

June 2021

REGIONAL GREENHOUSE GAS INVENTORY (2014 - 2019)



PIMA ASSOCIATION OF GOVERNMENTS

June 2021

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LIST OF ACRONYMS

Btu	British thermal units
ClearPath	ICLEI's online tool for quantifying greenhouse gases
CAP	Central Arizona Project
CH ₄	Methane
CNG	Compressed Natural Gas
CO ₂	Carbon dioxide
CO ₂ e	Carbon dioxide equivalents
DOE	Department of Energy
EIA	Energy Information Administration (department within DOE)
GHG	Greenhouse gas
GWP	Global warming potential
ICLEI	Local Governments for Sustainability
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt-hour(s)
LED	Light Emitting Diode
MMBtu	Million British thermal units
MWh	Megawatt-hour(s)
N ₂ O	Nitrous Oxide
PAG	Pima Association of Governments
PDEQ	Pima County Department of Environmental Quality
RCI	Residential, Commercial and Industrial sectors
RWRD	Pima County Regional Wastewater Reclamation Department
SWG	Southwest Gas Corp.
TEP	Tucson Electric Power Co.
TOUA	Tohono O'odham Utility Authority
TRP	Travel Reduction Program
UPRR	Union Pacific Railroad
USEPA	U.S. Environmental Protection Agency
VMT	Vehicle Miles Traveled
WARM	EPA's Waste Reduction Model

EXECUTIVE SUMMARY

This report is the latest in a series of greenhouse gas (GHG) inventories for the eastern Pima County region, the last of which was completed in 2019. This inventory used the most current data, tools and methodology and complies with the *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions* v.1.2 (ICLEI, 2019) and the *Local Government Operations Protocol for the Quantification and Reporting of Greenhouse Gas Emissions Inventories* v.1.1 (ICLEI, 2010).

The ICLEI-Local Governments for Sustainability's *ClearPath* tool is a cloud-based emissions management software. It was used to develop the community scale and government operations GHG emissions inventories for eastern Pima County and the City of Tucson. Each inventory component tracks the production of the three major GHGs: carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O). These are expressed as carbon dioxide equivalents (CO₂e) based upon global warming potential (GWP) values. Global warming potential values were first established through global scientific consensus by the Intergovernmental Panel on Climate Change (IPCC). The values were assessed over 100 year time frames. This inventory uses the IPCC 4th Assessment Report values of 25 for CH₄ and 298 for N₂O.

These inventories track GHG emissions resulting from the actions and activities of the community and the government. It does not inventory all sources of GHG emissions. The goal is to quantify the major GHG emission sources that are under the control of the City of Tucson and Pima County to identify feasible practices and policies to reduce emissions. Examples of emissions not covered in this report are hydrofluorocarbons (HFCs), perfluorocarbon (PFC) refrigerants, sulfur hexafluoride (SF₆), fugitive emissions from natural gas distribution and emissions from agriculture-related activities. These sources are not tracked as part of this report due to the lack of data available to monitor their impacts.

Pima Association of Governments (PAG), on behalf of member jurisdictions developed this inventory that tracks GHG emissions from 2014 to 2019, and is organized as follows:

Eastern Pima County Community GHG Emissions Inventory: (hereinafter referred to as County Community) Inventory includes emissions credited to the communities and governments of Tucson, South Tucson, Marana, Oro Valley, Sahuarita, the Tohono O'odham Nation, the Pascua Yaqui Tribe and unincorporated eastern Pima County. Included are emissions from stationary energy use by sector (electricity, natural gas, diesel), transportation (onroad, nonroad vehicle use, locomotive and aircraft), waste (solid and wastewater reclamation), industrial sources and Central Arizona Project (CAP) (Other) energy use.

Subsets of the County Community GHG Inventory:

- Tucson Community GHG Emissions Inventory: (hereinafter referred to as the City Community) Inventory includes GHG emissions attributed to residents and activities within the Tucson city limits and by Tucson government operations. This inventory tracks emissions from stationary energy use by sector (electricity, natural gas), transportation (onroad, nonroad vehicle use), waste (solid and the City's portion of wastewater reclamation) and the City's portion of CAP (Other) energy use.
- Pima County Government Operations GHG Emissions Inventory: (hereinafter referred to as the County Government) Inventory includes emissions from the activities under the County Government's control and contains emissions from stationary energy use (facilities and parks, street and traffic lighting and wastewater reclamation), fleet (onroad, nonroad vehicle use), waste (solid and wastewater reclamation) and employee commuting.
- Tucson Government Operations GHG Emissions Inventory: (hereinafter referred to as the City Government) Inventory includes emissions from activities under the City Government's control and tracks emissions from stationary energy use (facilities and parks, street and traffic lighting, potable, reclaimed and CAP water handling), fleet (onroad, nonroad vehicle use), solid waste and employee commuting.

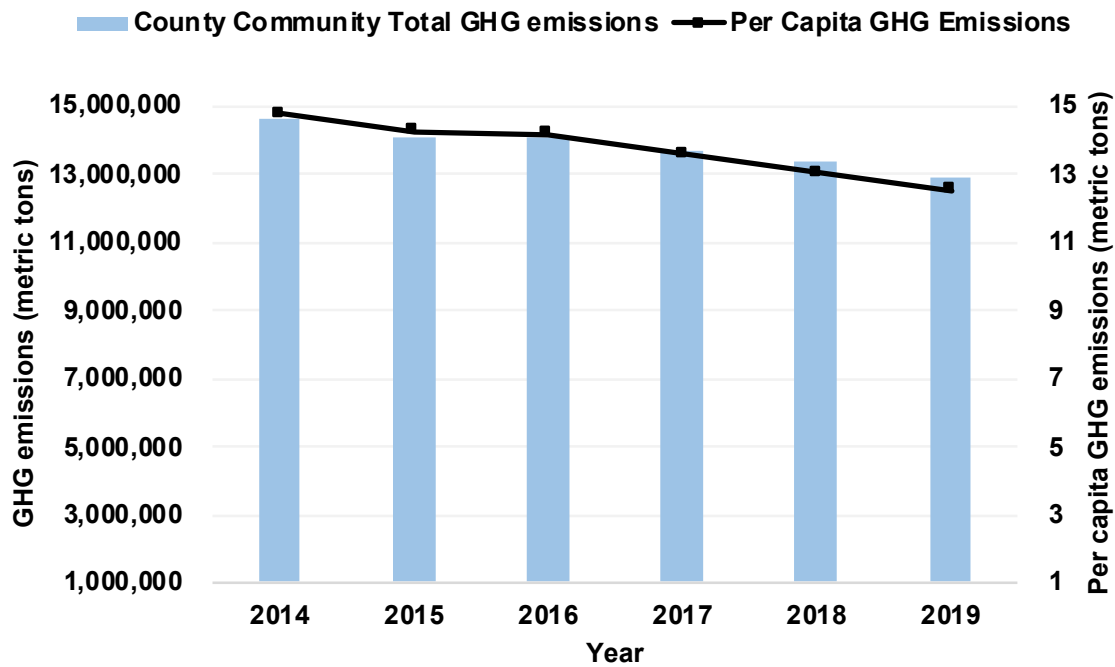
COMMUNITY INVENTORIES OVERVIEW

Generally, regional GHG emissions trends and sources mirror those of the United States. Over the 2014 to 2019 period, national GHG emissions declined by 4 percent from 6,825 million metric tons in 2014 to 6,558 million metric tons in 2019. The 2019 per capita emissions were 19.98 metric tons, down from 21.44 metric tons in 2014 (USEPA, 2021, US Census Bureau, 2019) (Appendix B).

Over the same period, County Community GHG emissions declined by 11 percent from 14.6 million metric tons in 2014 to 12.9 million metric tons in 2019, and per capita emissions also declined due to a combination of a drop in emissions and population growth trends over this time (Figure ES-1) (Appendix C and D). Eastern Pima County's 2019 per capita emissions were 12.52 metric tons, down from 14.80 metric tons in 2014 and Tucson Community's 2019 per capita emissions were 11.31 metric tons in 2019, down from 13.72 in 2014 (Appendix B).

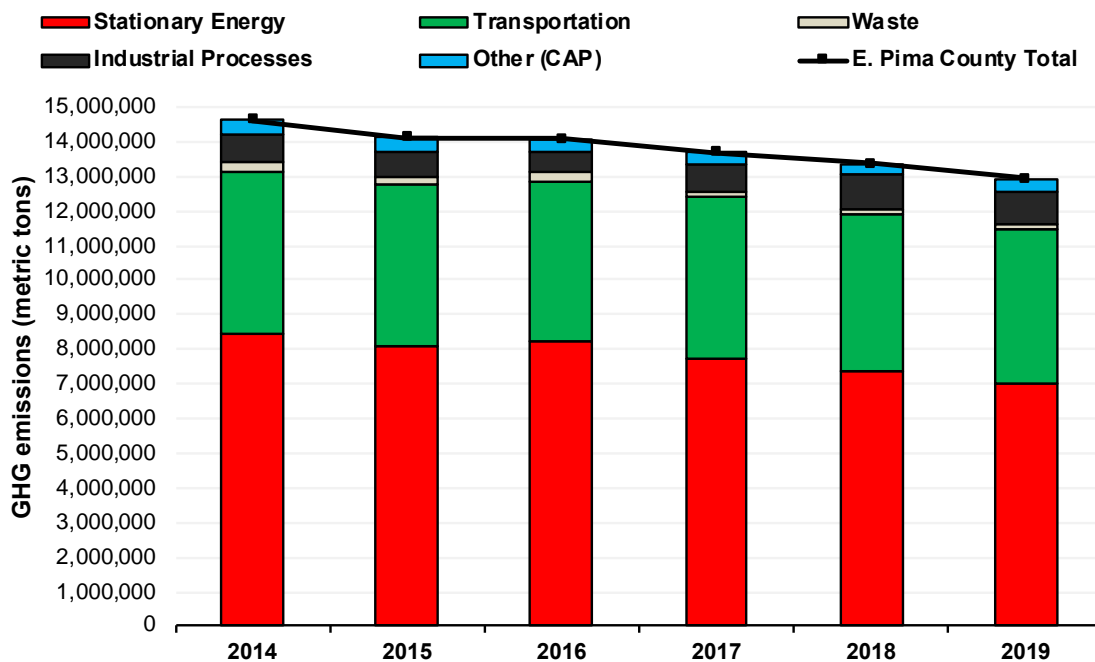
The major U.S. GHG emission sources were electricity use and transportation, as was true for both eastern Pima County and the City of Tucson.

Figure ES-1. County Community Greenhouse Gas and Per Capita Emissions 2014 to 2019



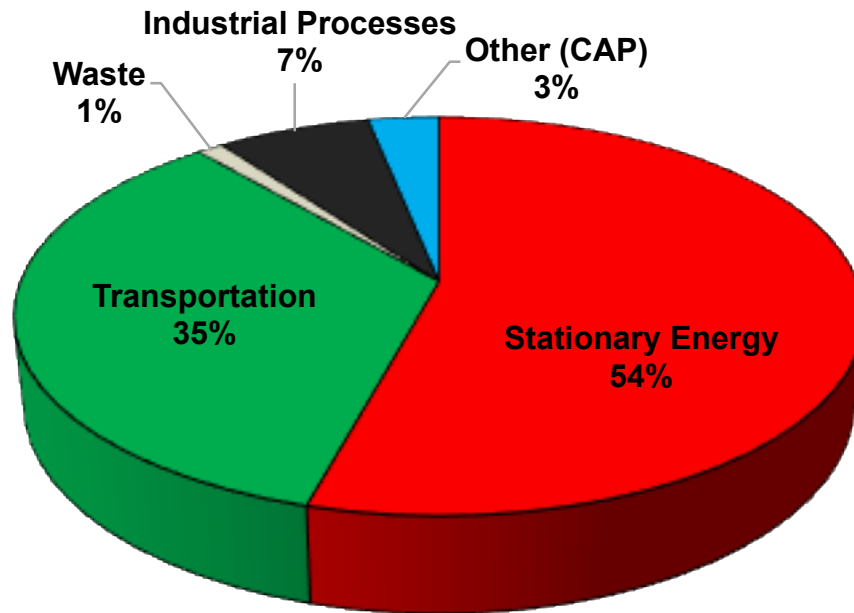
Over the inventory period, County Community emissions showed reductions in all categories except for industrial processes and CAP water delivery (other) (Figure ES-2). Stationary energy use was the major source of County Community emissions, averaging 57 percent of total emissions. Within the stationary energy sector, residential energy use was the major contributor (44 percent). Electricity use was responsible for 88 percent of stationary energy emissions and over half of total County Community emissions over the inventory period.

Figure ES-2. County Community Greenhouse Gas Emissions 2014 to 2019



Transportation was the other major source of emissions, averaging about one-third of total annual GHG emissions from 2014 to 2019. Private and commercial vehicle emissions comprised 74 percent of transportation emissions. Figure ES-3 shows the relative contributions of each sector to the 2019 total.

Figure ES-3. 2019 County Community Greenhouse Emissions by Source



From 2014 to 2019, City Community emissions dropped by 15 percent. Emission reductions occurred in all sectors (Figure ES-4). Energy use and transportation were the major sources of emissions in 2019 (Figure ES-5).

Figure ES-4. City Community Greenhouse Gas Emissions 2014 to 2019

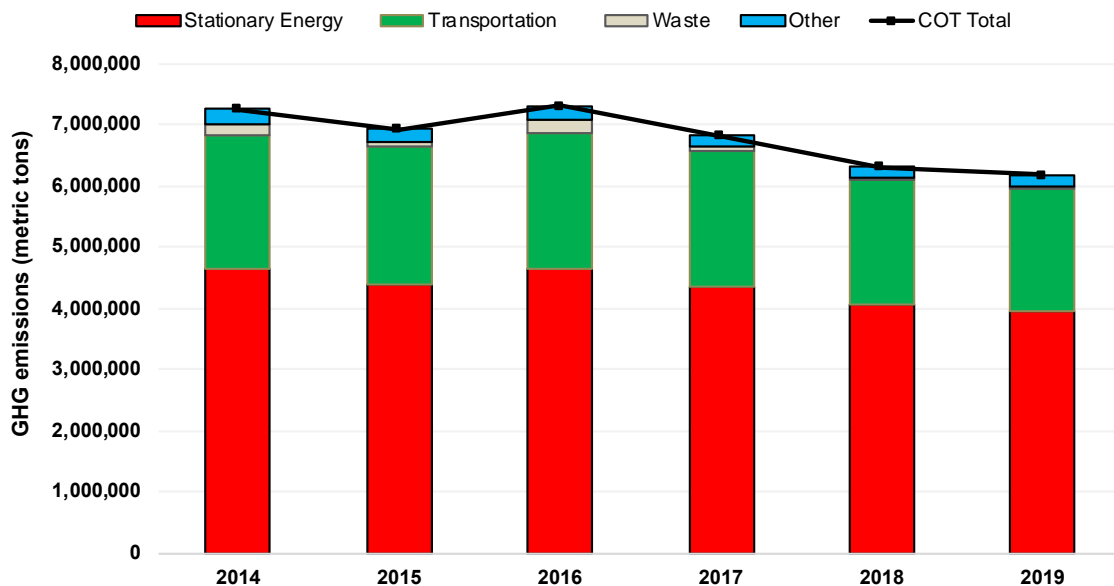
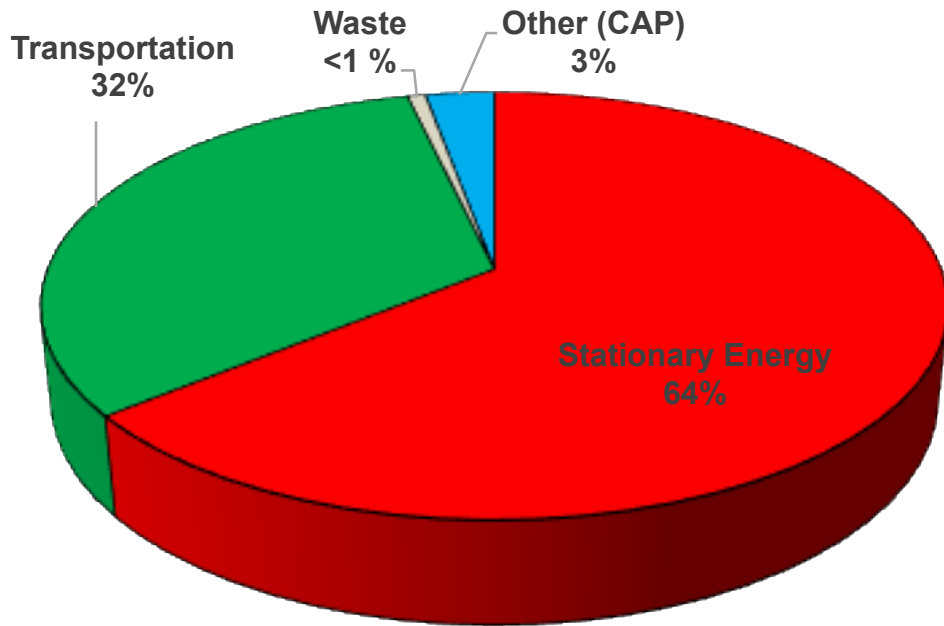


Figure ES-5. 2019 City Community Greenhouse Gas Emissions by Source



GOVERNMENT OPERATIONS INVENTORIES OVERVIEW

Government-generated emissions were a small portion of Community totals. Stationary energy, primarily electricity use, generated most of the County and City Governments' emissions.

From 2014 to 2019, County Government emissions dropped by 22 percent, due largely to reductions in the stationary energy and employee commute sectors (Figure ES-6). Nearly three-quarters of 2019 County Government emissions can be attributed to stationary energy use (Figure ES-7).

