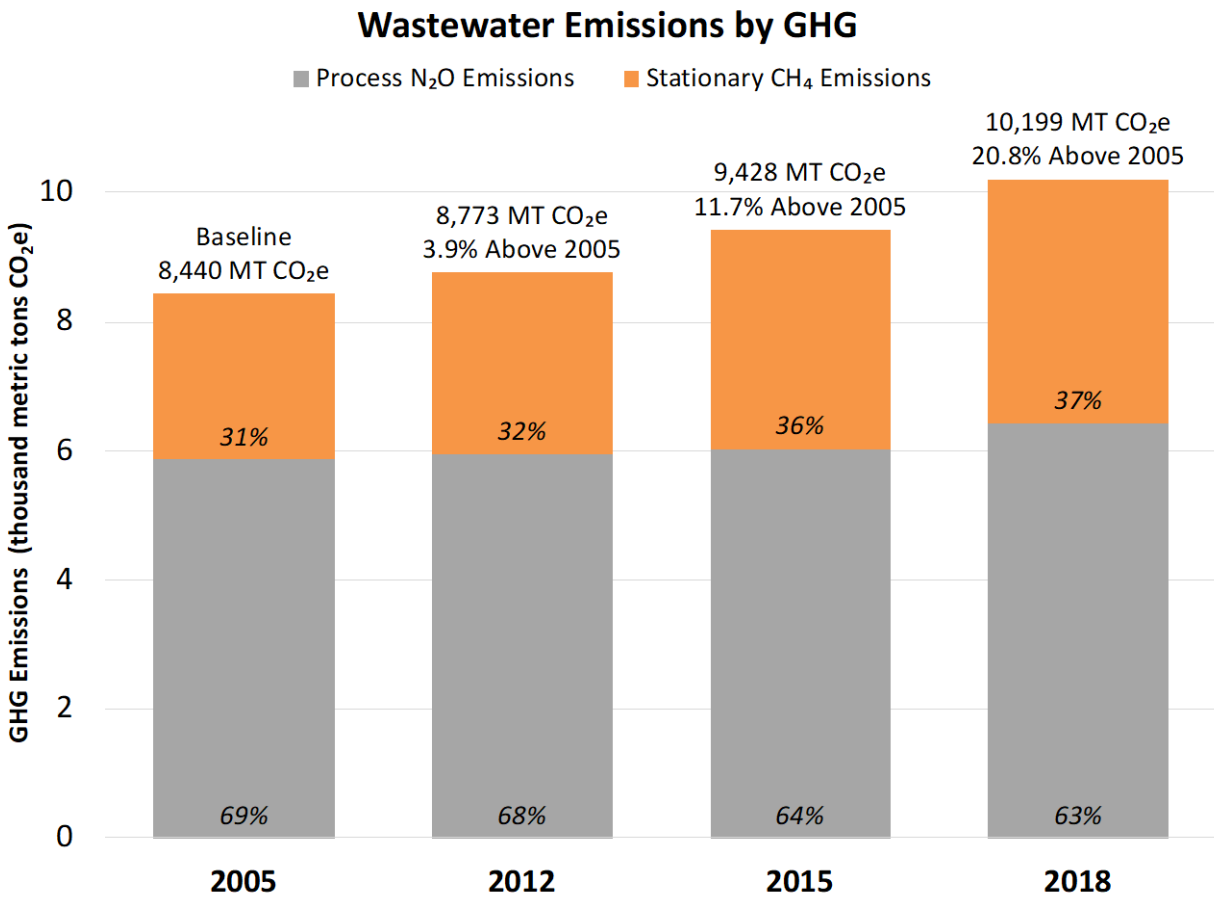

Figure 9. Wastewater Treatment GHG Emissions Between 2005 and 2018

GHG emissions at the 23rd Avenue and 91st Avenue WWTPS are shown in Table 8. The 91st Avenue WWTP is the larger of the two WWTPs and emits more than twice the GHG emissions of the 23rd Avenue Plant. The increase in GHG emissions between the 91st Avenue and 23rd Avenue comes from process N_2O emissions; CH_4 emissions from the incomplete combustion of digester gas is similar at both WWTPs.

The 91st Avenue WWTP accepts wastewater from Glendale, Mesa, Scottsdale, and Tempe. Currently, the City accounts for all GHG emissions at the 91st Avenue WWTP because the plant is under the City's operational control. As other cities develop their own emissions inventories, the emissions from 91st Ave. may be distributed differently.

