



# Regional **GREENHOUSE GAS** Inventory (2016-2021)

# PIMA ASSOCIATION OF GOVERNMENTS

October 2023

This report was funded in part through grant(s) from the Federal Highway Administration and/or Federal Transit Administration, U.S. Department of Transportation. The content of this report reflects the views and opinions of the author and contributors who are responsible for the accuracy of the data presented herein. The contents do not necessarily state or reflect the official views or policies of the U.S. Department of Transportation, or any other state or federal agency. This report does not constitute a standard, specification or regulation.

## Acknowledgements

Numerous representatives from various organizations have contributed information to this report and their efforts are greatly appreciated. We extend a special note of thanks to Pima County and City of Tucson staff for their contributions. Additionally, various staff from Pima Association of Governments (PAG), Town of Marana, Tucson Electric Power, Southwest Gas, Tohono O'odham Utility Authority, Trico Electric Cooperative Inc., Tucson Airport Authority, Ryan Airfield, Davis-Monthan Air Force Base, Marana Airport, Union Pacific Railroad, Arizona Department of Transportation, Central Arizona Project and others provided valuable information needed for compiling this report. A full list of contributors is contained in Appendix A. The report was reviewed and approved by PAG's Environmental Planning Advisory Committee.

# TABLE OF CONTENTS



<b>List of Acronyms .....</b>	<b>v</b>
<b>Executive Summary.....</b>	<b>1</b>
<b>Regional Background .....</b>	<b>8</b>
<b>Project Objectives .....</b>	<b>11</b>
<b>General Methodology .....</b>	<b>12</b>
<b>Community Inventories .....</b>	<b>12</b>
<i>Eastern Pima County Regional Inventory Overview .....</i>	<i>21</i>
<i>Eastern Pima County Regional Synopsis .....</i>	<i>27</i>
<i>Tucson Community Inventory Overview .....</i>	<i>29</i>
<i>Tucson Community Synopsis .....</i>	<i>33</i>
<i>Pima County Government Operations Inventory Overview.....</i>	<i>35</i>
<i>Pima County Government Synopsis .....</i>	<i>39</i>
<i>City of Tucson Government Operations Inventory Overview.....</i>	<i>41</i>
<i>City of Tucson Government Synopsis .....</i>	<i>45</i>
<b>Report Summary.....</b>	<b>47</b>
<b>References Cited .....</b>	<b>48</b>
<b>Appendices.....</b>	<b>51</b>

# LIST OF FIGURES



<b>Figure 1.</b> Map of Boundaries for the County and City Community GHG Inventories .....	13
<b>Figure 2.</b> County Community Greenhouse Gas Emissions 2016-2021 .....	21
<b>Figure 3.</b> 2021 County Community Greenhouse Gas Emissions by Source .....	22
<b>Figure 4.</b> 2021 County Community Stationary Energy Emissions.....	23
<b>Figure 5.</b> 2021 County Community Transportation Emissions .....	24
<b>Figure 6.</b> 2021 County Community Waste Emissions.....	25
<b>Figure 7.</b> City Community Greenhouse Gas Emissions 2016-2021 .....	29
<b>Figure 8.</b> 2021 City Community Greenhouse Gas Emissions by Source .....	29
<b>Figure 9.</b> 2021 City Community Stationary Energy Emissions.....	30
<b>Figure 10.</b> 2021 City Community Transportation Emissions .....	31
<b>Figure 11.</b> 2021 City Community Waste Emissions .....	32
<b>Figure 12.</b> County Government Greenhouse Gas Emissions 2016-2021 .....	35
<b>Figure 13.</b> 2021 County Government Greenhouse Gas Emissions by Source .....	35
<b>Figure 14.</b> 2021 County Government Stationary Energy Use Emissions.....	36
<b>Figure 15.</b> 2021 County Government Fleet Emissions.....	37
<b>Figure 16.</b> 2021 County Government Waste Emissions.....	38
<b>Figure 17.</b> City Government Greenhouse Gas Emissions 2016-2021 .....	41
<b>Figure 18.</b> 2021 City Government Greenhouse Gas Emissions by Source.....	42
<b>Figure 19.</b> 2021 City Government Stationary Energy Use Emissions.....	43
<b>Figure 20.</b> 2021 City Government Fleet Emissions.....	44