Figure ES-6. County Government Greenhouse Gas Emissions 2014 to 2019

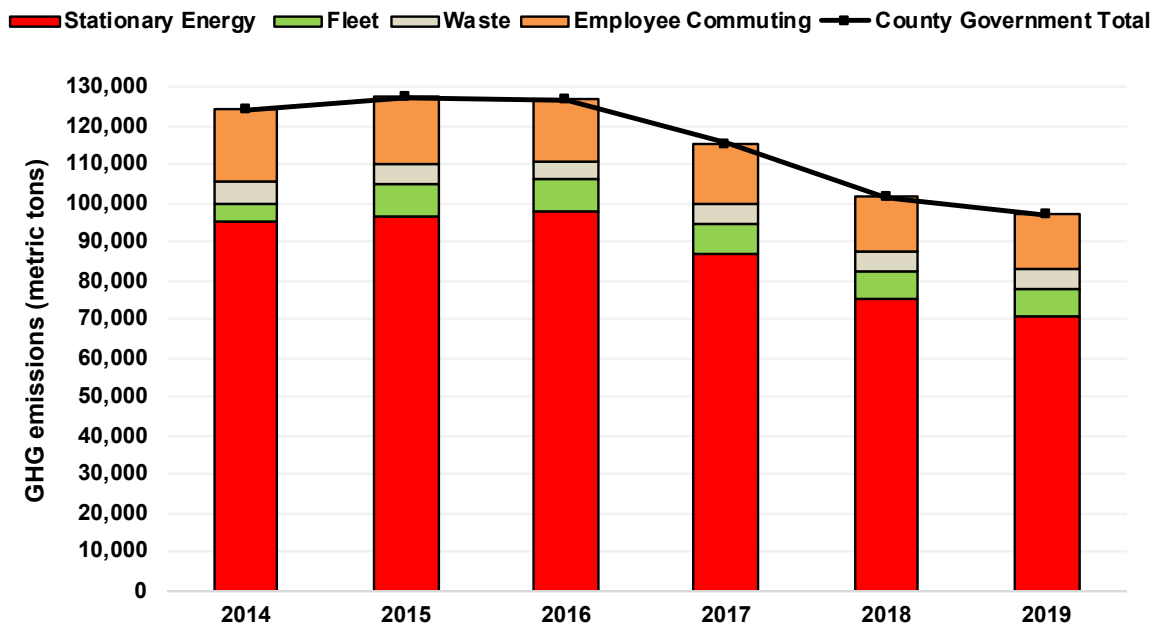
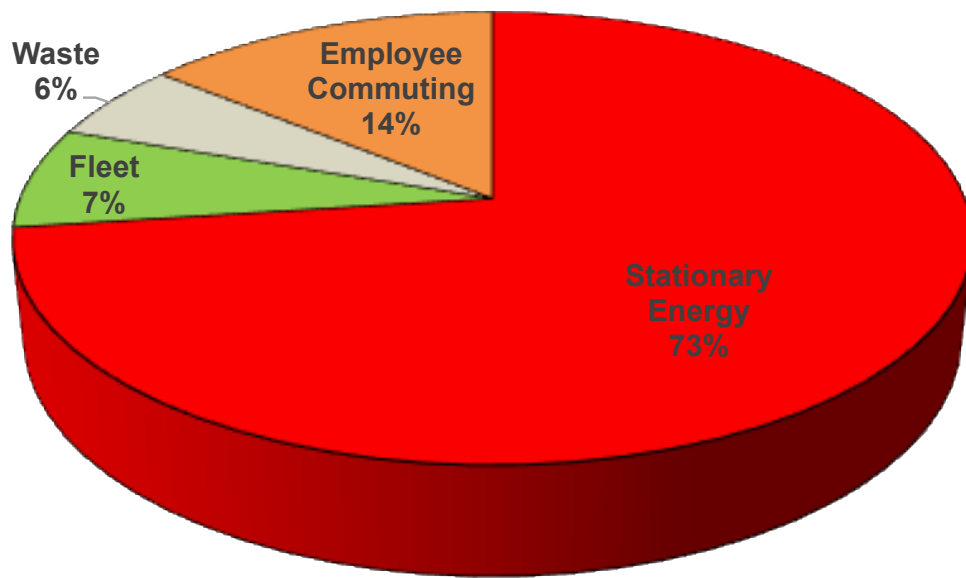


Figure ES-7. 2019 County Government Greenhouse Gas Emissions by Source



From 2014 to 2019, City Government emissions dropped by 6 percent reflecting slight reductions in all sectors overall (Figure ES-8). In 2019, stationary energy consumption emissions were the major source of City government emissions; water-related energy use was the predominant contributor to stationary energy use emissions (Figure ES-9).

Figure ES-8. City Government Greenhouse Gas Emissions 2014 to 2019

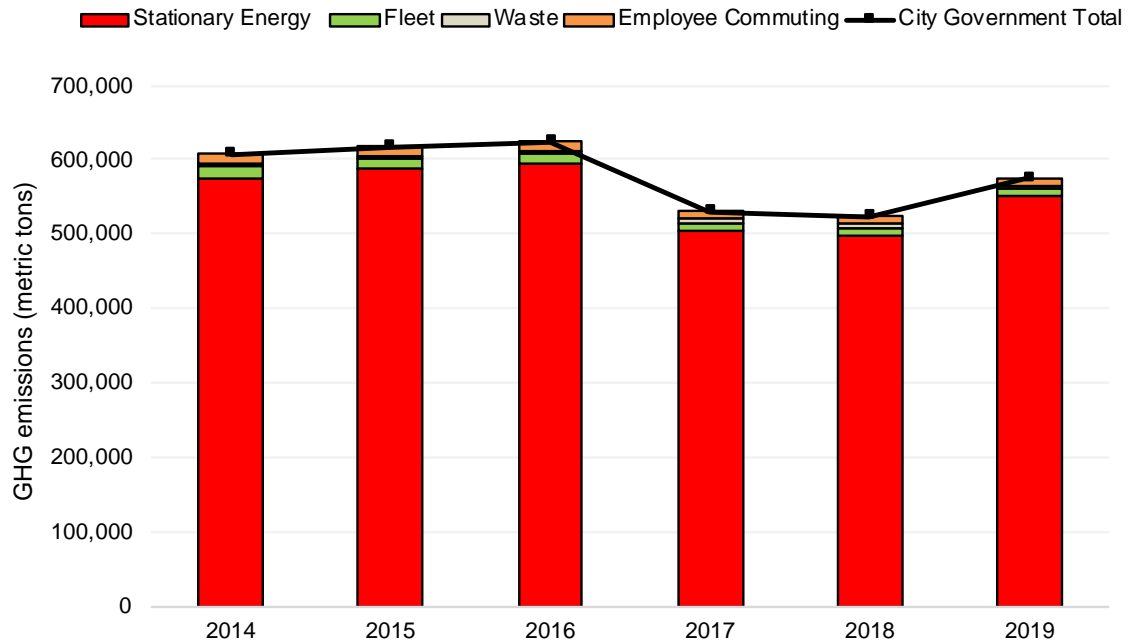
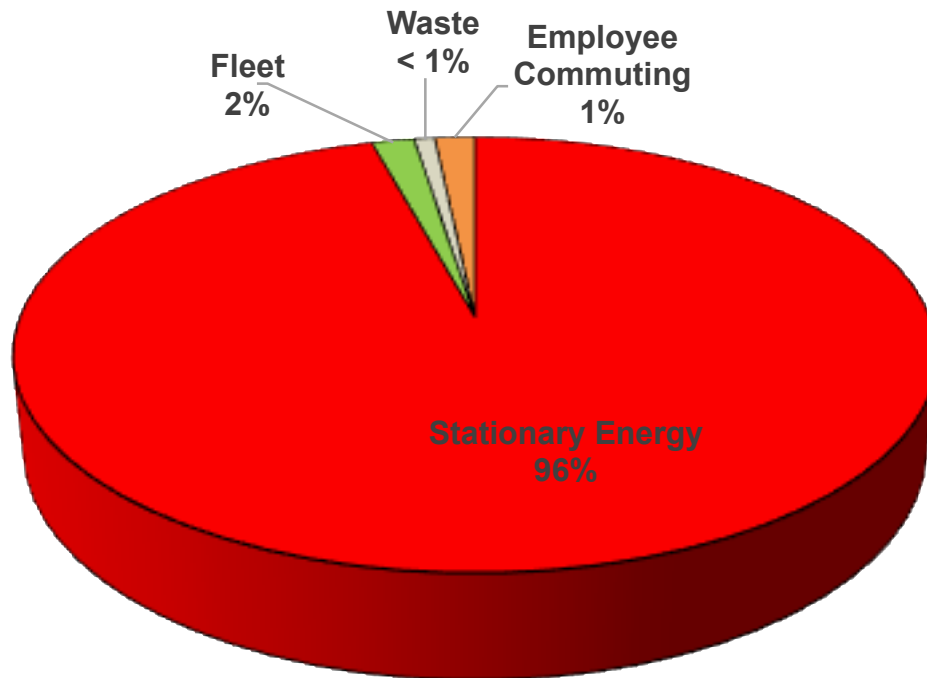


Figure ES-9. 2019 City Government Greenhouse Gas Emissions



BACKGROUND

In October 2007, the Pima Association of Governments' (PAG) Regional Council adopted a resolution directing staff to conduct a greenhouse gas (GHG) emissions inventory for eastern Pima County. The goal of this resolution was to generate a regional, broad-based GHG emissions inventory to provide baseline information and support PAG's regional partners in tracking progress and developing strategies to achieve their GHG reductions goals.

Both Pima County and the City of Tucson made and continue to make commitments to reduce energy, fuel use and GHG emissions. In 2017 the Pima County Board of Supervisors (Board) adopted Resolution 2017-39 and Resolution 2017-51, which direct the County government to align its operational efforts to meet the United States' commitment to the Paris Agreement on Climate Change. The Paris Agreement seeks to reduce global carbon emissions by 26 percent to 28 percent below 2005 levels by the year 2025.

In 2018, Pima County approved a new seven-year Sustainability Plan that strengthened Pima County's commitment to environmental sustainability by adopting rigorous greenhouse gas reduction targets and expanding other sustainability efforts within the County government (Pima County, 2018a). The Plan is a roadmap for the County to integrate emerging low-carbon technologies such as adding electric vehicles to the county fleet, and climate adaptation strategies to cool down the urban environment with green infrastructure. The Plan is an update of previous sustainability plans and was a follow up to the climate resolutions adopted by the Board in 2017. The Board adopted the first five-year sustainability plan in 2008, and a subsequent plan in 2013.

Also, in 2018, the Board approved a Memorandum of Understanding (MOU) to join the Tucson Emerging 2030 District along with the City of Tucson and University of Arizona. Representatives from the four organizations developed this agreement which makes them community partners in working collaboratively toward the goals of the District: reduce building energy and water consumption and climate-changing emissions from transportation by 50 percent by the year 2030.

In 2016, the City of Tucson approved funding for a neighborhood-scale stormwater harvesting program utilizing funds from the Water Conservation Fee. This program provides funding for neighborhood projects that slow down stormwater flow and distribute this water into green space along the city streets and public areas. The project's goal is to advance green infrastructure and alleviate the urban heat island effect. Tucson Clean and Beautiful, a non-profit organization, implements project applications, provides administrative oversight, and coordinates and manages the grant review and selection process.

Also, in 2016, the City of Tucson began a project to upgrade existing government-owned lighting to more energy efficient light emitting diodes (LEDs). Facilities that were included in this conversion included street and traffic lights, parking garages and underpasses.

In 2017, the Pima association of Governments provided grant funding to introduce a bike-share program in Tucson which now includes over 300 bikes in 36 locations strategically located throughout the City. This program provides public access to the bicycles for short trips, thereby circumventing the need to use motor vehicles.

In 2020, the City of Tucson declared a climate emergency and passed a resolution to develop and implement a 10-year Climate Action and Adaptation Plan. In 2021, the City of Tucson approved an Electric Vehicle (EV) Readiness Roadmap to increase citywide adoption of EVs.

PAG also manages programs that help reduce GHG emissions. PAG's support of the region's rainwater harvesting programs work at reducing the demand for potable water for irrigation. The Travel Reduction Program (TRP) promotes alternative transportation modes and carpooling to reduce single-occupancy vehicle travel, congestion and emissions. PAG completed the Arizona I-10 Alternative Fuels Corridor Deployment Plan for Electric Vehicle Charging and Compressed Natural Gas Fueling in 2020, which will result in increased adoption of lower lifecycle GHG vehicles.

PROJECT OBJECTIVES

The goal of this report is to track regional GHG emissions, identify major emission sources to assist regional officials and their staff in developing GHG reduction strategies and monitor progress on reaching GHG reduction goals. The inventory continues to be a living document and can be updated as new and more accurate data become available.

It is important to note that this report has not been validated by an independent party and is not a tool designed for developing regulations. Care also should be exercised in comparing the results of this inventory to those done by other communities since the sources analyzed and/or the GHG included could be different.

GENERAL METHODOLOGY

The ICLEI-Local Governments for Sustainability's *ClearPath* 2013 model was used to develop a basic level¹ emissions inventory for 2014 to 2019 County and City Communities and their respective government operations² inventories. The *ClearPath* model is an online GHG inventory tool available to local governments in support of the Global Covenant of Mayors for Climate & Energy through a membership with ICLEI. In 2014, an initiative was launched by the then U.N. Secretary-General Ban Ki-moon and his Special Envoy for Cities and Climate Change, Michael R. Bloomberg, under the leadership of the world's global city networks, C40 Cities Climate Leadership Group, ICLEI-Local Governments for Sustainability and the United Cities and local governments. This initiative establishes a consistent platform to assess cities' emissions and actions through standardized emissions measurement and a unified public reporting system.

The *ClearPath* model is an advanced web application and is the most widely used software tool for managing local climate mitigation efforts. This model estimates emissions from stationary energy use, transportation, waste, industrial processes and from other miscellaneous sources. The County/City Communities and Government operations inventories track these sources of emissions.

All inventories chart the County's and City's production of the three major GHGs: carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O). These are expressed as carbon dioxide equivalents (CO₂e). Hydrofluorocarbons (HFCs), perfluorocarbons

¹ U.S. Community Protocol for Accounting and Reporting of GHG Emissions requires the following activities of a basic level inventory: community electricity use; residential and commercial stationary combustion; onroad passenger and freight motor vehicle travel; energy use for potable and wastewater treatment and distribution and community-generated solid waste. (ICLEI, 2019)

² Local Government Operations Protocol for the Quantification and Reporting of GHG Emissions Inventories requires the reporting of stationary energy use, onroad/nonroad fleet vehicles; emissions from district energy and biogas combustion, waste disposal, wastewater treatment and employee commuting. (ICLEI, 2010)

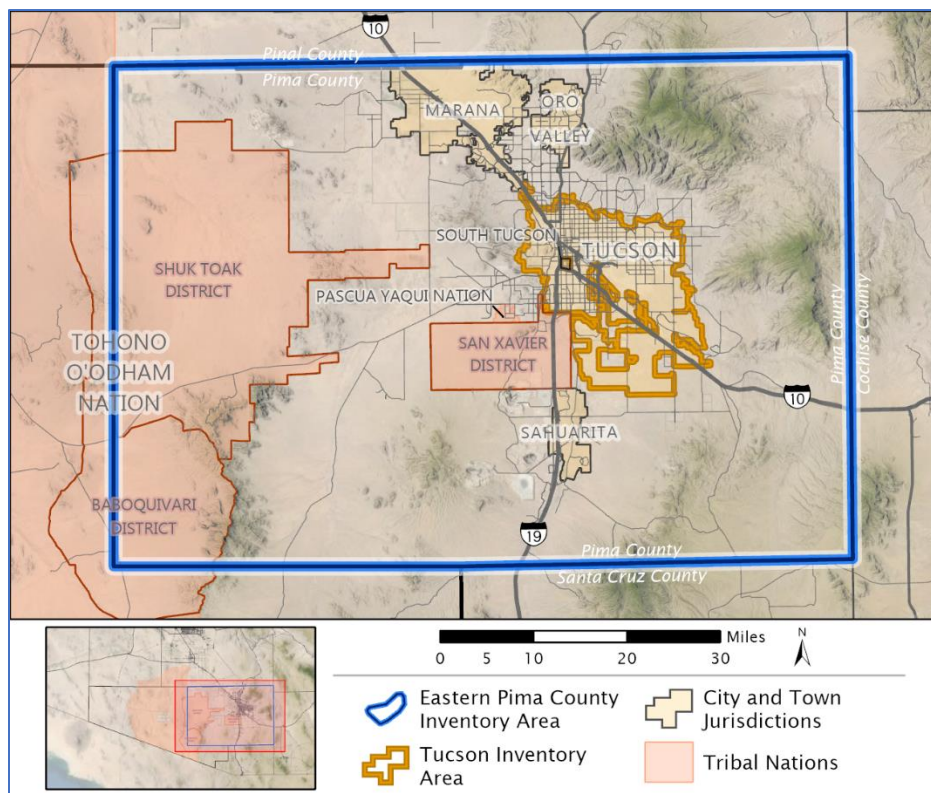
(PFCs) and sulfur hexafluoride (SF₆) emissions were not included since data were not available on these pollutants.

COMMUNITY INVENTORIES

Separate County and City Community inventories were prepared for 2014 through 2019. These inventories do not track all the GHG emissions generated in the region but were designed to track emissions attributed to the communities' actions and activities. The County Community inventory includes emissions generated by activities in unincorporated Pima County, Tucson, nearby cities and towns and tribal areas and their governments (Figure 1). The County Community inventory includes emissions from stationary energy use by the residential, commercial and industrial (RCI) sectors (electricity, natural gas, and diesel), transportation (onroad, nonroad vehicle use, locomotives and aircraft) waste (solid and wastewater processing), industrial processes and Central Arizona Project (CAP) energy use (Other).

The City Community inventory includes emissions generated by the community and by the City Government that lie within the City of Tucson's boundary (Figure 1). This inventory includes emissions from RCI sectors' energy use (electricity, natural gas), transportation (onroad, nonroad vehicle use), waste (solid and the City's portion of wastewater reclamation) and other, the proportion of CAP water that is associated with City Community use as estimated by Tucson Water staff.

Figure 1. Map of Boundaries for the County and City Community GHG Inventories



Emissions from the generation of electricity were tracked but not included in the County and City Community totals to avoid double counting. These emissions were included in the emission factor determination and the RCI sectors' electricity use emissions.

Stationary Energy

Residential, Commercial and Industrial (RCI)

RCI sectors' energy use includes fossil fuel combustion and grid-supplied electricity. The residential sector's GHG emissions are based on household energy used for heating, cooling and lighting, etc. The commercial sector encompasses electricity and natural gas used in non-residential buildings (e.g. schools, hospitals, retail, institutional and government-owned facilities). The industrial sector includes electricity, natural gas and diesel used in mining, agriculture and manufacturing operations.

Southwest Gas Corporation (SWG) staff provided 2014 through 2019 RCI natural gas use for eastern Pima County and for the City of Tucson. The Tohono O'odham Nation and Pascua Yaqui Tribe's natural gas use is captured in the SWG totals. Natural gas is the predominant component of fossil fuel consumption, but the County Community industrial sector also includes non-vehicle diesel use. Industrial diesel use data were supplied by Pima County Department of Environmental Quality (PDEQ) staff. Emissions from fossil fuel combustion are calculated using fuel volumes and *ClearPath* emission factors for natural gas and diesel.

Tucson Electric Power Company (TEP) natural gas use was removed from the County Community and City Community industrial natural gas volumes for all years. This was done to avoid double counting since the GHG released in the generation of electricity were incorporated into the electricity use totals and in the calculations of 2014 to 2019 TEP emission factors.

Electricity use data (2014 to 2019) by sector and jurisdiction were provided by TEP staff. TEP electricity use data were aggregated into customer classes based on average annual energy use, not necessarily by customer operations. Consequently, the industrial sector may include some large commercial operations, and the commercial sector may include some small industrial operations.

Trico staff provided electricity use data by sector and by jurisdiction. Trico staff indicated that the TEP emission factors were applicable to the electricity delivered by Trico. The Pascua Yaqui Tribe's electricity use was included in the County's Trico totals.

The Tohono O'odham Utility Authority (TOUA) staff provided electricity use data by sector for the Tohono O'odham Nation, which was included in the County Community inventory only. TOUA purchases electricity from TEP, so the TEP emission factors were used to estimate these GHG emissions.

Annual electricity generation emission factors for TEP and Trico were calculated by PAG staff using data supplied by TEP staff. Composite emission factors for each

inventory year were developed by first determining the fraction of electricity produced at each plant type and fuel type combination as compared to the total annual generation. Each plant/fuel type combination has a unique emission factor (pounds GHG/MWh); see formulas below. The composite annual emission factor was determined by calculating the weighted average of the individual plant/fuel emission factors (Appendix E).

$$\text{Fraction} = \text{Annual MWh (by Plant/Fuel type)} / \text{Total Annual Electricity Generation (MWh)}$$
$$\text{Annual Electricity Generation Emission Factor} = \text{sum (Fractions} \times \text{Unique Generation Factor)}$$

Stationary energy emissions from RCI natural gas and electricity use were based on end-use energy consumption data; emissions from the local generation of electricity are listed under Energy Industries (Table 1 and Table 3) but are not included in the County or City Community totals to avoid double counting.