Table 8. 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	1,860	1,911	3,771
Process N_2O Emissions	Effluent Discharge	428	1,486	1,914
	Nitrification/Denitrification	1,034	3,480	4,515
Total		**3,322**	**6,877**	**10,199**

5.3.3 GHG Metrics: Water Services

Water Services indicators in Table 9 below shows that the GHG intensity of drinking water served by the City has consistently decreased since 2005.

Table 9. Water Services Emissions Indicators

Indicator	2005	2012	2015	2018
Gallons of Drinking Water Treated (billion gallons)	105.9	112.4	106.0	110.5
MT CO_2e per Billion Gallons Treated	1,556	1,310	1,238	1,203
Water Treatment Plants	6	5	5	5
MT CO_2e per WTP	27,471	29,447	26,236	26,593
Million Gallons of Wastewater Treated	69,523	69,524	65,442	65,600
MT CO_2e per Million Gallons Wastewater Treated	2.37	2.12	2.00	2.03

5.4 Solid Waste

Solid Waste Findings

Total Emissions: 119,508 MT CO_2e
19.8% of government operations emissions
10% decrease from 2005 levels

Emissions Sources

- City landfills emitted 111,383 MT CO_2e
- The 27th Avenue Compost Facility emitted 8,125 MT CO_2e

City Action Highlights

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

5.4.1 2005 to 2018: 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 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 in the future as it is the only active landfill in the City. However, methane emissions are expected to decline at the other City landfills as these landfills are closed (Figure 10).

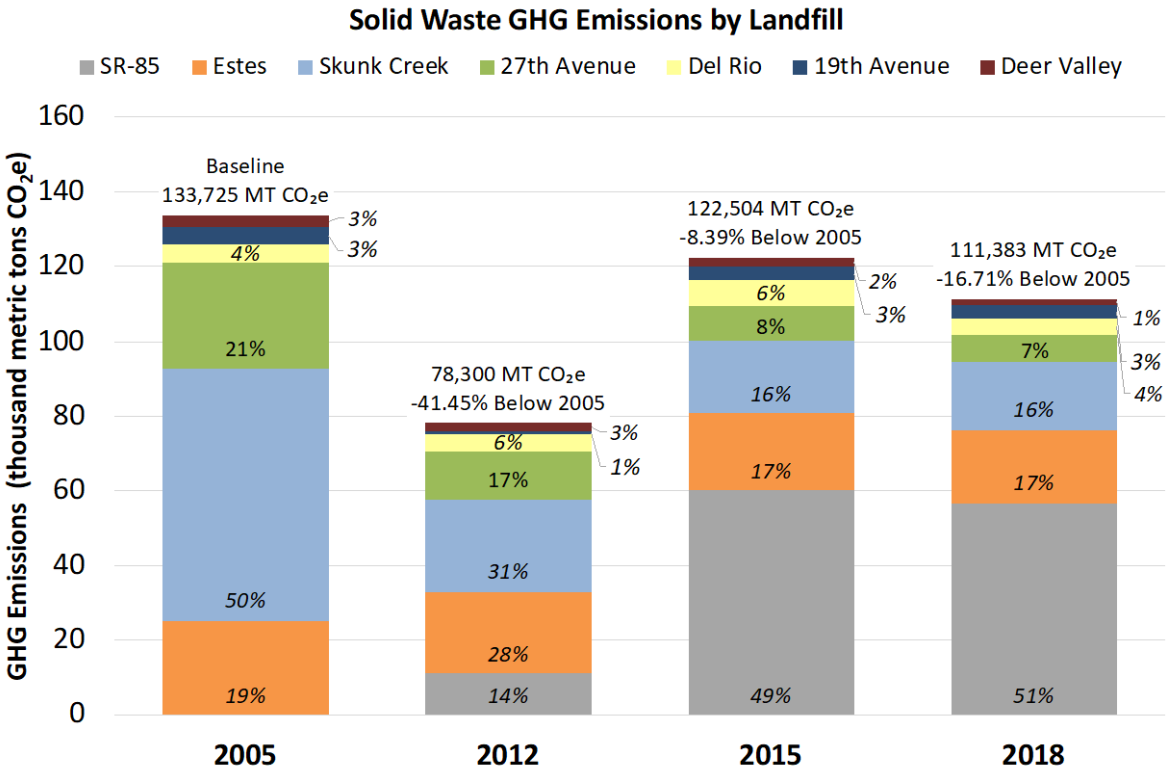

Figure 10. Phoenix Landfills Emissions Changes between 2005 and 2018

Table 10 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 10. 2018 Solid Waste Emissions by Landfill

Landfill	Tons CH_4 Collected/Flared	Tons CH_4 Released	MT CO_2e Emissions
Skunk Creek	4,970	645	18,047
27th Avenue	2,232	264	7,403
Del Rio	312	158	4,419
Deer Valley	208	59	1,664
19th Avenue	472	129	3,598
Estes	694	694	19,432
SR-85	7,163	2,029	56,820
Total	**16,051**	**3,978**	**111,383**

Landfill GHG emissions in this report will differ from data reported to the EPA for its GHG mandatory reporting. This GHG update uses formulas contained in the LGOP to calculate emissions, 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 46,768 tons of compost in CY 2018, resulting in the emission of 170 MT CH_4 and 13 MT N_2O. Total GHG emissions from the compost facility were 8,125 MT CO_2e. This facility will reduce long-term GHG emissions associated with the hauling and disposal of green & organic solid waste at the SR-85 Landfill.

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 11 shows Solid Waste sector GHG indicators for the City.

Table 11. GHG Emissions Indicators for Solid Waste

Indicator	2005	2012	2015	2018
Amount of Waste in Place (short tons)	44,030,052	50,257,923	52,405,666	54,666,679
Kg CO_2e Per Ton of Solid Waste in Landfills	3.037	1.558	2.338	2.215
Compost Processed (short tons)	—	—	—	46,768
Kg CO_2e Per Ton of Compost Processed	—	—	—	173

5.5 Employee Commute

Employee Commute Findings

Total Emissions: 29,519 MT CO_2e
4.8% of government operations emissions
2.5% 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 2018: What has Changed?

- City employees fill out surveys as part of the Trip Reduction Program (TRP) overseen by Maricopa County Air Quality Department. The TRP, which started in 1989, provides employers a yearly analysis of employee community statistics and behaviors.
- 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 2012, 2015, and 2018 GHG emissions inventories.
- Employee commuting using city vehicles is counted in the City Vehicle Fleet sector to avoid double counting.

5.5.2 Emissions Sources and Distribution

Employee commuting by employees in 2018 increased by 3.6% from 2005 levels to 87,386,610 miles. However, due to increasing motor vehicle fuel efficiency in the U.S. auto fleet, required by the Energy Policy and Conservation Act, the associated GHG emissions fell by 5.8% to 29,519 MT CO_2e (Table 12). 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. 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 been an increase in hybrid-electric and plug-in electric vehicle employee commuting miles since 2015.

Table 12. Employee Commute Emissions by Fuel Type/Mode in 2005 and 2018

Fuel Type	2005		2012		2015		2018	
	Commuting Miles	MT CO_2e	Commuting Miles	MT CO_2e	Commuting Miles	MT CO_2e	Commuting Miles	MT CO_2e
Gasoline	80,555,678	30,075	93,917,068	34,932	83,504,307	31,059	82,130,508	28,454
Hybrid	0	0	0	0	1,210,096	246	2,824,676	979
Electric	36,477	5	118,470	18	118,455	18	239,474	36
CNG	277,905	106	172,979	66	45,136	17	83,459	32
LPG	284,192	86	83,046	26	29,209	9	57,960	18
E85	12,609	0	766,210	0	0	0	0	0
Bus*,°	3,158,885	—	4,503,309	—	3,158,239	—	1,838,854	—
Light Rail‡,°	—	—	376,188	—	430,983	—	211,680	—
Totals	**81,166,860**	**30,272**	**99,937,270**	**35,042**	**95,803,331**	**31,350**	**87,386,610**	**29,519**

*Commuting miles for 2005 were backcast from 2015 levels using employment data.
‡The Valley Metro Light Rail did not exist in 2005.
°GHG Emissions not included in total.

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

GHG indicators measure the GHG emissions performance of various government operations. Table 13 details GHG Indicators for City of Phoenix government operations.