Transportation

Onroad

Private and Commercial Vehicle Travel

The annual vehicle miles traveled (VMT) shown in Appendices F and G represent total travel that occurred in eastern Pima County and the City of Tucson, respectively. It represents VMT by the jurisdictional residents, visitors and pass-through travelers. It does not include travel by community residents outside of these jurisdictions. This calculation method will over-report emissions for jurisdictions with a high proportion of pass-through traffic³.

Annual VMT, meteorological, vehicle inspection parameters, Arizona Department of Transportation's Pima County vehicle registrations, fuel, speed and vehicle travel patterns data were developed for 2014 through 2019 for eastern Pima County and for the City of Tucson by PAG staff. EPA's MOVES2014b model was used to estimate annual GHG emissions for all onroad vehicles' use/travel. Transit emission totals were removed from the County and City GHG onroad annual totals and calculated independently.

Public transit

Various regional transportation providers (Appendix A) submitted VMT by fuel type and jurisdiction. County transit data included all VMT/fuel data from Cat Tran, the Loop, Sun Shuttle ADA Dial-a-Ride, Sun Shuttle, Oro Valley Sun Shuttle, Sun Tran, Sun Link and Sun Van (Appendix F). For transit operating within the City of Tucson boundary, City VMT/fuel data were collected from Cat Tran, the Loop, Sun Shuttle ADA Dial-a-Ride, Sun Shuttle, Sun Tran, Sun Link and Sun Van (Appendix G).

County and City transit fuel use fractions, weighted by jurisdictional VMT, were developed for 2014 through 2019 to create MOVES2014b input files using the data supplied by local transit providers. Individual MOVES2014b runs were conducted for

³ ICLEI. 2019

each of the inventory years using the County and City transit VMT/fuel mix. Unique transit emission factors by jurisdiction were calculated based on the MOVES2014b model outputs (kilograms CO₂e/mile) and each emission factor was applied to the total transit VMT for each year and jurisdiction.

Total emissions from all public transit are reported as “Transit” for the County and City communities in Tables 1 and 3, and in Figures 5 and 10, respectively.

Nonroad

EPA’s MOVES2014b model was used to calculate Pima County nonroad vehicle emissions. In addition to being an onroad emissions model, the MOVES2014b model houses a nonroad vehicle component, which is a modified version of the EPA’s original 2009 NONROAD2008a model.

Nonroad vehicles include those from the agricultural, commercial, industrial and construction industries and residential lawn and garden equipment, airport and railroad support and recreational vehicles. County Community nonroad emissions represent 98.9 percent of the total Pima County MOVES2014b emission results reflecting the population, employment and land use data for the eastern portion of Pima County.

City Community nonroad emissions were estimated by applying the City:County population ratio to County nonroad emissions for each year since many of the MOVES2014b model emissions allocation factors are based on human population and associated activities.

Locomotives

Emissions from locomotive travel within eastern Pima County were calculated using diesel consumption data submitted by Union Pacific Railroad staff and a diesel emission factor (0.01 metric tons CO₂e/gallon) embedded in the *ClearPath* model. Only the County Community inventory contains locomotive emissions due to the difficulty in separating rail tracks by jurisdiction.

Aircraft

Volumes of dispensed aviation gas and Jet A data (2014 to 2019) were collected from the various airport staff for Marana, La Cholla and Tucson International Airport (TIA), Davis Monthan Air Force Base and Ryan Airfield (Appendix A).

Emissions were calculated using the aviation gas and Jet A emission factors found in the *ClearPath* model. Aircraft-associated emissions are included in the County Community inventory only due to the complexity of separating City and County airspace.

Waste

Solid waste disposal

County Community waste totals and emissions include those from Los Reales, Sahuarita, Marana Regional and Speedway landfills (2014 to 2019, as applicable). Solid waste disposal totals and emissions for Los Reales (2014 to 2019) and Marana Regional (2018-2019) landfills were obtained from the EPA's Greenhouse Gas Reporting Program (USEPA, 2020a). Emission totals were also obtained from EPA's Greenhouse Gas Reporting Program for the Tangerine Landfill, which opened in 1983 and closed in 2013 but continues to generate methane emissions.

The Speedway Recycling and Landfill Facility (2014 to 2019) disposal totals were provided by ADEQ and landfill staff. Sahuarita landfill waste totals were supplied by Tucson Waste and Recycling staff. Sahuarita landfill stopped accepting waste in 2016.

Emissions for Marana Regional (2014 to 2017) and the Sahuarita (2014 to 2016) landfills were estimated by adapting the EPA's Greenhouse Gas Reporting Program's Subpart HH Municipal Solid Waste Landfills (40 CFR part 98) calculations conducted by Waste Management staff for its 2018 submittal (USEPA, 2013).

Speedway landfill debris was characterized using data from a Cascadia construction and demolition waste study (Cascadia, 2006) (Appendix H). Waste emission factors embedded in the *ClearPath* were used to estimate the Speedway landfill GHG emissions.

The City Community waste emissions and waste volume totals represent those from Los Reales and Speedway landfills only.

Emissions from waste disposal depend on the waste composition and the treatment of the waste and landfill gas. The methods for calculating landfill GHG emissions are different for landfills having active gas collection systems, such as at the Los Reales Landfill (USEPA, 2020b). Emissions from landfills with gas collection systems tend to produce less GHG emissions than those that lack a gas collection system (USEPA, 2020b).

Wastewater reclamation

Pima County staff provided data for all regional facilities (2014 to 2019), and *ClearPath* model emission factors were used to calculate GHG emissions from the nitrification/denitrification process, lagoon treatment, digester gas flaring and digester gas combustion for onsite energy production. The Town of Marana staff provided wastewater processing emissions data for its facility (2014 through 2019).

For year 2014 inventory data, 75 percent of County Government wastewater-associated process emissions were attributed to the City. For years 2015 through 2017, 73 percent of the County Government wastewater-associated process emissions were attributed to the City. For year 2018 and 2019, 76 percent of the County Government wastewater-associated process emissions were attributed to the City. These fractions

reflect the estimated portion of City's wastewater that is treated at the County Government facilities as estimated by Pima County's Regional Wastewater Reclamation Department (RWRD) staff.

Recycled materials

The *ClearPath* model does not include a method to estimate GHG emissions sinks or reduction benefits. County and City Community recycling emissions and energy savings are presented for informational purposes only and are not incorporated into the calculations for County or City Community GHG totals.

Recycling emission and energy reductions were estimated using the EPA's Waste Reduction Model (WARM) Version 15 – May 2019, updated November 2020 (USEPA, 2020c). The model uses a life-cycle approach, accounting for emissions avoided in producing replacement materials (upstream) and disposal-related emissions (downstream). Calculations are based on the difference between the CO₂e emitted and energy expended if materials were landfilled and the savings realized through alternate waste management practices such as recycling (Appendix I).

County Community recycling totals are from all eastern Pima County activities. County staff provided totals from private haulers and Tucson Waste and Recycling staff provided data from the Sahuarita Landfill. The results of the Cascadia Consulting Group's study, commissioned by the City of Tucson, were used to characterize the County's recyclable materials (Cascadia, 2014) (Appendix H).

The City Community recycling totals represent activities occurring within the City of Tucson's boundary only. The City's Environmental Services staff provided recycling data which included curbside, commercial, community and Los Reales collections. The recycled materials were characterized by the Environmental Services staff and emission and energy reductions were estimated using the EPA's WARM model.

Industrial Processes

County Community emissions from the CalPortland Company Rillito Cement Plant (2014 to 2019) were obtained from the EPA GHG Reporting Program (USEPA, 2020a).

City Community industrial process emissions were not included in the inventory since those facilities listed in the PDEQ inventory data and the EPA GHG reporting system showed natural gas combustion as the only CO₂e source. These emissions were included in the industrial SWG totals.

Other

Emissions from the electricity used to deliver CAP water to Tucson Water facilities were listed as "Other." CAP electricity use data (2014 to 2019) were provided by Tucson Water staff. Electricity used for CAP pumping is primarily from the Navajo Generating Station (NGS), which ceased operations in November 2019. Electricity generation emission factors for the NGS (Appendix E) were calculated by PAG staff using the EPA GHG emissions reporting data (2014 to 2019) (USEPA, 2020a) and Department of

Energy's 2014 to 2019 energy production survey Form EIA-923 (DOE, 2019).

To estimate electricity use, Tucson Water staff calculated the kWh needed to pump water to individual pumping stations to deliver one acre-foot⁴ (AF) of water to every location used by Tucson Water. A composite pumping electricity factor was developed for each year as the weighted average of the kWh/AF calculated for each facility (Philbin, A. 2012). This emission factor was applied to the total annual acre-feet delivered to Tucson Water facilities.

Energy Industries

These emissions were provided for informational purposes only, since they were already captured in the RCI electricity use emission factors and emissions. County emissions (2014 to 2019) from energy generation (TEP's H. Wilson Sundt, DeMoss Petrie power plants) were obtained from the EPA's Greenhouse Gas Reporting Program (USEPA, 2020a). PDEQ staff provided natural gas consumption information for TEP's North Loop facility. Emissions from North Loop were estimated using the gas consumption volumes and *ClearPath* natural gas emission factors. Emissions from these three facilities are shown in the County Community inventory summary (Table 1).

Energy industries data for City Community include the emissions associated with the TEP H. Wilson Sundt and DeMoss Petrie plants generation only.

GOVERNMENT OPERATIONS INVENTORIES

Separate County and City Government inventories were prepared for the 2014 through 2019 period. Government inventories encompass emissions generated from sources under the management of the specific government entity. The County and City Government inventories tracked emissions from stationary energy use, fleet activity, waste and from employee commuting.

Stationary Energy

The County Government inventory includes purchased natural gas and electricity used in government facilities and parks, wastewater reclamation and electricity used for street and traffic lighting. All data were provided by Pima County staff.

The City Government inventory accounts for emissions from purchased electricity used in facilities and parks, fleet operations, CAP, combined potable and reclaimed water pumping/delivery totals and street and traffic lighting. Additionally, emissions resulting from the use of natural gas from government facilities, potable water handling and district energy generation were included.

The City Government purchases hot and chilled water and electricity from a district energy source operated by NRG Tucson. Natural gas is combusted, and this energy is

⁴ An acre-foot (AF) equals 325,851 gallons, approximately the amount of water used by a family of four for one year.

Greenhouse Gas Inventory Report

used to provide hot and chilled water to the Tucson Convention Center and hot and chilled water and electricity to police and fire station buildings in downtown Tucson, a total of six buildings.

The Bureau of Indian Affairs provides a portion of electricity for potable water pumping, but no emissions are associated with it since it is primarily hydropower.

Fleet

Onroad

Onroad VMT by fuel and vehicle type data were provided by County and City government staff for 2014 to 2019. The emission factors developed in the County Community EPA's MOVES2014b model runs were applied to the County and City fleets' VMT by vehicle type (passenger cars, motorcycles, light duty trucks and heavy-duty trucks) for inventory years 2014 through 2019. Emissions for each vehicle type were totaled by the inventory year and jurisdiction to estimate County and City Governments' fleet onroad emissions.

Nonroad

Nonroad vehicle fuel use data were provided by County and City government staff for 2014 to 2019. Emissions were calculated using *ClearPath* specific fuel emission factors for nonroad vehicles.

Waste

Solid waste

Government-generated solid waste totals (2014 to 2019) were supplied by County staff and City of Tucson staff.

Government solid wastes were characterized using the Default California Waste Characterization, 2007-Present (ICLEI, 2010) (Appendix H). Emissions were estimated using this characterization and waste emission factors contained in the *ClearPath* model.

Wastewater reclamation

The County Government wastewater reclamation emissions for 2014 to 2019 were calculated using data submitted by County staff and *ClearPath* emission factors for nitrification/denitrification and lagoon treatment and the flaring and combustion of digester gas.

Recyclables

The *ClearPath* model does not contain a tool to estimate GHG emissions sinks or reduction benefits. Recycling emissions and energy savings are presented for informational purposes only and were not used to calculate County or City Government inventory totals. County and City staff provided the recycling totals (2014 to 2019).

Recycling emission and energy reductions were estimated using the EPA's WARM Version 15 – May 2019, updated November 2020 (USEPA, 2020c). The results of the Cascadia Consulting Group's study commissioned by the City of Tucson were used to characterize the County and City Governments' recycled materials (Cascadia, 2014) (Appendix H).

Employee Commute

PAG's Travel Reduction Program (TRP) began in 1989 to reduce carbon monoxide levels and traffic congestion in the Tucson metropolitan area. Surveys are sent on a regular basis to regional employers with 100 or more full-time employees. The data in this section represents the most recent results from the County and City governments' employee surveys.

TRP staff provided County Government employees' survey data for annual, roundtrip drive-alone and carpool commuting VMT for 2014 through 2019.

TRP staff provided City government employees' survey data for annual, roundtrip drive-alone and carpool VMT for 2014 through 2019.

County and City Government employee commuting emissions (2014 to 2019) were estimated using a composite emission factor for each survey year (kilograms CO₂e /mile) calculated from VMT-weighted factors for "commuter vehicles" (motorcycles, passenger cars and passenger trucks) and multiplied by the number of miles driven. County and City Community MOVES2014b results for each year were used to calculate the VMT-weighted emission factors for County and City government employees, respectively.

Solar Energy Generation

County and City Government solar energy production data are included for information purposes only since no GHG emissions were produced. The solar produced and used by Government operations reduces their respective GHG emissions. In addition, the County and City Governments purchase 9,000,000 kWh/year and 1,428,150 kWh/year, respectively, through TEP's Community Solar program resulting in an overall lower GHG emission factor per kWh delivered by TEP.

COMMUNITY INVENTORY RESULTS

EASTERN PIMA COUNTY REGIONAL INVENTORY OVERVIEW

From 2014 to 2019 County Community emissions dropped by 1.67 million metric tons, or 11 percent (Figure 2, Table 1). Emission reductions occurred in all categories except for industrial processes and CAP water delivery (other).

For all inventory years, stationary energy use was the major contributor to GHG emissions, averaging about 57 percent of annual total emissions (Figure 3). Around 88

percent of these stationary energy emissions resulted from electricity use; natural gas and non-vehicle diesel use were responsible for the remaining 12 percent.

Transportation emissions (onroad, nonroad vehicle use, aircraft and railroad) averaged about one-third of total GHG emissions during the inventory years. Private and commercial vehicle travel was the largest component of these emissions, contributing about 74 percent to the total transportation emissions.

Figure 2. County Community Greenhouse Gas Emissions 2014 to 2019

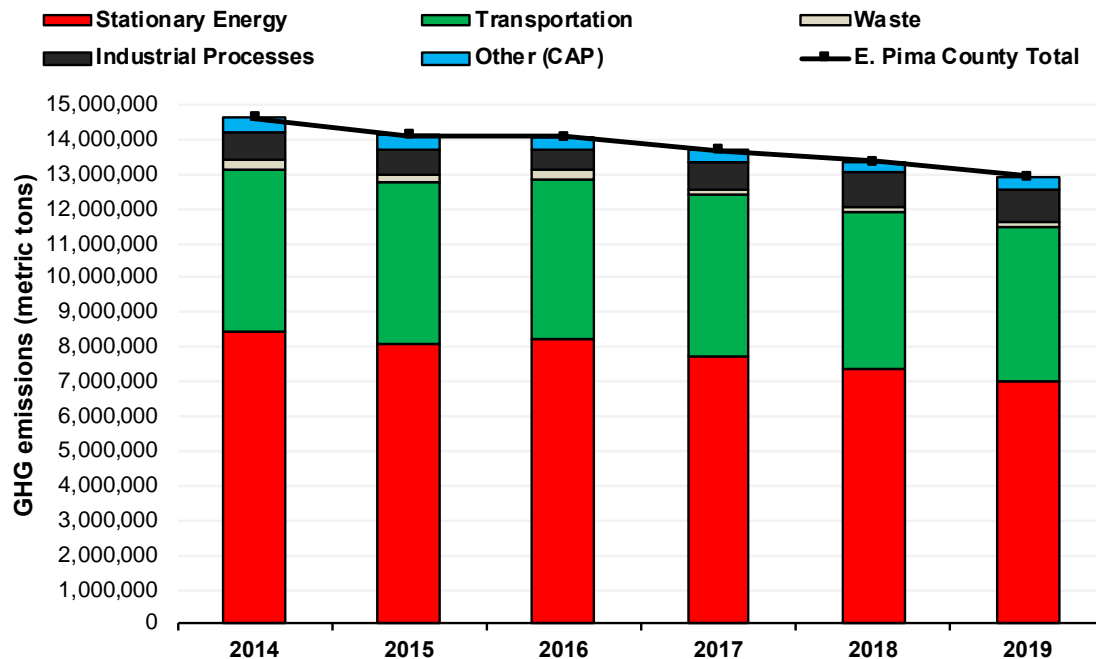
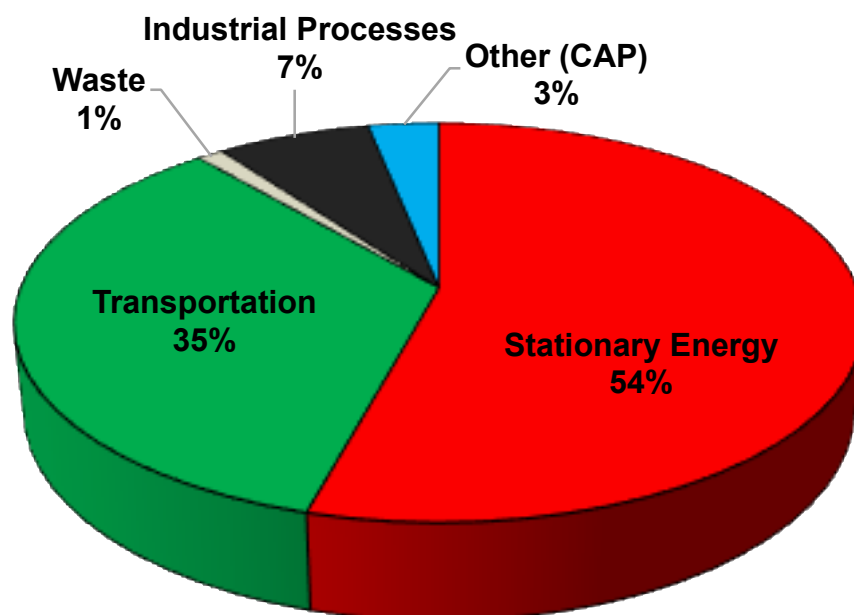


Figure 3. 2019 County Community Greenhouse Gas Emissions by Source



Stationary Energy

In 2019, stationary energy was the largest source of County Community GHG emissions (Figure 3). From 2014 to 2019, total RCI energy use and emissions fell by 17 percent. All the sectors showed a drop in emissions (Table 1).

In 2019, stationary energy use generated 54 percent of annual emissions (Figure 3). As in other inventory years, residential energy use was the largest component (45 percent) of 2019 stationary energy use emissions (Figure 4). A more detailed discussion of each source follows.