Table 13. Internal Government operations Indicators

Government operations Indicators	2005	2012	2015	2018	Unit
Population	1,377,980	1,473,405	1,537,058	1,660,272	People
Employees	14,667	12,849	14,664	14,615	Employees
Building Area	25,948,884	30,624,893	12,599,324	11,495,864	Sq. ft.
Cooling Degree Day (CDD)	4,709	5,065	5,065	4,943	CDD
Building Area GHG Intensity	7.35	6.22	12.89	12.62	kg CO_2e per sq. ft
Per Capita GHG Intensity	138.4	129.3	105.7	87.4	kg CO_2e per resident
CDD Electricity GHG Intensity	39.1	36.3	30.9	28.3	kg CO_2e per CDD
FTE GHG Intensity	13.00	12.64	11.08	9.92	kg CO_2e per FTE
Drinking Water Treated	105.9	112.4	106.0	110.5	billion gallons
Drinking Water GHG Intensity	1,556	1,310	1,238	1,203	MT CO_2e per billion gallons
Water Treatment Plants (WTP)	6	5	5	5	number
WTP GHG Intensity	27,471	29,447	26,236	26,593	MT CO_2e per WTP
Wastewater Treated	69,523	69,524	65,442	65,600	million gallons
Wastewater GHG Intensity	2.37	2.12	2.00	2.03	MT CO_2e per million gallons
Solid Waste in Place (WIP)	44,030,052	50,257,923	52,405,666	54,666,679	tons
Solid Waste GHG Intensity	3.037	1.558	2.338	2.1986	kg CO_2e per Ton WIP
Fleet Size	6,090	7,387	7,389	7,340	Number of Vehicles
Fleet Vehicle GHG Intensity	9.2	7.1	6.6	6.7	MT CO_2e per Fleet Vehicle
Vehicle Miles Traveled (VMT)	52,825,683	48,022,781	—	35,990,125	VMT
VMT GHG Intensity	1.06	1.09	—	1.36	kg CO_2e per VMT
Gasoline Consumption	3,172,441	3,976,124	3,813,990	3,936,224	gallons
Diesel Consumption	5,452,613	3,324,829	1,777,341	2,579,301	gallons
Diesel + B20 Biodiesel Consumption	5,452,613	6,359,174	5,172,051	5,607,270	gallons
CNG Consumption	1,744,813	1,349,993	3,239,129	6,151,022	GGE
Commuting Gasoline Miles Traveled	80,555,678	93,917,068	83,504,307	82,130,508	miles
Commuting Gasoline Miles Per Employee	5,576	7,167	5,711	5,772	mile per FTE
% Single Occupancy Vehicle	73.8%	74.1%	75.8%	72.1%	%
Alternative Fuel Vehicle Miles	891,044	1,140,705	1,402,897	3,354,038	mile

7 Biogenic 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 the guidelines set by LGOP, biogenic CO_2 emissions are currently not considered to add carbon into the atmosphere as these sources of CO_2 are part of the natural carbon cycle and do not count toward

GHG emissions total. As part of the strategy to achieve net-zero GHG emissions, the City can shift fossil fuel CO_2 emissions to biogenic CO_2 emissions that are not replaceable with other forms of energy, like solar. This is being done with the continued conversion of diesel fleet vehicles to biodiesel blends in addition to the development of biomass-based sources of electricity. Table 14 shows biogenic emissions from City government operations in 2005, 2012, 2015, and 2018.

Table 14. Sources and Quantities of Biogenic Emissions (MT CO_2e)

Biogenic CO_2 Summary	**2005**	**2012**	**2015**	**2018**
Biogenic Landfill	66,739	74,946	86,937	98,264
Biogenic B20 Biodiesel	0	5,735	6,416	5,723
Biogenic E85 Ethanol	0	1,405	1,665	1,522
On-Site Biogas Use-91st Ave. WWTP	3,978	2,701	2,213	2,622
Flared Biogenic Wastewater CO_2 – 91st Ave. & 23rd Ave. WWTPs	58,146	37,117	39,175	32,550
Total Biogenic	**128,863**	**121,903**	**136,407**	**140,682**
% of Fossil	**18%**	**19%**	**22%**	**23%**

Sources of biogenic emissions come from blended biofuels, such as B20 biodiesel and E85 ethanol, municipal landfills, and wastewater treatment plants. For blended biofuels, the biofuel component of the fuel is considered biogenic. Emissions, primarily N_2O and CH_4, from the diesel or gasoline component are considered to be fossil emissions.

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 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 2015 and 2018 GHG emissions inventories of government operations.

Solid Waste Facilities

The 2018 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; 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 and Planned Solar Projects

Solar Projects/Partnerships				
Project #	**Description**	**Completed**	**kW**	**Projected kWh/year**
1	Transit - Pecos Park & Ride (SRP Grid)	2004	100	147,000
2	N. Transfer Station Parking Lot (32 x 40w fixtures)	2006	1.3	1,955
3	North Transfer Station	2006	7	10,700
4	Phoenix Convention Center - West Bldg	2007	100	125,800
5	Camp Colley (off grid)	2007	8.5	12,335
6	North Mountain Park Visitor Ctr.	2008	3.2	4,597
7	Pecos Community Center	2009	30	43,785
8	Paradise Village Apts (Housing)	2010	2	2,845
9	Helen Drake Senior Center	2011	40	58,285
10	McCarty on Monroe (Housing/NSD)	2011	30	44,100
11	Maryvale Pool	2011	15	22,050
12	Washington Adult Center	2011	10	14,700
13	Audubon Visitor Center	2011	30	44,100
14	US Airways Parking Garage	2011	238	347,385
15	ASU DT – Cronkite School of Journalism	2011	77	112,390
16	Burton Barr Central Library	2011	150	198,000
17	Fire Training Academy	2011	10	14,595
18	Fire Station #12	2011	10	14,595
19	Fire Station #1	2011	20	29,190
20	Sunnyslope CC – Main & Gym	2011	100	147,000
21	Aviation – East Economy Parking Garages	2011	1,290	2,004,565
22	Aviation – Rental Car Center	2011	4,100	6,388,700
23	DT Transit Building	2012	30	43,785
24	Phoenix Children's Museum	2012	85	126,855
25	Water Department – Lake Pleasant WTP	2012	7,500	12,803,250
26	Metro Facilities Building	2012	90	141,750
27	Walker Building	2013	10.5	15,990
28	Washington St. Parking Garage (305 Garage)	2014	486.6	754,135
29	Adam St. Parking Garage (310 Garage)	2014	695.9	1,078,505
30	Valley Metro Light Rail- Operations Center	2015	783	1,151,010

Solar Projects/Partnerships				
Project #	**Description**	**Completed**	**kW**	**Projected kWh/year**
31	SR-85, DESERT STAR (APS utility-scale)	2015	15,625	24,609,375

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.