Residential Energy Use

From 2014 to 2019, residential energy use emissions dropped by 15 percent, reflecting a shift toward low and zero emissions sources of electricity generation and use, despite a 25 percent increase in natural gas use. Estimated 2019 County Community per household energy-associated emissions was approximately 7.86 metric tons per year (Appendix D).

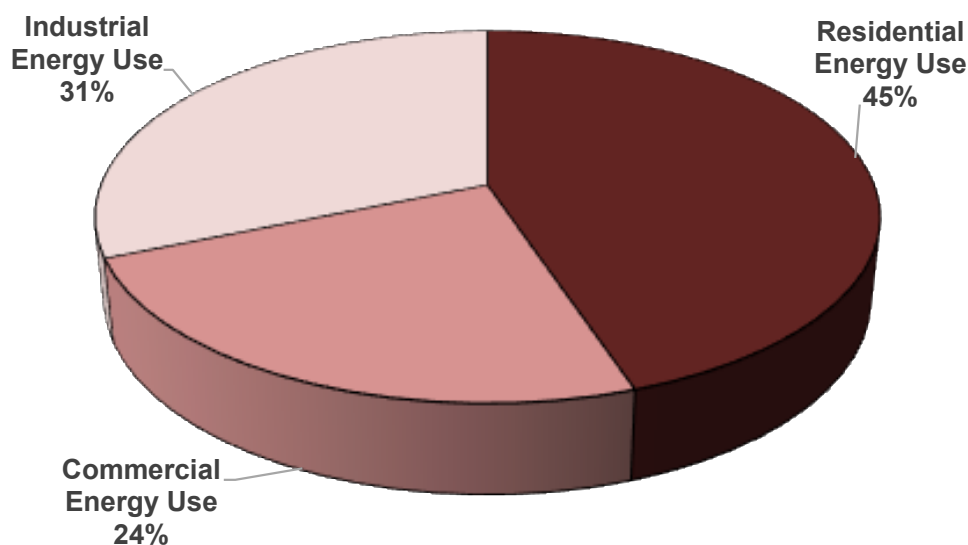
Residential energy use contributed 24 percent to the 2019 County Community emission total.

Commercial Energy Use

Commercial energy use emissions fell by 19 percent over the inventory period, again reflecting a shift toward low and zero emission sources and lower use of electricity, even with a 9 percent increase in natural gas use.

In 2019, commercial energy use produced 13 percent of the total County Community emissions.

Figure 4. 2019 County Community Stationary Energy Emissions



Industrial Energy Use

Industrial energy use includes emissions from electricity use and fossil fuel combustion (natural gas and diesel). From 2014 to 2019, sector emissions declined by about 19 percent, indicating a shift toward low and zero emission and lower use of electricity despite a 123 percent increase in natural gas use.

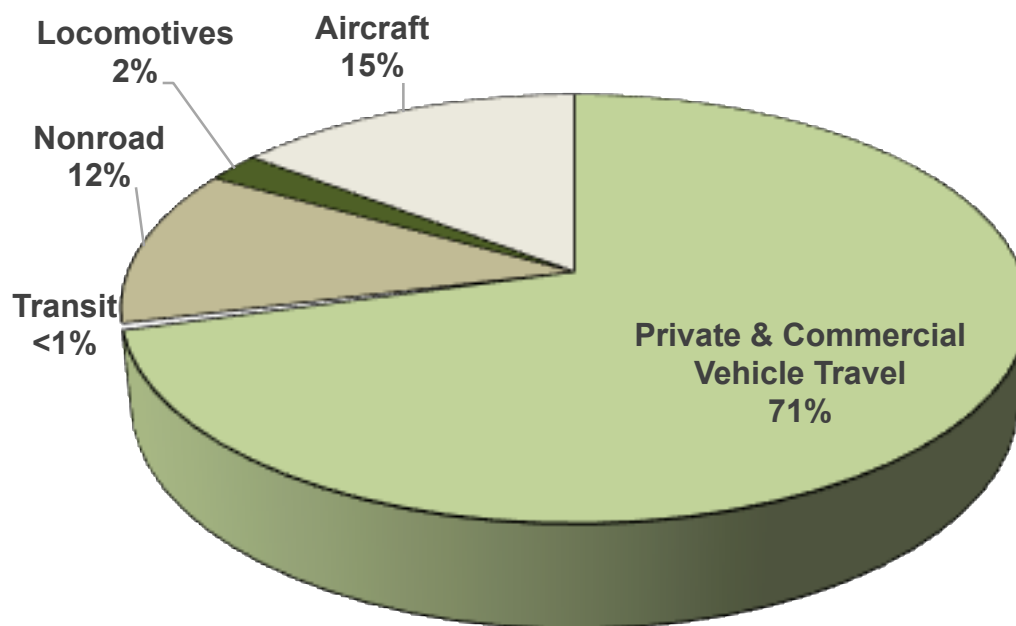
Industrial energy emissions were 17 percent of the 2019 total County Community emissions.

Transportation

Transportation emissions averaged about one-third of total County Community emissions over the inventory period. Overall, transportation emissions dropped by 4 percent (Table 1) from 2014 to 2019, reflecting declines in most of the subcategories (private and commercial vehicle travel, nonroad and transit) while there was an increase in aircraft and locomotive emissions.

In 2019, transportation emissions were 35 percent of the County Community total (Figure 3).

Figure 5. 2019 County Community Transportation Emissions



Onroad

Private and commercial vehicle travel

Regional private and commercial vehicle travel averaged 71 percent of regional transportation emissions in 2019. Over the inventory period, emissions dropped by 11 percent, although VMT increased by 5 percent (Appendix F). This drop in emissions was due to improved vehicle fuel efficiencies.

In 2019, private and commercial vehicle emissions were 24 percent of the County Community total.

Public transit

Over the inventory period, there was a 2 percent decrease in transit VMT and a 7 percent decrease in transit-related GHG emissions. In 2019, transit emissions were responsible for less than 1 percent of transportation emissions (Figure 5).

Nonroad

Nonroad emissions represent the 2014 to 2019 MOVES2014b model results based on eastern Pima County population, sector employment and land use data. Over the inventory period, nonroad emissions increased by 10 percent.

Nonroad vehicle emissions were 12 percent of 2019 transportation emissions and about 4 percent of 2019 total County Community emissions.

Locomotives

Emissions from Union Pacific Railroad County travel increased by 19 percent over the inventory period, due to an increase in intermodal freight over this period (UPRR, 2020).

In 2019, locomotive emissions were 2 percent of 2019 transportation emissions (Figure 5) and less than 1 percent of total County emissions.

Aircraft

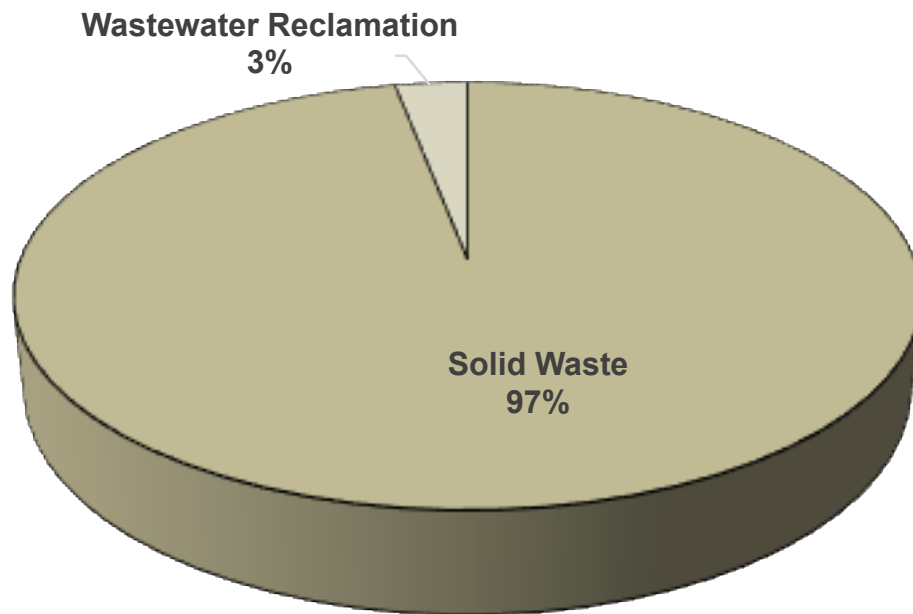
Aircraft emissions represent the combustion of Avgas and Jet A dispensed at the TIA, Marana and La Cholla Airports, Ryan Airfield and Davis Monthan Air Force Base. Emissions from aircraft emissions increased by 33 percent over the inventory period.

In 2019, aircraft emissions represented an estimated 15 percent of the transportation emissions (Figure 5) and 5 percent of the total County emissions.

Waste

From 2014 to 2019, total waste emissions dropped by 47 percent. In 2019, as in other years, solid waste disposal accounted for the majority of waste emissions and was 97 percent of total waste emissions (Figure 6). Waste remains a small component (just over 1 percent) of the 2019 County Community emissions total (Figure 3).

Figure 6. 2019 County Community Waste Emissions



Solid Waste

From 2014 to 2019, waste disposal emissions declined by 48 percent (Table 1). These emissions vary by waste composition and the handling of landfill gas. By 2019, only three County Community landfills, Los Reales, Marana Regional and Speedway Recycling and Landfill Facility were open and receiving waste (Appendix F). Only Los Reales has a landfill gas recovery system that captures the gas and uses it for energy generation. This recovery process is factored into the EPA's method of calculating landfill emissions (USEPA, 2020a) and generally results in lower emissions than facilities lacking a gas capture system.

Table 1. County Community GHG Emissions (metric tons CO₂e) 2014 to 2019

	2014	2015	2016	2017	2018	2019	Percent CO ₂ e change 2019 - 2014
	CO ₂ e (metric tons)	CO ₂ e (metric tons)	CO ₂ e (metric tons)	CO ₂ e (metric tons)	CO ₂ e (metric tons)	CO ₂ e (metric tons)	
STATIONARY ENERGY							
Residential							
Fossil fuel combustion	373,794	399,392	412,129	362,466	385,247	466,543	
Grid-supplied electricity	3,309,504	3,139,064	3,258,605	3,095,519	2,900,831	2,679,347	
Residential Subtotal	3,683,298	3,538,456	3,670,734	3,457,985	3,286,078	3,145,890	
Commercial							
Fossil fuel combustion	292,245	295,355	293,087	287,307	297,377	318,599	
Grid-supplied electricity	1,776,267	1,635,591	1,698,510	1,613,407	1,494,430	1,361,977	
Commercial Subtotal	2,068,512	1,930,946	1,991,597	1,900,714	1,791,807	1,680,576	
Industrial							
Fossil fuel combustion	147,083	300,122	261,403	288,418	293,952	327,334	
Grid-supplied electricity	2,551,056	2,349,889	2,294,991	2,089,085	2,006,570	1,863,532	
Industrial Subtotal	2,698,139	2,650,011	2,556,394	2,377,503	2,300,522	2,190,866	
STATIONARY ENERGY TOTAL	8,449,949	8,119,413	8,218,725	7,736,202	7,378,407	7,017,332	-17
TRANSPORTATION							
Onroad							
Private & commercial vehicle travel	3,563,731	3,500,811	3,442,697	3,453,724	3,228,722	3,154,601	
Transit	23,829	23,139	26,005	24,990	22,862	22,074	
Onroad Subtotal	3,587,560	3,523,950	3,468,702	3,478,714	3,251,584	3,176,675	
Nonroad	485,158	471,753	480,265	498,565	519,259	532,403	
Locomotives	84,820	65,417	74,991	74,389	121,910	100,752	
Aircraft	492,489	605,647	585,427	618,510	657,670	653,078	
TRANSPORTATION TOTAL	4,650,027	4,666,767	4,609,385	4,670,178	4,550,423	4,462,908	-4
WASTE							
Solid waste disposal	284,926	156,688	282,141	133,188	137,855	147,331	
Wastewater reclamation process	3,643	3,572	3,573	3,576	3,884	4,627	
WASTE TOTAL	288,569	160,260	285,714	136,764	141,739	151,958	-47
INDUSTRIAL PROCESSES TOTAL	832,824	769,167	552,814	801,277	954,086	893,556	7
OTHER- Central Arizona Project	387,402	412,461	418,268	342,686	346,538	412,352	6
E. PIMA COUNTY COMMUNITY TOTAL	14,608,771	14,128,068	14,084,906	13,687,107	13,371,193	12,938,106	-11
ENERGY INDUSTRIES TOTAL*	659,503	596,106	486,357	471,448	876,258	1,031,696	56

* Data not included in totals

Wastewater Reclamation

Process emissions were from the nine Pima County governments and the Marana wastewater reclamation facilities. All of these facilities treat regional wastewater from residents and from commercial and industrial activities. Totals represent the sum of nitrification/denitrification and lagoon treatments and the handling of digester gas.

Over the inventory years, wastewater reclamation emissions increased by 27 percent (Table 1). Although most of GHG emissions from wastewater treatment is from the processing of waste, the County is addressing those emissions associated with biogas flaring. In its *Sustainable Action Plan 2018-2025*, Pima County set a target to reduce GHG emissions through several strategies including the beneficial use of biogas as an energy source (Pima County, 2018a). A system to upgrade biogas from the Tres Ríos Water Reclamation facility to renewable natural gas is underway.

Recyclables

Data are provided for informational purposes only and GHG savings are not accounted for in the annual totals. County Community recycling totals reflect County landfill, private haulers and the City of Tucson collections. There was a 45 percent increase in recycling totals over this inventory period (Table 2).

Table 2. County Community Recycled Material Totals and Emissions Saved 2014 to 2019

Year	Recycled totals (metric tons)	CO2e Saved (metric tons)
2014	52,495	107,637
2015	55,291	105,356
2016	62,547	126,000
2017	84,311	170,623
2018	81,763	168,744
2019	76,272	158,269

Industrial Processes

CalPortland Company Rillito Cement Plant

According to the Portland Cement Association (2019), Arizona cement production increased steadily over the inventory years and is expected to continue. EPA-reported CalPortland Company Rillito Cement Plant emissions increased 7 percent from 2014 to 2019 (USEPA, 2020a).

Industrial process emissions were approximately 7 percent of the 2019 County Community total (Figure 3).

Other

Central Arizona Project (CAP)

Energy-related Tucson Water CAP water delivery emissions (Other) increased by 6

percent over the inventory period. These emissions were about 3 percent of 2019 County Community totals (Figure 3).

Energy Industries

TEP has three electricity-generating facilities in eastern Pima County (H. Sundt, DeMoss Petrie and North Loop). These emissions are shown for informational purposes and were not included in the County Community totals to avoid double counting of electricity emissions. These emissions were captured in the calculation of emission factors for RCI electricity use. From 2014 to 2019, there was a 56 percent increase in the EPA-reported emissions, mainly due to an increase in H. Sundt plant GHG emissions of 78 percent over the inventory period.

EASTERN PIMA COUNTY REGIONAL SYNOPSIS

From 2014 to 2019, County Community's GHG emissions fell by more than 1.67 million metric tons, or 11 percent. Stationary energy use and transportation-related emissions continue to be the major GHG emission sources in the County Community. Stationary energy use was the largest contributor to County Community GHG emissions over this period, averaging about 57 percent of total emissions. All stationary energy sectors, residential, commercial and industrial, showed a decline in emissions over this time. Electricity use produces approximately 88 percent of stationary energy emissions; natural gas and non-vehicle diesel use contributed approximately 12 percent of stationary energy emissions.

Over the inventory period, transportation-related emissions averaged about one-third of the County Community emissions and private/commercial vehicle use averaged 74 percent of total transportation emissions. From 2014 to 2019, GHG reductions occurred in all transportation subcategories except for aircraft and locomotives.

Solid waste disposal is the primary component of waste emissions and averaged about 1 percent of the County Community total. Over the inventory period, waste emissions declined by 47 percent.

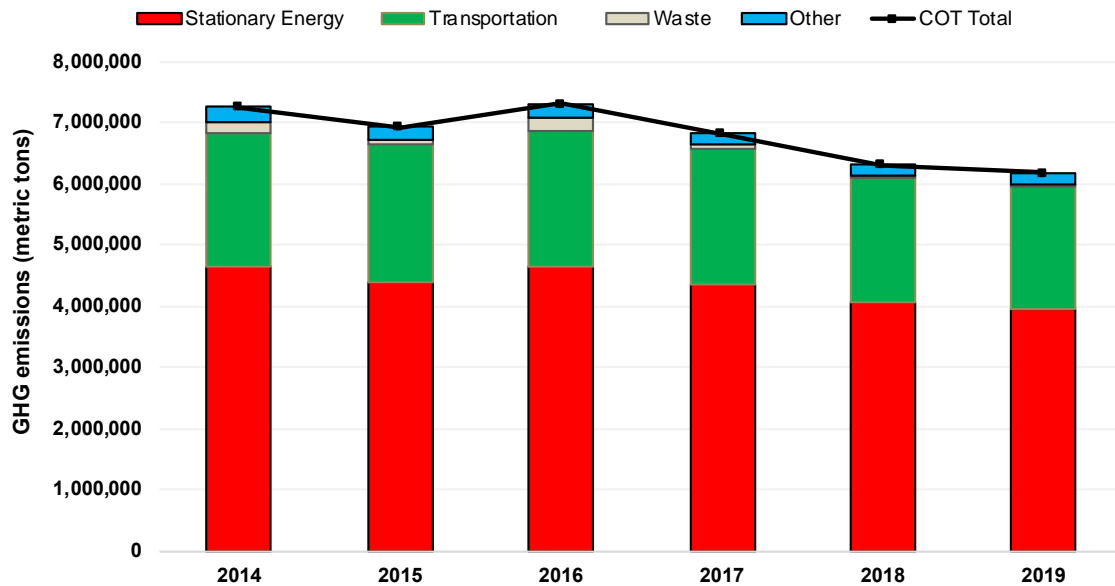
Industrial processing emissions increased by 7 percent over the inventory period due to a reported increase in cement production emissions. These emissions are about 7 percent of 2019 County Community total emissions.

From 2014 to 2019, CAP electricity-use emissions increased by 6 percent with CAP emissions contributing about approximately 3 percent of total 2019 County emissions.

TUCSON COMMUNITY INVENTORY OVERVIEW

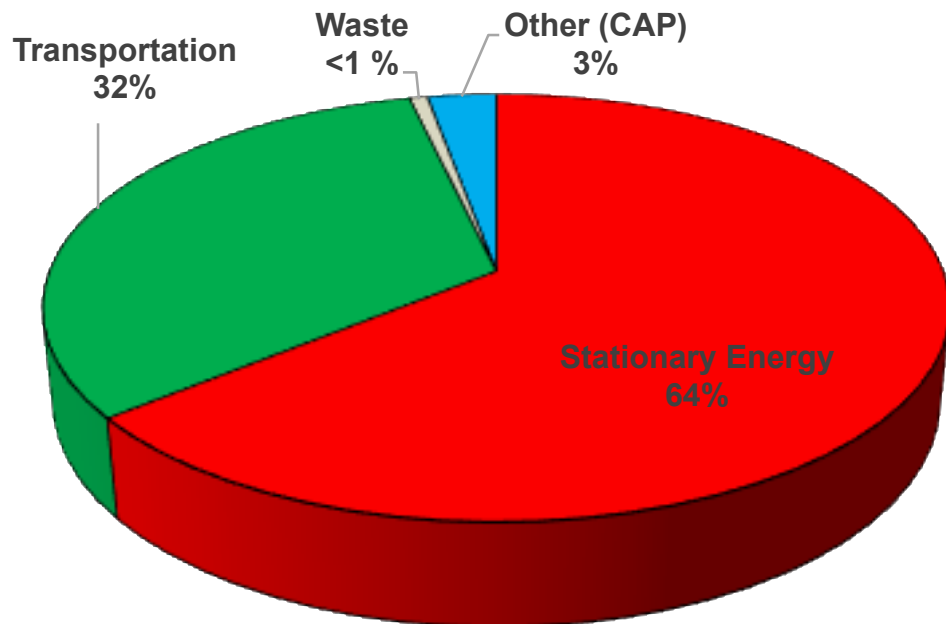
From 2014 to 2019, City Community emissions dropped over 1 million metric tons, or 15 percent (Table 3 and Figure 7).