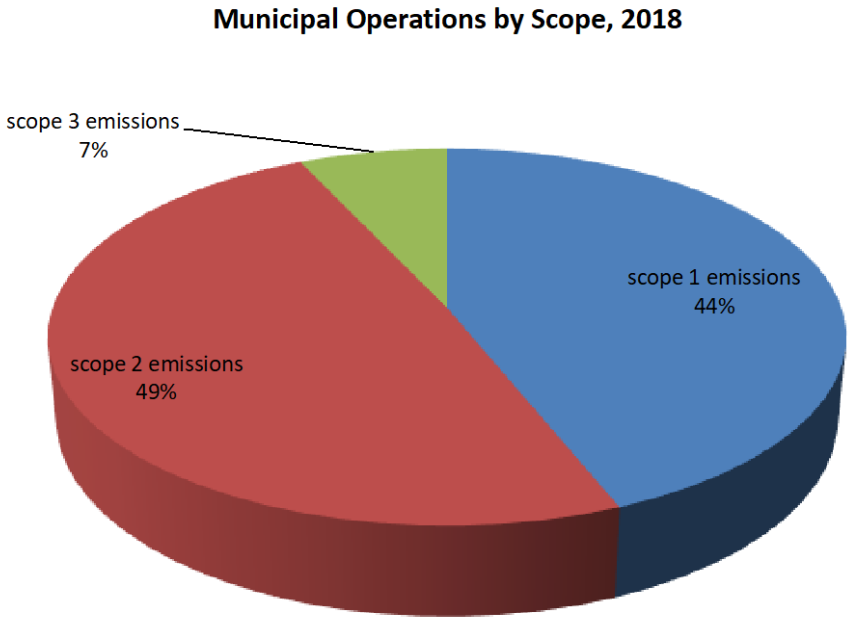

Figure D1. 2018 Emissions by Scope

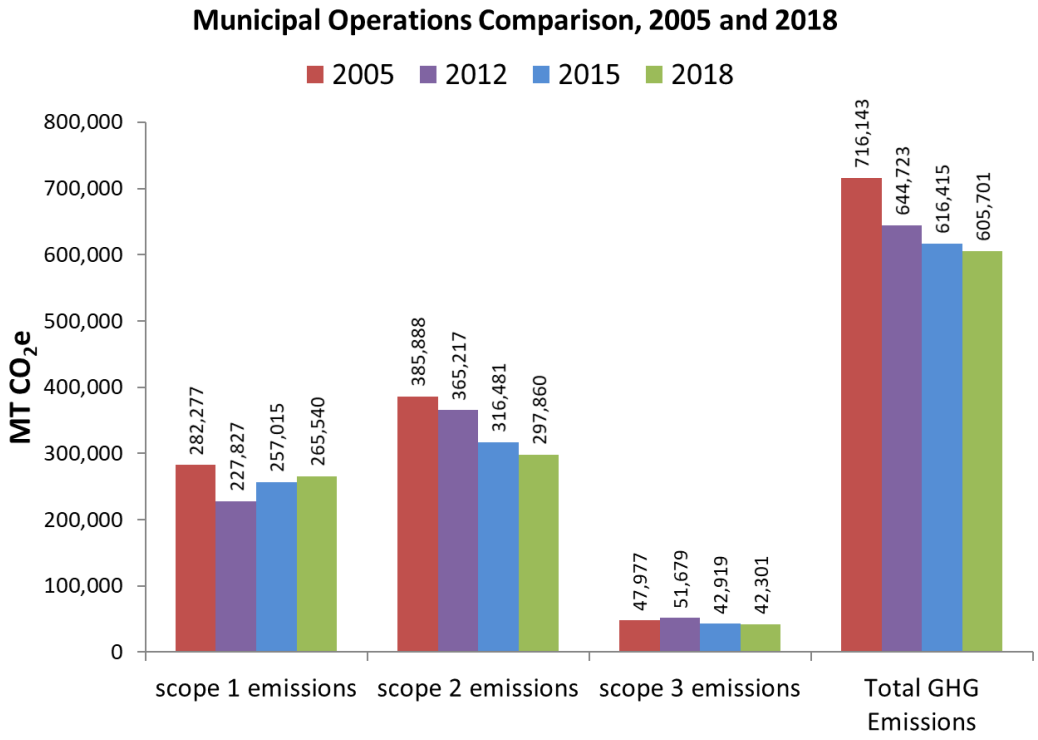

Figure D2. Government operations comparison, 2005, 2012, 2015 and 2018

Scope 1

Scope 1 emissions contribute 44% of the city's total emissions accounting for 265,540 MT CO_2e. From 2005 to 2018, Scope 1 emissions decreased 5.9%. Scope 1 is comprised of stationary combustion, fleet fuels, and fugitive and process emissions from landfills and wastewater treatment plants (Figure D3). Stationary sources of Scope 1 emissions come from use at city buildings, use for water distribution, and use for wastewater treatment. The combustion of natural gas in buildings, and the resulting emissions, decreased 17% between 2005 and 2018, while natural gas combustion for water distribution treatment decreased 25%. The City's fugitive and process GHG emissions decreased 9% between 2005 and 2018. Fugitive methane emissions from landfills were reduced by 17%, due to the installation of advanced landfill gas capture systems at the Skunk Creek and the new SR-85 landfills. Fugitive and process emissions from wastewater treatment increased significantly (21%) as city WWTPs treated more effluent in 2018 than in 2005 due to population growth. The 27th Avenue Compost Facility was a new source of fugitive and process emissions in 2018.

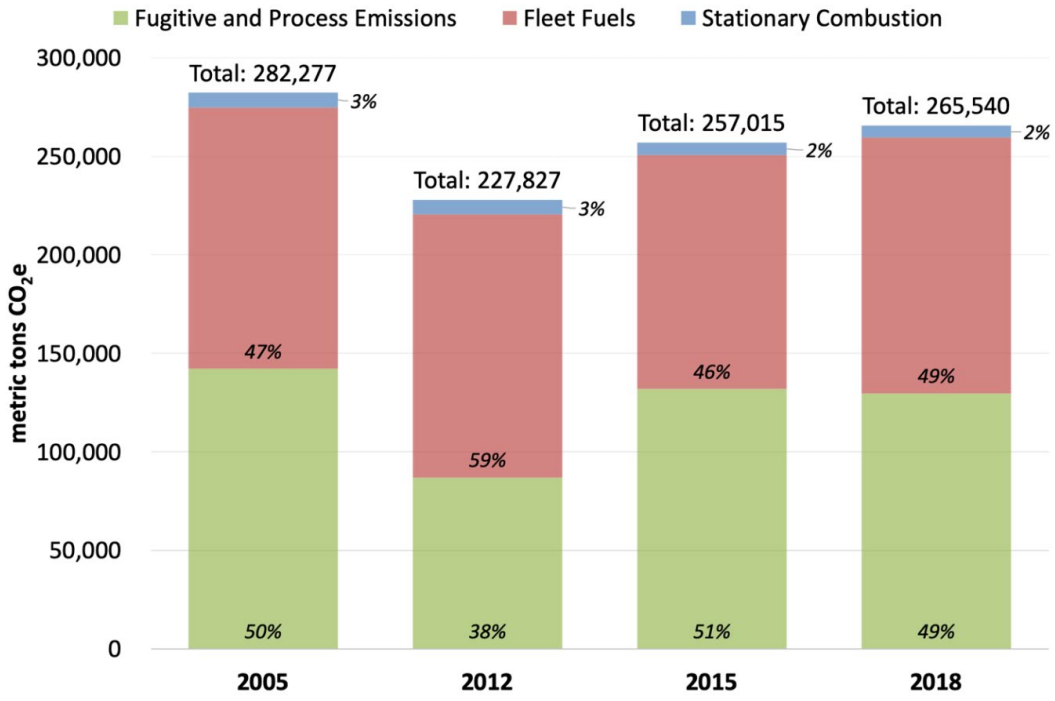

Figure D3. Breakdown of 2018 Scope 1 Emissions

The City's fuel portfolio has changed dramatically between 2005 and 2018 with the addition of B20 biodiesel vehicles and E85 flex fuel vehicles. The incorporation of biofuels into the fleet fuel portfolio helped to reduce Scope 1 emissions overal from the city's vehicle fleet by 2% between 2005 to 2018. However, an increase in Public Transit service miles caused an 9% increase in emissions between 2015 and 2018.

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, so the benefits of on-site generation of electricity from solar enery projects are not directly accounted for and buildings may consume more electricity (both solar and grid-based generated) than what is billed (grid-based only).

Scope 2 emissions account for 50% of the City's total emissions and totaled 304,113 MT CO_2e in 2018. Between 2005 to 2018, Scope 2 GHG emissions decreased 21% (Figure D4) while purchased only decreased 1%. Between 2005 and 2018, the carbon intensity of purchased electricity in Arizona decreased 22% due to increased natural gas generation and decreased coal generation in the region electricity grid in combination with increased renewable energy genration.