Figure 7. City Community Greenhouse Gas Emissions 2014 to 2019



Emission reductions occurred in stationary energy use (14 percent), transportation (9 percent), waste (74 percent) and in the CAP energy-related emissions (Other) (29 percent). Stationary energy use is the major source of emissions and in 2019 were 64 percent of the annual total; transportation was the second most significant GHG source comprising 32 percent of the annual total (Figure 8).

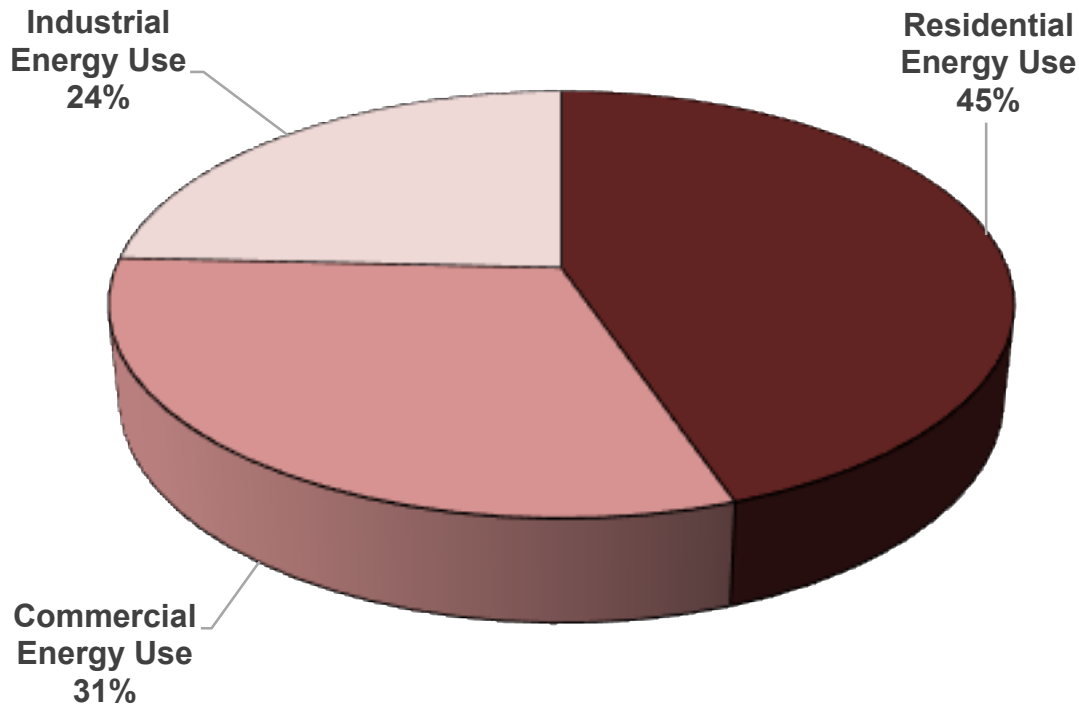
Figure 8. 2019 City Community Greenhouse Gas Emissions by Source



Stationary Energy

From 2014 to 2019, total City Community RCI energy-related emissions declined by 14 percent. Reductions occurred in all sectors with commercial emissions showing the sharpest decline. Residential energy use was the major contributor, averaging 45 percent of total stationary energy emissions in 2019 (Figure 9).

Figure 9. 2019 City Community Stationary Energy Emissions



Residential

From 2014 to 2019, total City Community residential energy use emissions dropped by 10 percent, resulting from a shift toward low and zero emission sources of and use of electricity despite a 22 percent increase in natural gas use. In 2019, the estimated City per household energy-related emissions were approximately 8.34 metric tons per year (Appendix D).

Residential energy use was responsible for 29 percent of the 2019 City Community's total emissions.

Commercial

From 2014 to 2019, City Community commercial energy use emissions fell by 19 percent, due to a shift toward low and zero emission sources and lower use of electricity, even with natural gas use increasing 5 percent.

Commercial energy emissions were almost one-third of 2019 stationary energy emissions (Figure 9) and represented 20 percent of the 2019 City Community total emissions.

Industrial

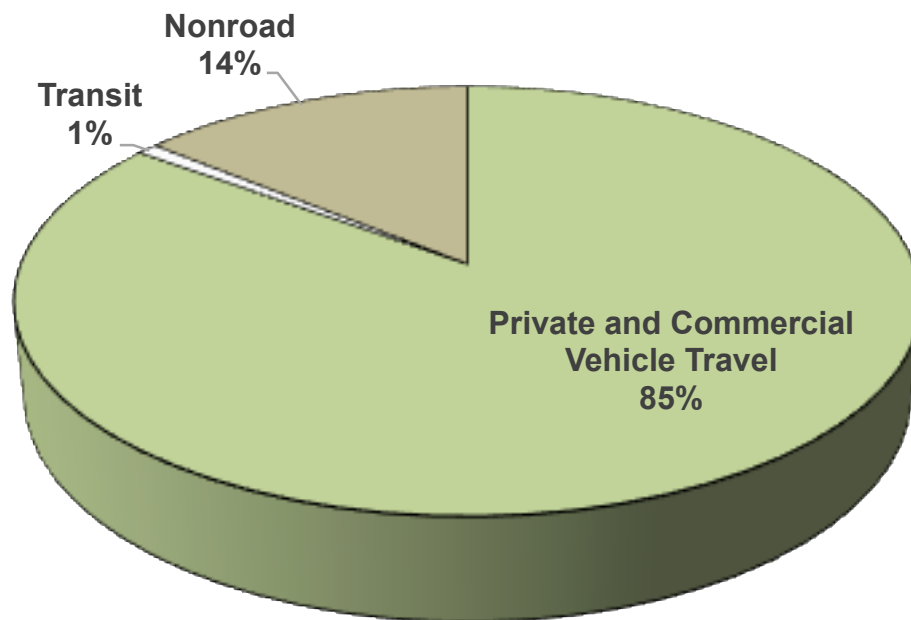
From 2014 to 2019, industrial electricity-use emissions declined by 15 percent, resulting from a shift toward low and zero emission sources and decreased electricity use, notwithstanding a 39 percent increase in natural gas use.

Industrial energy use was responsible for nearly one-fourth of stationary energy emissions (Figure 9) and nearly 16 percent of the 2019 City Community annual emissions.

Transportation

From 2014 to 2019, total transportation emissions decreased by 9 percent (Table 3) and were 32 percent of total City Community emissions in 2019. Private and commercial vehicle travel was the major contributor to transportation emissions (Figure 10).

Figure 10. 2019 City Community Transportation Emissions



Onroad

Private and Commercial Vehicle Travel

For all inventory years, private and commercial vehicle use was responsible for the majority of the City Community transportation-related emissions, contributing 85 percent in 2019 (Figure 10). From 2014 to 2019, City Community private/commercial vehicle travel VMT increased by 10 percent (Appendix G) and the associated GHG emissions dropped by 11 percent (Table 3). Emissions are calculated based on vehicle speed, and travel characteristics and VMT. Increasing vehicle fuel efficiencies resulted in a decrease in emissions, despite City Community private and commercial vehicle increase in VMT. Private and commercial vehicle emissions were 27 percent of total 2019 City Community emissions.

Public Transit

From 2014 to 2019, City Community public transit VMT decreased by nearly 2 percent and emissions fell by 6 percent. Transit emissions are a small portion of onroad transportation emissions, averaging about 1 percent over the inventory period.

Nonroad

These nonroad emissions represent the 2014 to 2019 MOVES2014b results for the County Community proportioned by the individual year's City:County population ratios. Over the inventory period, nonroad emissions increased by 8 percent. In 2019, nonroad vehicle emissions were 14 percent of the total transportation emissions and approaching 5 percent of the annual City Community emissions.

Waste

From 2014 to 2019, City Community total waste emissions declined by 76 percent, mostly due to the drop in the Los Reales reported emissions (Table 3). Solid wastes were the major component of waste emissions (Figure 11) but remain a small portion of annual City Community emissions (Figure 8).

In 2019, City Community waste emissions were less than 1 percent of the annual total.

Figure 11. 2019 City Community Waste Emissions



Table 3. City Community GHG Emissions (metric tons CO₂e) 2014 to 2019

	2014	2015	2016	2017	2018	2019	Percent CO ₂ e change 2019 - 2014
	CO ₂ e (metric tons)	CO ₂ e (metric tons)	CO ₂ e (metric tons)	CO ₂ e (metric tons)	CO ₂ e (metric tons)	CO ₂ e (metric tons)	
STATIONARY ENERGY							
Residential							
Fossil fuel combustion	289,048	308,843	320,053	276,989	299,588	351,734	
Grid-supplied electricity	1,685,818	1,585,050	1,687,390	1,613,920	1,498,046	1,420,830	
Residential Subtotal	1,974,866	1,893,893	2,007,443	1,890,909	1,797,634	1,772,564	
Commercial							
Fossil fuel combustion	246,719	249,345	246,929	242,170	245,502	259,707	
Grid-supplied electricity	1,273,808	1,135,239	1,202,254	1,143,145	1,041,774	970,248	
Commercial Subtotal	1,520,527	1,384,584	1,449,183	1,385,315	1,287,276	1,229,955	
Industrial							
Fossil fuel combustion	76,155	82,654	88,339	93,428	91,273	105,581	
Grid-supplied electricity	1,059,670	1,033,547	1,107,981	992,055	897,753	855,550	
Industrial Subtotal	1,135,825	1,116,201	1,196,320	1,085,483	989,026	961,131	
STATIONARY ENERGY TOTAL	4,631,218	4,394,678	4,652,946	4,361,707	4,073,936	3,963,650	-14
TRANSPORTATION							
Onroad							
Private & commercial vehicle travel	1,908,993	1,979,194	1,948,035	1,929,485	1,732,296	1,694,471	
Transit	17,961	18,559	21,025	20,241	17,284	16,810	
Onroad Subtotal	1,926,954	1,997,753	1,969,060	1,949,726	1,749,580	1,711,281	
Nonroad	260,189	252,689	256,371	266,559	275,914	281,644	
TRANSPORTATION TOTAL	2,187,143	2,250,442	2,225,431	2,216,285	2,025,494	1,992,925	-9
WASTE							
Solid waste disposal	190,012	59,089	199,128	49,166	53,538	46,604	
Wastewater reclamation process (City portion)	1,915	1,756	1,826	1,858	2,952	3,517	
WASTE TOTAL	191,927	60,845	200,954	51,024	56,490	50,121	-74
OTHER - Central Arizona Project (City portion)	251,811	219,330	224,473	187,825	147,899	179,257	-29
TOTAL CITY OF TUCSON	7,262,099	6,925,295	7,303,804	6,816,841	6,303,819	6,185,953	-15
ENERGY INDUSTRIES TOTAL*	658,243	595,180	485,762	469,820	870,260	1,022,073	55

* Data not included in totals

Solid Waste

Data represents emissions from Los Reales and Speedway landfills. The waste disposal volumes from Los Reales and the Speedway landfills increased over the inventory period. Despite these increases, GHG emissions dropped by 75 percent from 2014 to 2019, reflecting declines in Los Reales emissions (USEPA, 2020a).

Wastewater Reclamation

These emissions represent the City's portion of County Community wastewater treated by the Pima County Wastewater Reclamation Department, as estimated by County staff (75 percent in 2014; 73 percent in 2015 to 2017; and 76 percent in 2018 and 2019). Emissions represent the sum of nitrification/denitrification and lagoon treatments and the handling of digester gas. Emissions increased 84 percent during the inventory period, but were less than 8 percent of the total waste emissions in 2019.

Recyclables

Emission and energy saving data are provided for information purposes only and are not incorporated into the City Community totals. Recycling totals reflect curbside, community and landfill collections. Recycling totals declined by 19 percent over the inventory period (Table 4).

Table 4. City Community Recycled Material Totals and Emissions Saved 2014 to 2019

Year	Recycled totals (metric tons)	CO2e Saved (metric tons)
2014	28,490	58,542
2015	28,658	55,805
2016	28,797	56,790
2017	28,023	55,191
2018	25,031	52,397
2019	22,955	48,925

Other

Table 3 shows the electricity-use emissions proportional to the City of Tucson's CAP water use, estimated to be 43 percent of total CAP water use in 2019. Over the 2014 to 2019 inventory period, CAP electricity-related emissions dropped by 29 percent and were 3 percent of the City Community total in 2019.

TUCSON COMMUNITY SYNOPSIS

From 2014 to 2019, City Community emissions declined by over 1 million metric tons or 15 percent; stationary energy emissions were responsible for about two-thirds of City Community's total emissions. Residential energy use was the largest component of stationary energy use and averaged around 45 percent of stationary energy emissions.

Transportation was the other major contributor to City Community emissions; averaging 32 percent of the City Community totals during the inventory period. From 2014 to 2019, overall transportation emissions decreased by 9 percent. Private/commercial vehicle travel emissions decreased by 11 percent and were responsible for 85 percent of the City Community's transportation emissions. Transit emissions decreased by 6 percent and contributed less than 1 percent to the City Community emissions.

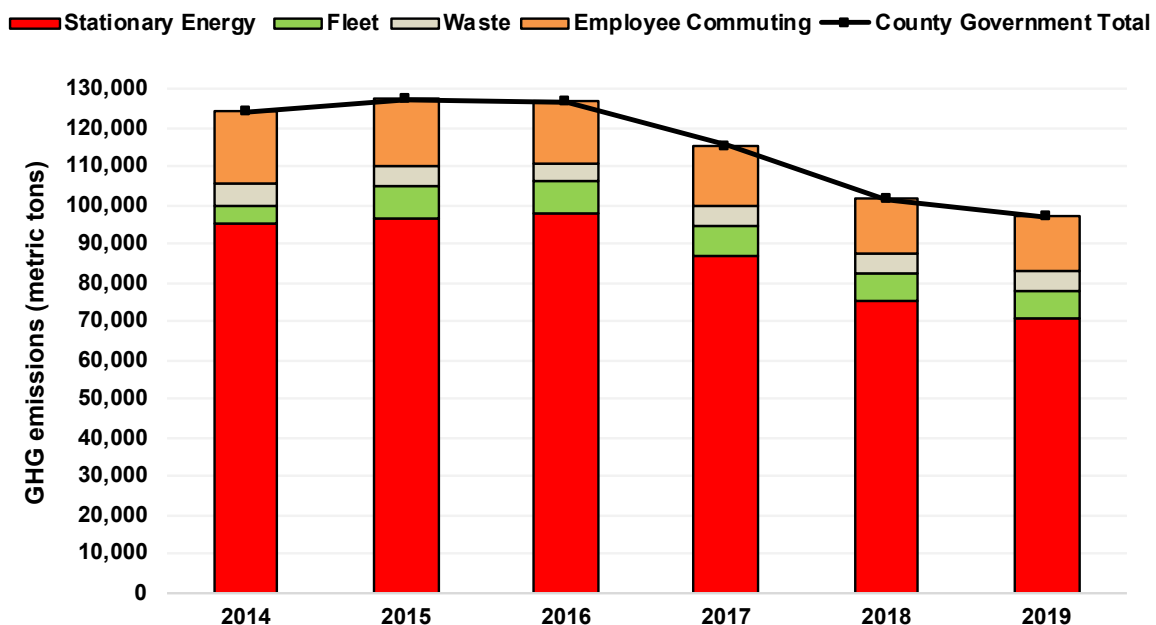
Waste emissions decreased by 76 percent and contribute less than 1 percent to total emissions.

CAP water-pumping, electricity use emissions declined over this inventory period by 29 percent and represented 3 percent of the City's Community emissions.

PIMA COUNTY GOVERNMENT OPERATIONS INVENTORY OVERVIEW

County Government emissions were a small portion of the County Community's total. From 2014 to 2019, total County Government emissions dropped by more than 27,000 metric tons or 22 percent (Table 6, Figure 12). Over the inventory period, emission declines were evident in stationary energy use (26 percent) and in employee commuting (27 percent). However, waste related emissions increased (4 percent) as did fleet activity (37 percent) over this time (Table 6).

Figure 12. County Government Greenhouse Gas Emissions 2014 to 2019

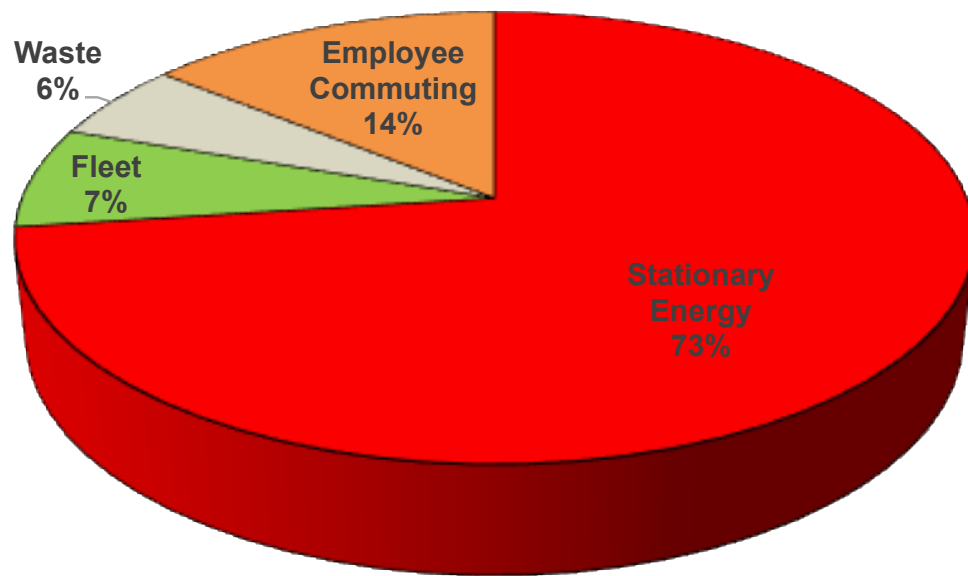


Stationary energy use was the predominant source of emissions, and in 2019 was 73 percent of County Government emissions (Figure 13).

Employee commuting was another major contributor to the 2019 County Government

total, representing 14 percent of annual emissions.

Figure 13. 2019 County Government Greenhouse Gas Emissions by Source



Stationary Energy

Emissions included purchased electricity and natural gas for all County-operated facilities and parks, wastewater reclamation and street and traffic lighting and the treatment of digester gas. From 2014 to 2019, total stationary energy emissions declined by 26 percent; these reductions were due to a shift toward low and zero emission sources of electricity despite slightly increased energy usage. In 2019, facility energy use was the largest component within the stationary energy category (Figure 14).

County Government has made substantial efforts to incorporate renewable energy to power its facilities. Solar energy production more than tripled over the inventory period (Appendix J).

Facilities and Parks

From 2014 to 2019, facility emissions fell by 16 percent due to a shift toward low and zero emission sources of electricity, despite an 18 percent increase in electricity use and 8 percent increase in natural gas use. In 2019, facility energy use was 48 percent of total County Government emissions.

Wastewater reclamation

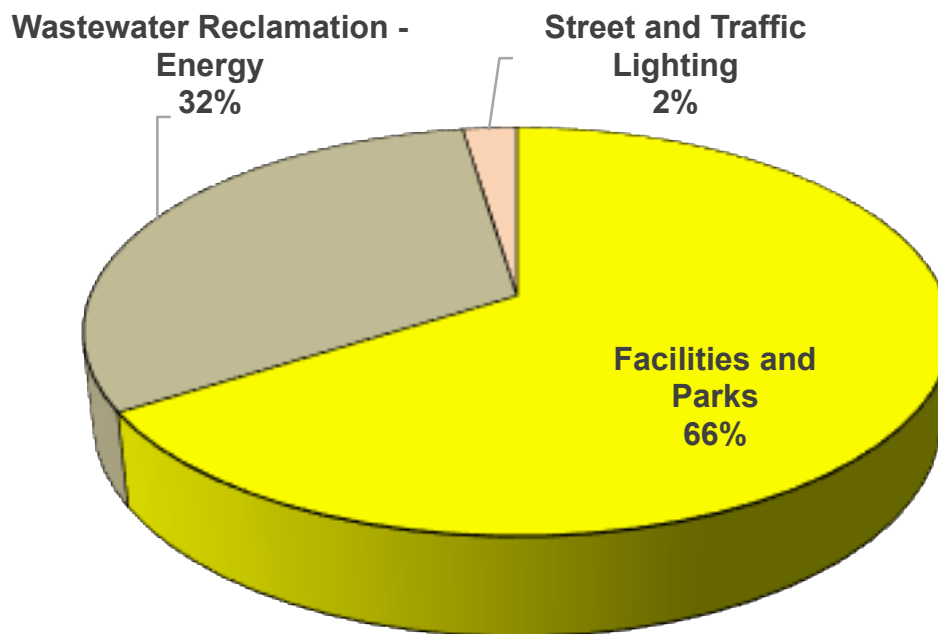
These emissions represent the total of purchased electricity and natural gas and the flaring and combustion of digester gas. From 2014 to 2019, wastewater-energy related emissions decreased by 40 percent (Table 6). Purchased electricity is the largest component, averaging over 96 percent of total wastewater reclamation emissions.

Over the inventory period, there were increases in electricity and natural gas use as well as digester gas combusted for energy, yet emissions were lower due to a shift toward low and zero emission sources of electricity. In 2019, wastewater-related emissions were 23 percent of total County Government emissions.

Street and Traffic Lighting

From 2014 to 2019, street and traffic lighting emissions decreased by 13 percent and represent a slightly more than 2 percent of the stationary energy use total (Figure 14).

Figure 14. 2019 County Government Stationary Energy Use Emissions



Fleet

Over the inventory period, total fleet emissions increased by 37 percent, due to a nearly doubling of total onroad VMT (Appendix J). Onroad fleet vehicles remain the major contributor to the 2019 fleet total (Figure 15). Fleet emissions represent 7 percent of the total 2019 County Government emissions (Figure 13). The County continues to make strides in improving the fuel efficiency of its passenger cars, primarily through the integration of fully electric cars.

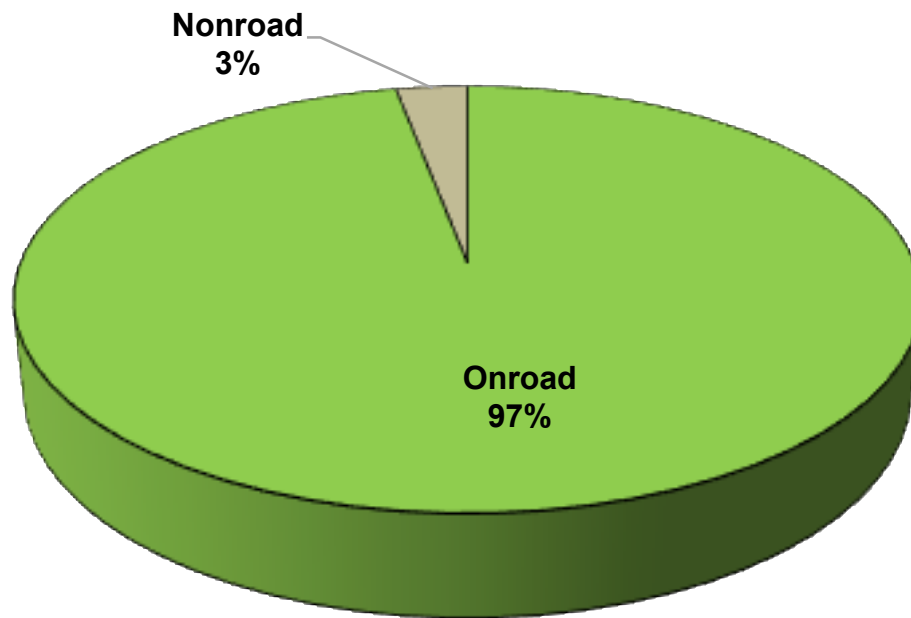
In a July 2017 follow-up memo to Resolutions 2017-39 and 2017-51, the Board of Supervisors committed to buying 20 electric vehicles per year for the next six years which will largely replace the gasoline-powered fleet sedans.

Onroad

From 2014 to 2019, emissions from the County Government onroad fleet emissions increased by 38 percent, reflecting an approximate 95 percent increase in gasoline and 40 percent drop in diesel vehicle VMT. Onroad fleet emissions are approximately 7

percent of the 2019 County Government total.

Figure 15. 2019 County Government Fleet Emissions



Nonroad

County government nonroad equipment is used primarily in construction. From 2014 to 2019, emissions decreased 1 percent and were a small portion of fleet emissions (3 percent)(Figure 15).

Waste

Emissions include those from the disposal of government-generated solid waste and community wastewater processing emissions. Wastewater processing emissions were the major component of total waste in 2019, as in all other inventory years (Figure 16, Table 5). From 2014 to 2019, total waste emissions increased by 4 percent. Waste contributed 6 percent to the total 2019 County Government emissions (Figure 13).

Solid waste disposal

Solid waste disposal emissions decreased by 48 percent over the inventory period, reflecting a similar decrease in waste disposal volumes (43 percent). Solid waste disposal represents less than 1 percent of total 2019 County Government emissions.

Wastewater processing

Total wastewater process emissions increased by 27 percent from 2014 to 2019, due to reductions in both the nitrification/denitrification process and lagoon treatment emissions. Wastewater processing emissions were less than 5 percent of the total 2019 County Government emissions.

Recycling

Emissions and energy savings data are presented for informational purposes and were not considered in computing the County Government totals. Emission savings from recycling remained constant over the inventory period (Table 5).

Figure 16. 2019 County Government Waste Emissions

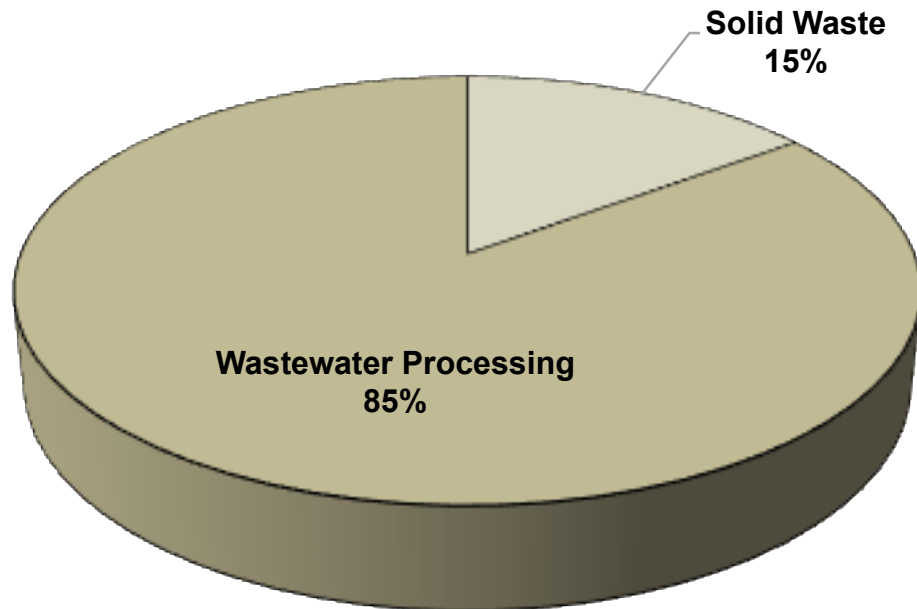


Table 5. County Government Recycled Material Totals and Emissions Saved 2014 to 2019

	Recycled totals (metric tons)	CO2e Saved (metric tons)
2014	407	931
2015	382	875
2016	385	879
2017	418	956
2018	410	938
2019	407	930

Table 6. County Government GHG Emissions (metric tons CO₂e) 2014 to 2019

	2014	2015	2016	2017	2018	2019	Percent change CO ₂ e 2019-2014
	CO ₂ e (metric tons)	CO ₂ e (metric tons)	CO ₂ e (metric tons)	CO ₂ e (metric tons)	CO ₂ e (metric tons)	CO ₂ e (metric tons)	
STATIONARY ENERGY							
Facilities and Parks							
Fossil fuel combustion	4,418	4,838	4,052	3,912	3,918	4,782	
Grid-supplied electricity	51,273	49,552	49,127	40,570	46,535	41,915	
Facilities Subtotal	55,691	54,390	53,179	44,482	50,453	46,697	
Wastewater Reclamation							
Fossil fuel combustion	8	32	32	11	21	444	
Grid-supplied electricity	36,535	39,616	41,765	39,797	22,277	21,530	
Digester gas flaring	748	599	593	628	299	350	
Digester gas combustion for energy	3	5	7	6	12	9	
Wastewater Reclamation Subtotal	37,294	40,252	42,397	40,442	22,609	22,333	
Street and Traffic Lighting							
Grid-supplied electricity	1,945	1,970	2,033	1,858	1,856	1,688	
STATIONARY ENERGY TOTAL	94,930	96,612	97,609	86,782	74,918	70,718	-26
FLEET							
Onroad fleet	4,932	8,208	8,223	7,657	7,332	6,814	
Nonroad fleet	214	276	113	354	225	211	
FLEET TOTAL	5,146	8,484	8,336	8,011	7,557	7,025	37
WASTE							
Solid Waste	1,571	1,460	1,446	1,617	885	814	
Wastewater Processing							
Nitrification/denitrification	1,621	1,550	1,551	1,554	1,872	1,885	
Lagoons	2,022	2,022	2,022	2,022	1,972	2,742	
Wastewater Processing Subtotal	3,643	3,572	3,573	3,576	3,844	4,627	
WASTE TOTAL	5,214	5,032	5,019	5,193	4,729	5,441	4
EMPLOYEE COMMUTE TOTAL	18,737	17,083	15,699	15,484	14,459	13,757	-27
TOTAL COUNTY GOVERNMENT GHG EMISSIONS	124,027	127,211	126,663	115,470	101,663	96,941	-22
SOLAR ENERGY GENERATION	-9,834	-12,357	-12,880	-12,407	-11,878	-12,199	

Employee Commute

From 2014 to 2019, emissions dropped by 27 percent. Commuter VMT declined 19 percent during the inventory period (Appendix J). In 2019, County Government employee commuting emissions were 14 percent of the annual total (Figure 13).

Energy Generation

Solar electricity generation does not contribute to GHG emissions but was included for informational purposes, as it avoids GHG emissions that would otherwise be emitted from fossil-fuel generation resources (Table 6). From 2014 to 2019, the County government more than tripled its solar energy production (Appendix J). Over 13 percent of County Government's electricity energy needs are met using solar-generated electricity (Pima County, 2018b).

PIMA COUNTY GOVERNMENT SYNOPSIS

From 2014 to 2019, County Government emissions dropped by more than 27,000 metric tons or 22 percent. Emission reductions were evident in stationary energy use (26 percent) and employee commuting (27 percent). Waste emissions increased by 4 percent and fleet emissions by 37 percent over the inventory period.

Stationary energy use was the major contributor to GHG production and in 2019 was **73 percent** of the County Government's annual total. Electricity use averaged 92 percent of stationary energy emissions. However, the County Government has made great strides in integrating renewable energy sources into its system; the County Government more than tripled its solar energy production over the inventory period.

Fleet emissions averaged about 7 percent of total County Government emissions (2014 to 2019). Onroad vehicle use accounted for 97 percent of fleet emissions, and from 2014 to 2019, onroad fleet VMT increased by 38 percent, resulting in a 38 percent increase in emissions. Nonroad fleet remained steady from 2014 to 2019.

Wastewater processing was the major component of waste emissions. From 2014 to 2019, wastewater processing emissions grew by 27 percent, while solid waste emissions declined by 48 percent.

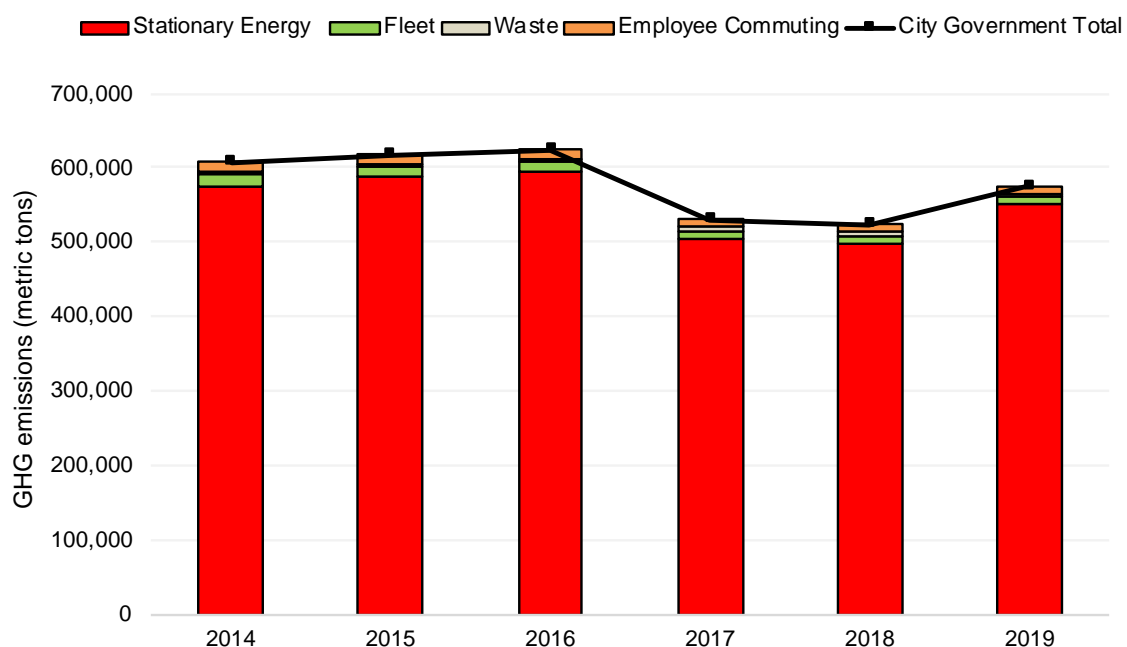
Waste emissions were a smaller component of total County Government emissions, averaging about 4 percent over the inventory period.

Employee commuting VMT decreased by 19 percent over the inventory period and was the second largest contributor to 2019 County Government emission totals.

CITY OF TUCSON GOVERNMENT OPERATIONS INVENTORY OVERVIEW

From 2014 to 2019, City Government emissions decreased by over 33,000 metric tons (5 percent) (Table 7, Figure 17). All categories showed a decrease in emissions over this period. Stationary energy use was the largest contributor to City Government emissions, averaging 95 percent of the City Government annual totals over the inventory years. Water-related energy use was the largest component of stationary energy emissions.

Figure 17. City Government Greenhouse Gas Emissions 2014 to 2019



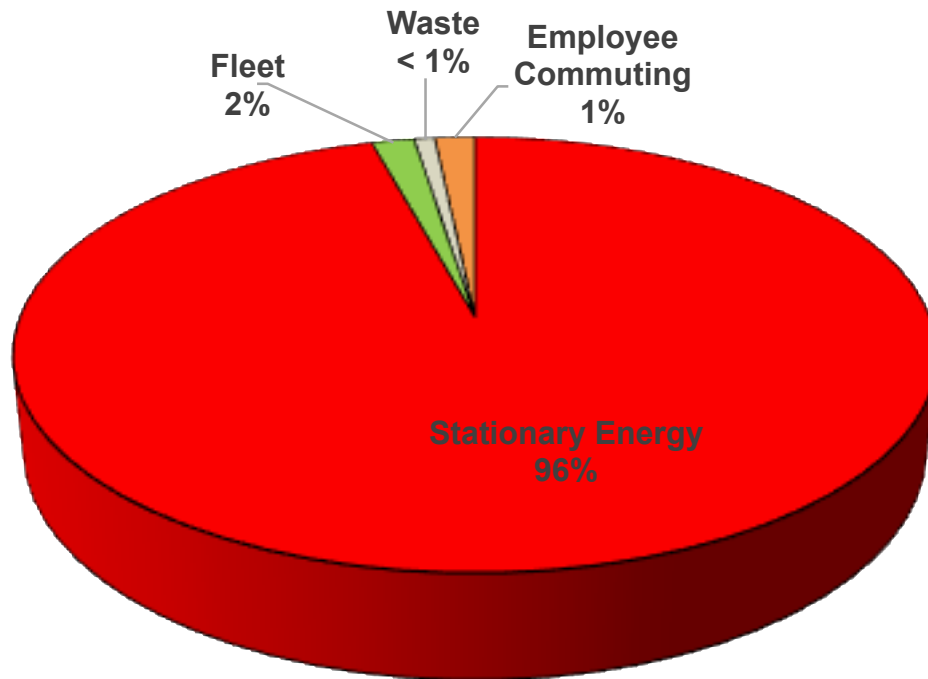
Stationary Energy

The City Government stationary energy emissions included purchased electricity and natural gas used in City Government facilities and parks and in potable water handling, and electricity used for the CAP and reclaimed water pumping, fleet facilities and street and traffic lighting, and natural gas used for district energy production.

From 2014 to 2019, total stationary energy emissions dropped by 4 percent (Table 7). This decline was likely linked to emission reductions in most of the categories within Stationary Energy. In 2019, stationary energy was responsible for 96 percent of 2019 City Government emissions total (Figure 18).

City Government has made a substantial effort to incorporate renewable energy sources to meet its energy needs. Over this inventory period, City Government has increased its solar energy production by 56 percent (Appendix K).

Figure 18. 2019 City Government Greenhouse Gas Emissions by Source



Facility and Parks Energy Use

Over the inventory period, facility energy use emissions dropped by 25 percent reflecting a shift toward low and zero emission sources of electricity as well as declines in electricity and natural gas use. Facility energy use was approximately 7 percent of the 2019 City Government stationary energy total (Figure 19).