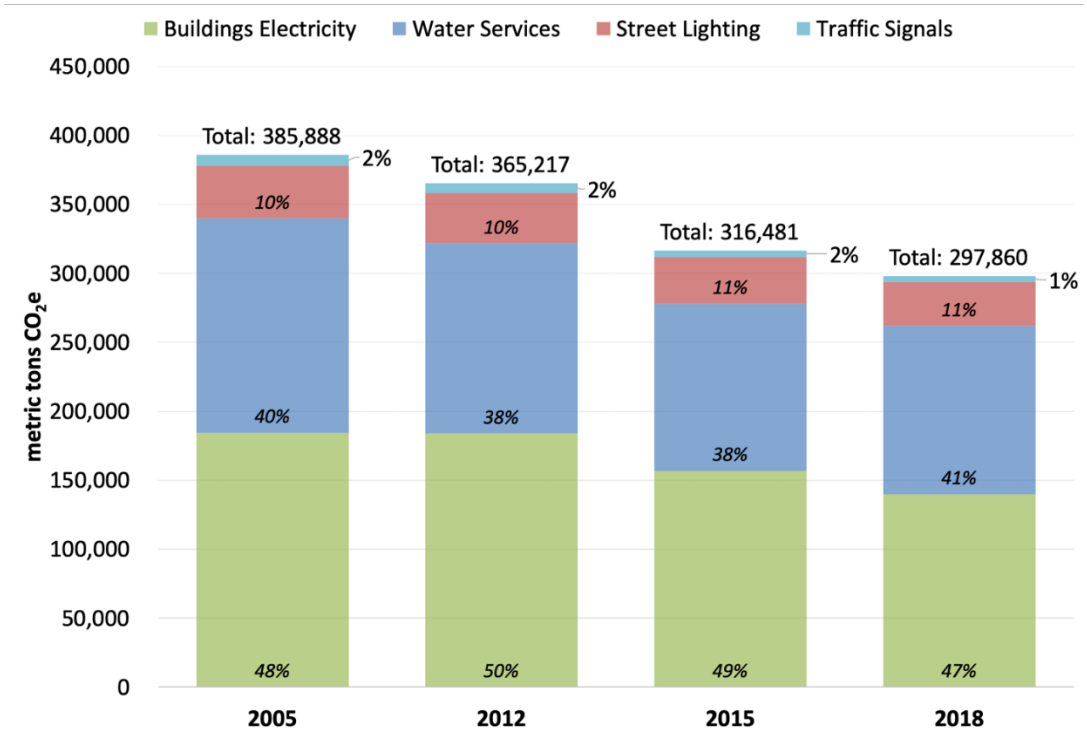

Figure D4. Breakdown of 2018 Scope 2 Emissions

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 7% of the City's total emissions with a total of 42,301 MT CO_2e. From 2005 to 2018, emissions from Scope 3 decreased 12%. GHG emissions from employee commuting are the largest component (69%) of Scope 3 emissions (Figure D5).

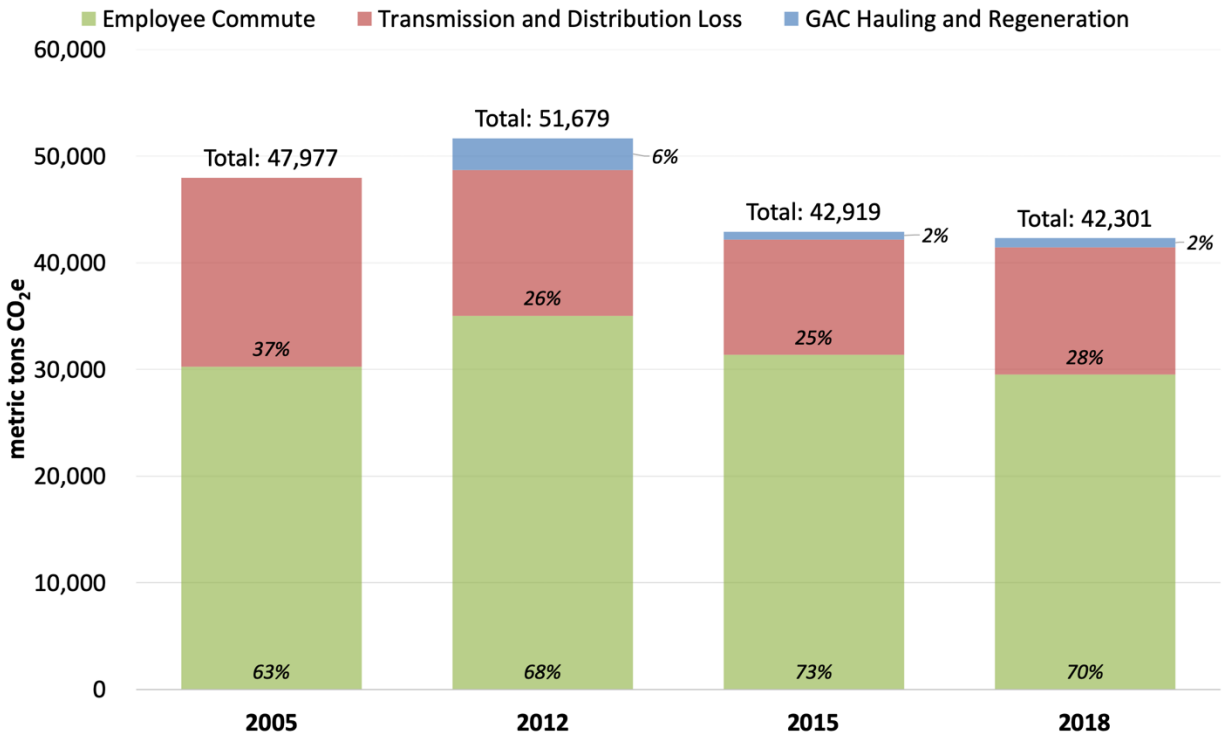

Figure D5. Breakdown of 2018 Scope 3 Emissions