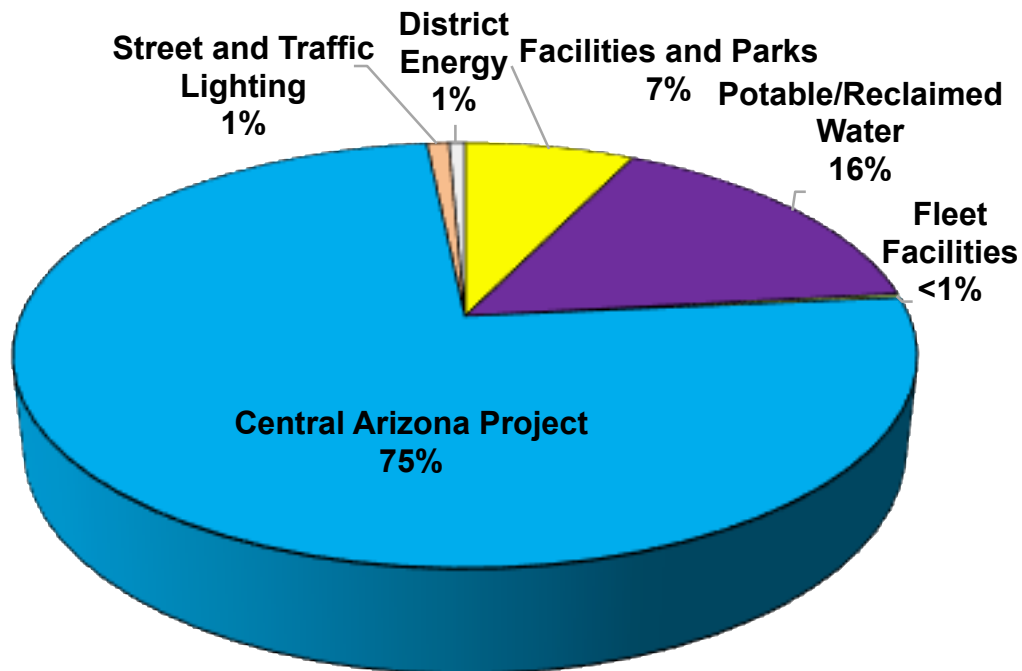
Tucson Water

Potable and Reclaimed Water

These emissions include electricity used for potable and reclaimed water management and CAP water delivery and natural gas used in potable water handling. Emissions from the energy related to water pumping and delivery were responsible for 16 percent of the total stationary energy use in 2019 (Figure 19).

Over the inventory period, total water-related GHG emissions decreased by 20 percent despite an increase in emissions from natural gas usage, reflecting the greater influence of a shift towards lower and zero emission sources of electricity by TEP and Trico. Potable and reclaimed water energy use emissions averaged 17 percent of total City Government emissions over the inventory period.

Figure 19. 2019 City Government Stationary Energy Use Emissions



Central Arizona Project (CAP)

Most of the Colorado River water delivered to Tucson is directed into Tucson Water recharge basins in Avra Valley at the Clearwater Renewable Resource Facility. The water percolates into the ground and blends with the native groundwater in the aquifer. The blend is then recovered by a number of wells and treated before delivery to Tucson Water customers. The use of this blended water reduces the reliance on groundwater and allows the water table to recover from over-pumping.

Energy-related emissions associated with CAP water conveyance increased by 6 percent from 2014 to 2019 (Table 7). CAP energy use emissions were 72 percent of the 2019 City Government total.

Fleet Facilities

These emissions were from the electricity needed to pump the CNG used in the City government's fleet. From 2014 to 2019, these emissions increased five-fold due to increased use of CNG vehicles but remain a small portion of the 2019 stationary energy total (Figure 19).

Street and Traffic Lighting

From 2014 to 2019, public lighting emissions fell by 74 percent and contributed about 1 percent to the 2019 annual total. This substantial drop in public lighting emissions is due to a City-wide project to upgrade the street and traffic lights to LED that began in 2016 (Ameresco, 2016).

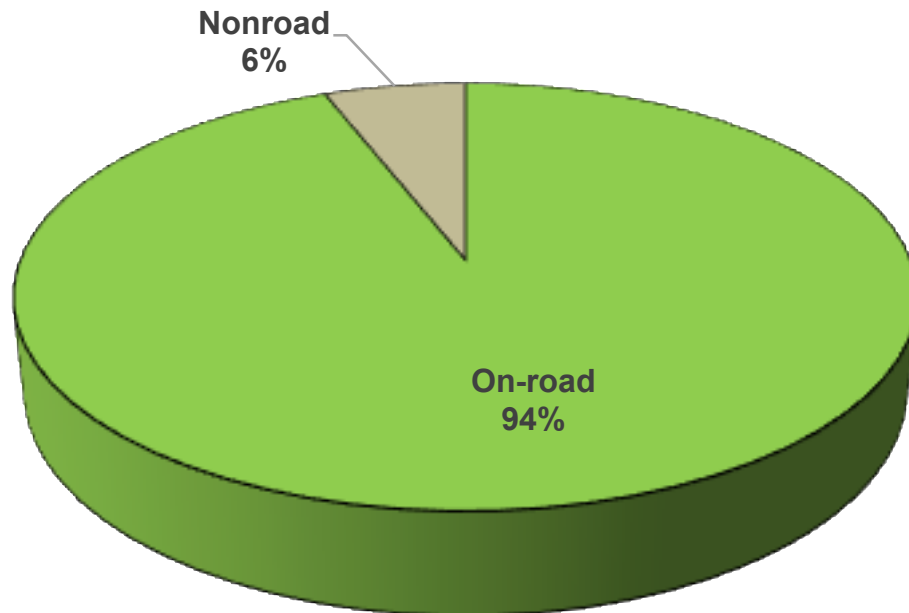
District Energy

District energy emissions fell by 23 percent over the inventory period and were a small component of the 2019 City Government emissions.

Fleet

From 2014 to 2019, total fleet emissions dropped by 35 percent (Table 7) and averaged about 2 percent of total annual City Government emissions. 94 percent of City Government fleet emissions were from onroad fleet travel (Figure 20).

Figure 20. 2019 City Government Fleet Emissions



Onroad

From 2014 to 2019, onroad fleet vehicle emissions dropped by 23 percent (Table 7), likely reflecting a drop in VMT, particularly in diesel-fueled vehicles, in addition to a large increase in VMT by CNG-fueled vehicles (Appendix K, Table 7). Onroad fleet vehicle emissions contributed 2 percent to the 2019 City Government total.

Nonroad

Nonroad emissions decreased by 80 percent over the inventory period due to decreases in diesel fuel usage over the inventory period, despite increases in gasoline and liquid petroleum gas (LPG, propane) (Appendix K).

Nonroad fleet vehicle emissions contributed 0.1 percent to the 2019 City Government total.

Waste

Solid Waste

City Government waste emissions result from the disposal of solid waste generated by government activities. Over the inventory years, waste volumes dropped by 8 percent, resulting in an 8 percent drop in emissions (Table 7).

Table 7. City Government GHG Emissions (metric tons CO₂e) 2014 to 2019

	2014	2015	2016	2017	2018	2019	Percent change CO2e 2019-2014	
	CO2e (metric tons)	CO2e (metric tons)	CO2e (metric tons)	CO2e (metric tons)	CO2e (metric tons)	CO2e (metric tons)		
STATIONARY ENERGY USE								
Facilities and Parks								
Fossil fuel combustion	6,673	5,075	5,274	4,649	5,119	5,613		
Grid-supplied electricity	46,549	47,692	47,865	43,196	39,150	34,423		
Facilities Subtotal	53,222	52,767	53,139	47,845	44,269	40,036		
Tucson Water								
Fossil fuel combustion	14,968	11,995	11,306	21,856	15,926	20,390		
Grid-supplied electricity	95,578	90,113	91,705	77,628	79,926	67,624		
Central Arizona Project								
Grid-supplied electricity	387,402	412,461	418,268	342,686	346,538	412,352		
Tucson Water Subtotal	497,948	514,569	521,279	442,170	442,390	500,366		
Fleet Facilities								
Grid-supplied electricity	331	1,372	1,723	1,940	1,859	1,698		
Street and Traffic Lighting								
Grid-supplied electricity	19,682	16,262	15,040	6,945	5,415	5,173		
District Energy								
Fossil fuel combustion	4,923	3,150	3,952	4,134	3,079	3,771		
STATIONARY ENERGY USE TOTAL	576,106	588,120	595,133	503,034	497,012	551,044		-4
FLEET								
City fleet onroad	12,490	11,225	11,223	10,459	10,366	9,561		
City fleet nonroad	3,101	2,306	2,188	2,303	751	608		
FLEET TOTAL	15,591	13,531	13,411	12,762	11,117	10,169	-35	
WASTE TOTAL	4,799	3,894	3,819	4,070	4,833	4,396	-8	
EMPLOYEE COMMUTE TOTAL	11,810	11,848	12,134	11,290	10,612	9,521	-19	
CITY GOVERNMENT GHG EMISSIONS TOTAL	608,306	617,393	624,497	531,156	523,574	575,130	-5	
SOLAR ENERGY GENERATION	-3,505	-3,966	-5,473	-7,647	-9,477	-10,126		

Recycled materials

These emissions and energy savings are presented for informational purposes and were not used in the calculation of the City Government totals. Over the inventory years, City Government recycling totals increased by over 49 percent (Table 8).

Table 8. City Government Recycled Material Totals and Emissions Saved 2014 to 2019

	Recycled totals (metric tons)	CO2e Saved (metric tons)
2014	1,205	2,755
2015	1,348	3,083
2016	1,338	3,060
2017	1,567	3,583
2018	1,751	4,004
2019	1,799	4,114

Employee Commute

From 2014 to 2019, City government employees' emissions decreased by an estimated 19 percent. Employee commuting contributed 1 percent to the 2019 City Government total (Figure 18) and averaged about 2 percent of total emissions over the inventory period.

Energy Generation

Solar electricity generation does not contribute to GHG emissions but was included for informational purposes, as it avoids GHG emissions that would otherwise be emitted from fossil-fuel generation resources (Table 7). Over the inventory period City Government solar energy production has increased 56 percent (Appendix K). Over 3 percent of the City Government's electricity energy needs are met using solar-generated electricity.

CITY OF TUCSON GOVERNMENT SYNOPSIS

The City Government's emissions were a small portion of the City Community's totals over the inventory period. From 2014 to 2019, City Government emissions dropped by more than 33,000 metric tons, or 5 percent. Emission reductions occurred in stationary energy, fleet, waste and employee commute. In 2019, stationary energy emissions were 96 percent of the total; the majority of these stationary energy emissions (91 percent) were from water-related energy use. The CAP energy use was the major contributor to water-related energy emissions.

Electricity use from all sources generated 91 percent of City Government emissions over the inventory period. City government has made advances in meeting its energy needs through renewable energy sources. From 2014 to 2019, the City's solar energy production increased by over half.

Stationary energy emissions declined by 4 percent over the inventory period due to reductions in both electricity use and the shift to clearer sources used in electricity generation. Stationary energy use emissions were 96 percent of 2019 City Government emissions.

Over the 2014 to 2019 period, fleet emissions decreased by 35 percent primarily due to a drop in onroad travel and transition from diesel to compressed natural gas fuel. Fleet emissions were 2 percent of the 2019 annual total.

Waste emissions decreased by 8 percent over the inventory period. City Government wastes contributed less than 1 percent to total 2019 emissions.

Employee commuting emissions declined by an estimated 19 percent over this inventory period. This can likely be attributed to an estimated 6 percent decrease in VMT along with overall increased fuel economy of commuter vehicles during the inventory period.

REPORT SUMMARY

Both Pima County and the City of Tucson communities showed greenhouse gas reductions over the 2014 to 2019 period, 11 and 15 percent, respectively. Stationary energy-use emissions were the major source of community greenhouse gas emissions, averaging 57 percent of emissions over the inventory period. Approximately 88 percent of the stationary energy emissions were from electricity use. However, both the County and City Communities exhibited substantial reductions in energy-use emissions over the inventory period due to reductions in consumption and the shift toward low and zero emission sources of electricity.

Transportation emissions were the other major source of regional Community emissions. Private and commercial vehicle use averaged about 74 percent of transportation emissions. Over the inventory period, regional private and commercial VMT increased by 5 percent while public transit VMT decreased by 2 percent.

In 2019, stationary energy use and transportation comprised 54 percent and 35 percent, respectively, of the regional GHG emission totals. Waste, industrial processes and Central Arizona Project energy-related emissions combined contributed the remaining 11 percent to the regional 2019 totals.

Both Pima County and the City of Tucson Governments exhibited GHG emission declines over the inventory period, 22 and 5 percent, respectively. These government entities had similar emission sources and trends with stationary energy being the largest component of the governments' totals. For the City of Tucson government, water-related energy use was the major source of stationary energy emissions. For the Pima County government, both facility and wastewater energy use were the major contributors to GHG totals.

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APPENDICES

- A. Inventory Data Sources
- B. Per Capita Greenhouse Gas Emissions
- C. Population Estimates, 2014 to 2019
- D. Number of Households in eastern Pima County and the City of Tucson, 2014 to 2019
- E. Emissions Factors for PAG GHG Inventory Electricity Use
- F. Eastern Pima County Community Inventory Data Summary
- G. City of Tucson Community Inventory Data Summary
- H. Waste & Recycling Characterizations
- I. EPA's WARM Model Emission Factors
- J. Pima County Government Inventory Data Summary
- K. City of Tucson Government Inventory Data Summary

APPENDIX A. INVENTORY DATA SOURCES

Community Inventories		
Category	Data type	Contact
STATIONARY ENERGY		
Electricity	Residential, commercial, industrial use; annual emission factors data	Jeff Yockey, TEP
	Residential, commercial use	Laree St. Onge, Trico
	Residential, commercial use	Alyssa Cruz, Tohono O'odham Utility Authority
Fossil fuel combustion	Residential, commercial, industrial natural gas use	Noreen Litty, Southwest Gas
	Industrial diesel use	Rupesh Patel, James Jones, PDEQ
TRANSPORTATION		
On-road		
	MOVES2014b emissions and modeling inputs	Hyunsoo Noh, Ryan Hatch, PAG
	Cat Tran	Araceli Gonzalez, University of Arizona
	Loop	John Zukas, City of Tucson
	Sun Shuttle ADA Dial-a-Ride	Katharine Mitchell, Amber Wagner, Bryce Whiteside, PAG
	Oro Valley Sun Shuttle	Katharine Mitchell, Amber Wagner, Bryce Whiteside, PAG
	Sun Shuttle	Katharine Mitchell, Amber Wagner, Bryce Whiteside, PAG
	Sun Link	James McGinnis, City of Tucson
	Sun Tran/Sun Van	James McGinnis, City of Tucson
Nonroad		
	Off road equipment and vehicles	EPA MOVES2014b Pima County default
Aviation	Gallons of Jet A and Avgas dispensed at various locations	TIA: Eric Roudebush, Mark Bourdeau; Ryan: Tim Amalong, Jim White, Velocity Air; Marana: Peter Barbier, Tucson Aeroservice Center; La Cholla: Larry Newman; Davis Monthan: Leah Proffitt
Locomotives	Gallons of diesel in line haul and yard operations in Pima County	Erica Bonkosky-Montefusco, Union Pacific
WASTE		
Solid waste		
	Tangerine Landfill	EPA Reported emissions and waste totals
	Sahuarita Landfill	Kurtis Wahl, Tucson Recycling & Waste Services
	Los Reales Landfill	EPA reported emissions and waste totals
	Speedway Recycling & Landfill Facility	Jason Tankersley, The Fairfax Companies
	Marana Regional Landfill	EPA Reported emissions and waste totals
Wastewater reclamation	Electricity, natural gas use; process and digester gas data by facility	Houssam El Jerdi, Pima County Regional Wastewater Reclamation Department; Mike Osborne, Town of Marana
Recycling		
	Pima County	Kurtis Wahl, Tucson Waste Recycling & Waste; Jennifer Lynch, Pima County
	City of Tucson	Frank Bonillas, City of Tucson
INDUSTRIAL PROCESSES	Cement production emissions	EPA reported emission totals
OTHER	Central Arizona Project (CAP) electricity use & water delivery	Michael Liberti, Jaimie Galayda, Tucson Water
ENERGY INDUSTRIES	Electricity generation emissions	EPA reported totals; PDEQ- North Loop Generating Station

Government Operations Inventories		
Category	Data type	Contact
STATIONARY ENERGY		
Facilities		
Electricity use	Pima County	Sandra Maina, Pima County
	City of Tucson	Michael Catanzaro, City of Tucson
Fossil fuel combustion	Pima County	Sandra Maina, Pima County
	City of Tucson	Michael Catanzaro, City of Tucson
Water energy data & Wastewater Reclamation		
Electricity use	Pima County	Houssam El Jerdi, Pima County Wastewater Reclamation
	City of Tucson	Michael Liberti, Jaimie Galayda, Tucson Water
Fossil fuel combustion	Pima County	Houssam El Jerdi, Pima County Wastewater Reclamation
	City of Tucson	Michael Liberti, Jaimie Galayda, Tucson Water
Fleet - electricity	City of Tucson	Michael Catanzaro, City of Tucson
Public lighting	Pima County	Sandra Maina, Pima County
	City of Tucson	Michael Catanzaro, City of Tucson
FLEET	Pima County	Sandra Maina, Pima County
	City of Tucson	Tony Leon, City of Tucson
WASTE		
Solid waste disposal totals, Recycling totals	Pima County	Sandra Maina, Pima County
	City of Tucson	Frank Bonillas, City of Tucson
Wastewater treatment process	Pima County	Houssam El Jerdi, Pima County Wastewater Reclamation
EMPLOYEE COMMUTING	Pima County and City of Tucson Government Employee VMT	Mary Carter, PAG

APPENDIX B. PER CAPITA GREENHOUSE GAS EMISSIONS (METRIC TONS CO₂E)

	CO ₂ e (metric tons per capita)		
	United States	Eastern Pima County	City of Tucson
2014	21.44	14.80	13.72
2015	20.80	14.28	13.07
2016	20.18	14.19	13.78
2017	19.94	13.61	12.68
2018	20.41	13.07	11.59
2019	19.98	12.52	11.31

APPENDIX C: POPULATION ESTIMATES: 2014 TO 2019

	2014	2015	2016	2017	2018	2019
City of Tucson	529,336	529,845	529,989	537,634	543,505	546,576
Eastern Pima County*	987,019	989,184	992,841	1,005,577	1,022,855	1,033,214

Data represents July population estimates of each year

* Calculation: Eastern Pima County is estimated by using 98.9 percent of Pima County population

Data Source: Arizona Office of Economic Opportunity (AOEO).

<https://www.azcommerce.com/oeo/population/population-estimates/>

APPENDIX D: NUMBER OF HOUSEHOLDS AND ENERGY CONSUMPTION: EASTERN PIMA COUNTY AND THE CITY OF TUCSON 2014 TO 2019

	2014	2015	2016	2017	2018	2019
Number of Households - City of Tucson	204,341	206,342	207,661	209,906	210,816	212,491
Residential Stationary Energy GHG emissions/household (metric tons)	9.66	9.18	9.67	9.01	8.53	8.34
Number of Households - Eastern Pima County*	381,918	385,383	391,052	394,158	396,509	400,299
Residential Stationary Energy GHG emissions/household (metric tons)	9.64	9.18	9.39	8.77	8.29	7.86

* Calculation: Eastern Pima County data is estimated using 98.9 percent of Pima County population

Data Source: U.S. Census Bureau. American Community Survey data.

<http://www.census.gov/programs-surveys/acs/>

APPENDIX E: GHG EMISSIONS FACTORS FOR ELECTRICITY USE

	2014			2015			2016			2017			2018			2019		
	Pounds per MWh			Pounds per MWh			Pounds per MWh			Pounds per MWh			Pounds per MWh			Pounds per MWh		
	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O
Tucson Electric Power (TEP)	1,737.2	0.17	0.03	1,633.0	0.12	0.02	1,684.8	0.17	0.02	1,570.4	0.16	0.02	1,483.8	0.13	0.02	1,391.2	0.15	0.02
Trico Electric Cooperative (Trico)	1,737.2	0.17	0.03	1,633.0	0.12	0.02	1,684.8	0.17	0.02	1,570.4	0.16	0.02	1,483.8	0.13	0.02	1,391.2	0.15	0.02
	2014			2015			2016			2017			2018			2019		
	Pounds CO ₂ per MWh			Pounds CO ₂ per MWh			Pounds CO ₂ per MWh			Pounds CO ₂ per MWh			Pounds CO ₂ per MWh			Pounds CO ₂ per MWh		
	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O
Navajo Generating Station (NGS)	2,198.4			2,292.8			2,336.9			2,314.9			2,345.4			2,395.9		

APPENDIX F. EASTERN PIMA COUNTY COMMUNITY INVENTORY DATA INPUTS

	2014	2015	2016	2017	2018	2019
STATIONARY ENERGY						
Residential						
Fossil fuel combustion (therms)	70,295,295	75,109,297	77,504,592	68,164,943	72,449,231	87,737,703
Grid-supplied electricity (MWh)						
TEP	3,727,000	3,724,400	3,724,044	3,785,635	3,766,234	3,698,302
Trico	410,328	453,987	480,465	497,820	514,132	516,732
TOUA	27,982	28,436	29,012	28,679	29,643	30,870
Commercial						
Fossil fuel combustion (therms)	54,959,292	55,544,208	55,117,607	54,030,581	55,924,407	59,915,369
Grid-supplied electricity (MWh)						
TEP	2,203,000	2,156,231	2,169,275	2,209,377	2,136,449	2,076,799
Trico	21,596	23,894	25,288	26,201	27,060	27,196
TOUA	59,462	58,577	57,121	56,511	56,891	54,301
Industrial						
Fossil fuel combustion	Per year					
Natural gas (therms)	17,181,290	18,647,509	19,306,348	20,906,275	20,145,460	24,069,411
Industrial diesel (gallons)	5,455,090	20,178,144	15,511,503	17,319,302	18,253,463	19,478,860
Grid-supplied electricity (MWh) - TEP	3,235,000	3,172,435	3,003,057	2,930,921	2,981,330	2,953,099
TRANSPORTATION						
Onroad						
Miles/year						
Private & commercial vehicle travel	7,494,877,490	7,523,349,830	7,506,926,630	7,632,859,270	7,806,686,310	7,885,892,750
Cat Tran	174,459	135,160	195,707	189,254	186,467	158,835
LOOP	27,757	17,160	discontinued	discontinued	discontinued	discontinued
Oro Valley Sun Shuttle	442,796	390,365	485,071	469,419	467,516	460,087
Sun Shuttle ADA Dial-a-Ride	1,619,569	1,843,727	1,865,065	1,707,095	1,494,994	1,461,114
Sun Shuttle	1,047,621	1,029,674	1,035,532	1,038,436	940,874	890,789
Sun Tran	9,566,033	8,576,479	10,448,029	9,708,068	9,665,805	9,531,976
Sun Van	4,464,354	4,503,949	4,641,935	4,551,159	4,514,773	4,348,381
Sun Link	83,173*	198,107	194,709	200,032	205,943	204,051
Transit total	17,342,588	16,694,621	18,866,048	17,863,463	17,476,372	17,055,233
Nonroad						
EPA MOVES2014b - E. Pima County 2014-2019						
Locomotives						
Diesel	8,229,006	6,346,540	7,275,362	7,217,037	11,827,309	9,774,695
Aircraft						
Avgas	398,949	413,549	392,651	412,851	418,289	271,608
Jet A	51,052,426	62,716,094	60,623,736	64,097,156	66,861,724	66,517,418
WASTE						
Solid waste						
Metric tons disposed/year						
Los Reales Landfill	495,053	506,331	527,388	708,235	761,501	644,840
Sahuarita Landfill	24,118	59,862	3,240	0-closed	0-closed	0-closed
Marana Regional Landfill	266,840	265,500	302,745	332,348	339,658	349,887
Speedway Recycling & Landfill Facility	40,849	42,252	58,018	49,529	52,814	48,754
Solid waste total	826,860	873,946	891,390	1,090,112	1,153,973	1,043,481
Wastewater reclamation						
Population served						
Pima County Nitrification/denitrification	621,703	588,561	588,561	588,561	709,233	713,338
Marana Nitrification/denitrification	5,649	6,014	6,271	7,483	8,680	9,409
Pima County Lagoons (Biochemical oxygen demand [BOD5] load)	Varies by treatment facility					
Standard cubic feet/day						
Digester gas flared	716,854	573,990	565,098	601,678	597,794	701,185
Digester gas combustion for energy	43,311	82,059	112,806	94,564	203,467	150,318
INDUSTRIAL PROCESSES						
Cement production	EPA reported emissions 2014-2019					
OTHER						
Grid-supplied electricity (MWh)- CAP	388,569	396,598	394,592	326,361	325,738	379,431
Water deliveries (acre-feet)	142,315	145,037	144,781	117,680	123,327	144,185
ENERGY INDUSTRIES**						
Energy generation (TEP H. Sundt, DeMoss Petrie, North Loop)	EPA reported emissions 2014-2019					

* In operation for six months

** Emissions not included in totals

APPENDIX G: CITY OF TUCSON COMMUNITY INVENTORY DATA INPUTS

	2014	2015	2016	2017	2018	2019
STATIONARY ENERGY						
Residential						
Fossil fuel combustion (therms)	54,358,158	58,080,744	60,188,772	52,090,295	56,327,891	66,146,800
Grid-supplied electricity (MWh)						
TEP	1,962,078	1,962,610	2,022,532	2,078,975	2,030,136	2,065,731
Trico	165,863	177,265	185,463	186,725	195,638	185,827
Commercial						
Fossil fuel combustion (therms)	46,397,692	46,891,489	46,437,285	45,542,247	46,158,706	48,840,324
Grid-supplied electricity (MWh)						
TEP	1,599,148	1,523,284	1,563,420	1,594,975	1,537,554	1,527,750
Trico	8,730	9,330	9,761	9,828	10,297	9,780
Industrial						
Fossil fuel combustion (therms)	14,348,563	15,573,042	16,644,176	17,603,049	17,197,233	19,892,946
Grid-supplied electricity (MWh)						
TEP	1,337,580	1,395,326	1,449,823	1,392,696	1,333,868	1,355,772
TRANSPORTATION						
Onroad						
Miles/year						
Private & commercial vehicle travel	3,777,111,470	4,014,079,550	4,006,875,280	4,025,179,770	4,091,581,120	4,138,344,070
Transit						
Cat Tran	174,459	135,460	195,707	189,254	186,467	158,835
LOOP	27,757	17,160	discontinued	discontinued	discontinued	discontinued
Sun Shuttle ADA Dial-a-Ride	85,240	195,638	783,327	716,980	627,897	613,668
Sun Shuttle	48,148	195,638	196,751	197,303	178,766	169,250
SunTran	8,863,886	8,007,858	9,755,325	9,064,423	8,109,936	7,947,432
Sun Van	4,136,670	4,173,359	4,301,217	4,217,104	4,183,389	4,029,210
Sun Link	83,173*	198,107	194,709	200,032	205,943	204,051
Transit total	13,336,160	12,923,220	15,427,036	14,585,096	13,492,398	13,122,446
Nonroad						
EPA MOVES2014b E. Pima County - 2014-2019 (Factored by City Population)						
WASTE						
Solid waste disposal						
Metric tons disposed/year						
Los Reales Landfill	495,053	506,331	527,388	708,235	761,501	644,840
Speedway Recycling & Landfill Facility	40,849	42,252	58,018	49,529	52,814	48,754
Solid waste totals	535,902	548,583	585,406	757,764	814,315	693,594
Wastewater reclamation						
Calculated City fraction of County's wastewater emission totals						
OTHER						
Grid-supplied electricity (MWh) - CAP (City portion)	252,570	210,895	211,767	178,878	139,022	164,946
Water deliveries (acre-feet) (City portion)	92,505	77,125	77,700	64,500	52,635	62,680
Energy Industries**						
Energy generation (TEP H. Sundt, DeMoss Petrie)	EPA reported emissions 2014-2019					

* In operation for six months

** Emissions not included in totals

APPENDIX H. WASTE & RECYCLING CHARACTERIZATIONS

WASTE	Waste Type	Percent Composition
Construction and Demolition	Paper products	3
Source: Cascadia, 2006	Food	0
	Plant debris	1
	Wood/textiles	20
	Other (not included - nonorganic)	76
Government-generated (2014-2019)	Newspaper	1.7
Source: ICLEI, 2010	Office paper	1.8
	Corrugated cardboard	4.8
	Magazines/glossy paper	9
	Food scraps	15.5
	Grass	1.9
	Leaves	3.2
	Branches	2
	Lumber	25.5
	Mixed municipal waste	34.6
RECYCLING	Waste Type	Percent Composition
County & City- 2014-2019 (Community and Government)	OCC and other paper	25.4
Source: Cascadia, 2014	ONP and other paper	40.1
	Aluminum	1.1
	Tin (steel cans)	2.3
	Other metal	0.0
	PET bottles	4.4
	HDPE natural bottles	1.1
	HDPE pigmented bottles	1.4
	Other plastics	2.0
	Mixed glass	22.1

APPENDIX I: EPA'S WARM MODEL (VERSION 15) PER TON ESTIMATES OF BASELINE AND ALTERNATIVE MANAGEMENT SCENARIOS

Material	GHG Emissions per Ton of Material Source Reduced (MTCO _{2e})	GHG Emissions per Ton of Material Recycled (MTCO _{2e})	GHG Emissions per Ton of Material Landfilled (MTCO _{2e})	GHG Emissions per Ton of Material Combusted (MTCO _{2e})	GHG Emissions per Ton of Material Composted (MTCO _{2e})
Corrugated Containers	(5.58)	(3.14)	0.18	(0.49)	NA
Magazines/third-class mail	(8.57)	(3.07)	(0.43)	(0.35)	NA
Newspaper	(4.68)	(2.71)	(0.85)	(0.56)	NA
Office Paper	(7.95)	(2.86)	1.13	(0.47)	NA
Phonebooks	(6.17)	(2.62)	(0.85)	(0.56)	NA
Textbooks	(9.02)	(3.10)	1.13	(0.47)	NA
Mixed Paper (general)	(6.07)	(3.55)	0.07	(0.49)	NA
Mixed Paper (primarily residential)	(6.00)	(3.55)	0.02	(0.49)	NA
Mixed Paper (primarily from offices)	(7.37)	(3.58)	0.11	(0.45)	NA
Food Waste	(3.66)	NA	0.50	(0.13)	(0.12)
Yard Trimmings	NA	NA	(0.20)	(0.17)	(0.05)
Grass	NA	NA	0.12	(0.17)	(0.05)
Leaves	NA	NA	(0.53)	(0.17)	(0.05)
Branches	NA	NA	(0.54)	(0.17)	(0.05)
HDPE	(1.42)	(0.76)	0.02	1.29	NA
LDPE	(1.80)	NA	0.02	1.29	NA
PET	(2.17)	(1.04)	0.02	1.24	NA
LLDPE	(1.58)	NA	0.02	1.29	NA
PP	(1.52)	(0.79)	0.02	1.29	NA
PS	(2.50)	NA	0.02	1.65	NA
PVC	(1.93)	NA	0.02	0.66	NA
Mixed Plastics	(1.87)	(0.93)	0.02	1.26	NA
PLA	(2.45)	NA	(1.64)	(0.63)	(0.09)
Desktop CPUs	(20.86)	(1.49)	0.02	(0.66)	NA
Portable Electronic Devices	(29.83)	(1.06)	0.02	0.65	NA
Flat-Panel Displays	(24.19)	(0.99)	0.02	0.03	NA
CRT Displays	NA	(0.57)	0.02	0.45	NA
Electronic Peripherals	(10.32)	(0.36)	0.02	2.08	NA
Hard-Copy Devices	(7.65)	(0.56)	0.02	1.20	NA
Mixed Electronics	NA	(0.79)	0.02	0.39	NA
Aluminum Cans	(4.80)	(9.13)	0.02	0.03	NA
Aluminum Ingot	(7.48)	(7.20)	0.02	0.03	NA
Steel Cans	(3.03)	(1.83)	0.02	(1.59)	NA
Copper Wire	(6.72)	(4.49)	0.02	0.03	NA
Mixed Metals	(3.65)	(4.39)	0.02	(1.02)	NA
Glass	(0.53)	(0.28)	0.02	0.03	NA
Asphalt Concrete	(0.11)	(0.08)	0.02	NA	NA
Asphalt Shingles	(0.19)	(0.09)	0.02	(0.35)	NA
Carpet	(3.68)	(2.38)	0.02	1.10	NA
Clay Bricks	(0.27)	NA	0.02	NA	NA
Concrete	NA	(0.01)	0.02	NA	NA
Dimensional Lumber	(2.13)	(2.66)	(0.92)	(0.58)	NA
Drywall	(0.22)	0.03	(0.06)	NA	NA
Fiberglass Insulation	(0.38)	NA	0.02	NA	NA
Fly Ash	NA	(0.87)	0.02	NA	NA
Medium-density Fiberboard	(2.41)	NA	(0.85)	(0.58)	NA
Vinyl Flooring	(0.58)	NA	0.02	(0.31)	NA
Wood Flooring	(4.03)	NA	(0.86)	(0.74)	NA
Tires	(4.30)	(0.38)	0.02	0.50	NA
Mixed Recyclables	NA	(2.85)	0.03	(0.42)	NA
Mixed Organics	NA	NA	0.18	(0.15)	(0.09)
Mixed MSW	NA	NA	0.31	0.01	NA

APPENDIX J: PIMA COUNTY GOVERNMENT OPERATIONS INVENTORY DATA INPUTS

	2014	2015	2016	2017	2018	2019
STATIONARY ENERGY						
Facilities and Parks						
Fossil fuel combustion (therms)	830,902	909,802	762,133	735,760	736,830	899,294
Grid-supplied electricity (kWh)	65,019,277	64,236,857	61,622,742	56,918,835	69,141,493	66,421,510
Wastewater						
Fossil fuel combustion (therms)	1,566	6,029	5,933	2,087	3,959	83,530
Grid-supplied electricity (kWh)	29,412,192	53,454,479	54,617,617	55,834,290	33,098,611	34,118,049
Digester gas flared	716,854	573,990	565,098	601,678	597,794	701,185
Digester gas combusted for energy	43,311	82,059	112,806	94,564	203,467	150,318
Street and Traffic Lighting (kWh)	2,465,983	2,660,000	2,660,867	2,606,577	2,757,138	2,675,569
FLEET	Miles/year					
Onroad (total)	8,470,763	16,276,144	10,780,342	15,361,971	15,370,105	14,673,445
Gasoline	7,089,431	15,357,152	9,620,759	14,378,622	14,380,286	13,849,226
Diesel	1,381,332	918,992	1,159,583	983,349	989,819	824,219
Nonroad	Gallons/year					
Diesel	20,756	26,819	10,986	34,362	19,084	20,237
Gasoline	0	0	0	41	3,214	329
WASTE	Metric tons disposed/year					
Solid Waste	3,830	3,560	3,528	3,944	2,382	2,190
Wastewater Treatment	Population Served					
Nitrification/denitrification	616,054	588,561	588,561	588,561	709,233	713,338
Lagoons (BOD5/day)	Varies by facility					
EMPLOYEE COMMUTING	Miles/year					
	44,661,408	40,426,246	38,635,126	37,911,970	37,042,772	36,074,584
ENERGY GENERATION	kWh					
Solar	4,424,774	5,350,699	7,156,618	10,728,263	14,080,529	16,046,468

APPENDIX K. CITY OF TUCSON GOVERNMENT OPERATIONS INVENTORY DATA INPUTS

	2014	2015	2016	2017	2018	2019
STATIONARY ENERGY						
Facilities and Parks						
Fossil fuel combustion (therms)	1,254,953	954,306	991,806	874,222	962,544	1,055,628
Grid-supplied electricity (kWh)						
TEP	58,756,987	64,351,529	62,595,189	60,603,024	58,167,728	54,548,628
Tucson Water (Potable and Reclaimed)						
Fossil fuel combustion (therms)	2,814,788	2,255,761	2,126,157	4,110,216	2,994,363	3,834,448
Grid-supplied electricity (kWh)						
TEP	66,238,597	57,644,992	72,433,915	71,445,647	65,308,144	64,988,623
Trico	54,406,698	64,037,972	47,565,482	37,532,374	53,445,545	42,173,656
BIA	38,953	55,130	28,630	11,673	12,107	8,065
Central Arizona Project						
Navajo Generating Station (kWh)	388,569,062	396,597,999	394,592,366	326,361,316	325,737,864	379,430,887
Water delivery (acre-feet)	142,315	145,037	144,781	117,680	123,327	144,185
Fleet Facilities						
TEP (kWh)	417,840	1,850,579	2,253,789	2,721,281	2,761,382	2,690,513
Street and Traffic Lighting						
TEP (kWh)	24,843,836	21,941,872	19,668,391	9,743,843	8,045,104	8,198,177
District Energy						
Fossil fuel combustion (therms)	925,745	592,350	743,240	777,520	578,920	709,070
TRANSPORTATION	Miles/year					
Onroad (Total)	20,275,836	19,701,739	19,796,712	17,977,228	18,297,482	17,261,487
Diesel	3,835,083	2,899,715	3,054,663	2,777,589	2,030,584	1,582,073
Gasoline	14,786,755	14,300,003	14,837,051	12,994,980	14,464,208	13,606,202
E-85	1,017,048	1,789,953	1,054,807	1,137,580	409,668	406,541
CNG	635,567	705,592	844,592	1,060,403	1,386,500	1,659,541
LPG	1,383	6,476	5,599	6,676	6,522	7,130
Nonroad	Gallons/year					
Diesel	229,451	223,284	211,006	222,149	59,533	46,467
Gasoline	845	661	593	598	12,896	12,627
LPG	1,573	1,687	1,602	1,527	4,195	3,093
WASTE	Metric tons disposed/year					
Solid waste	11,703	9,505	9,320	9,935	10,531	10,728
	Miles/year					
EMPLOYEE COMMUTING	26,468,180	24,625,367	28,158,504	26,653,947	27,185,881	24,964,992
	kWh					
Solar Energy Generation	12,412,525	16,672,930	16,843,462	17,406,202	17,648,151	19,331,066