# LIST OF TABLES



<b>Table 1.</b> County Community Recycled Material Totals and Emissions Saved 2016-2021 .....	26
<b>Table 2.</b> County Community GHG Emissions (metric tons CO <sub>2</sub> e) 2016-2021 .....	28
<b>Table 3.</b> City Community Recycled Material Totals and Emissions Saved 2016-2021 .....	32
<b>Table 4.</b> City Community GHG Emissions (metric tons CO <sub>2</sub> e) 2016-2021 .....	34
<b>Table 5.</b> County Government Recycled Material Totals and Emissions Saved 2016-2021 .....	38
<b>Table 6.</b> County Government GHG Emissions (metric tons CO <sub>2</sub> e) 2016-2021 .....	40
<b>Table 7.</b> City Government Recycled Material Totals and Emissions Saved 2016-2021 .....	44
<b>Table 8.</b> City Government GHG Emissions (metric tons CO <sub>2</sub> e) 2016-2021 .....	46

# LIST OF ACRONYMS



ClearPath	ICLEI's software tool for quantifying greenhouse gases
CAP	Central Arizona Project
CH <sub>4</sub>	Methane
CNG	Compressed Natural Gas
CO <sub>2</sub>	Carbon Dioxide
CO <sub>2</sub> e	Carbon Dioxide Equivalents
EIA	Energy Information Administration (department within USDOE)
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GHG	Greenhouse Gas
GWP	Global Warming Potential
ICLEI	International Council for Local Environmental Initiatives Governments
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt-hour(s)
MWh	Megawatt-hour(s)
N <sub>2</sub> 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 Corporation
TEP	Tucson Electric Power Company
TOUA	Tohono O'odham Utility Authority
TRP	Travel Reduction Program
UPRR	Union Pacific Railroad
USDOE	U.S. Department of Energy
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 biennial greenhouse gas (GHG) inventories compiled by Pima Association of Governments (PAG) for the eastern Pima County region, the last of which was completed in 2021. 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, 2021)* 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 cloud-based emissions management software was used to develop the community scale and government operations GHG emissions inventories for the eastern Pima County and City of Tucson communities and Pima County and City of Tucson government operations for 2016 through 2021. Each inventory component tracks the production of the three major GHGs: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O). These are expressed as carbon dioxide equivalents (CO<sub>2</sub>e) based on global warming potential (GWP) values. GWP values are established through global scientific consensus by the Intergovernmental Panel on Climate Change (IPCC). As climate science continues to develop, the GWPs of gases are updated. The values were assessed over 100-year time frames and this inventory uses the IPCC 5th Assessment Report (AR5) values of 28 for CH<sub>4</sub> and 265 for N<sub>2</sub>O, while the previous report used AR4 values.

These inventories do not track all sources of GHG emissions generated in the region or include sinks (a reduction in atmospheric GHG emissions by storing carbon in another form) but were designed to track emissions resulting from the actions and activities of communities and their governments. The goal is to quantify the major GHG emission sources that are the result of activities under the control or influence of the Pima County and City of Tucson communities and their governments to identify and develop practices and policies to reduce emissions. Solar electricity generation and recycling are included in the government inventories to demonstrate their impact in reducing emissions. Examples of emissions not covered in this report due to unavailability of adequate information are hydrofluorocarbons (HFCs), perfluorocarbon (PFC) refrigerants, sulfur hexafluoride (SF<sub>6</sub>), fugitive emissions from natural gas distribution, and emissions from agriculture-related activities.

PAG, on behalf of member jurisdictions, including Pima County and the City of Tucson, developed this inventory to identify, quantify and track GHG emissions from 2016-2021. The previous inventory covered 2014-2019. The report 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 eastern portion of the Tohono O'odham Nation including all of the San Xavier District, Pascua Yaqui Tribe and most of unincorporated eastern Pima County (See Figure 1). Included are emissions from stationary energy use by sector (electricity and natural gas), transportation (onroad, nonroad vehicle use, locomotive and aircraft), waste (solid and wastewater reclamation), industrial processes (cement production), Central Arizona Project (CAP) energy use (Other) and energy industry natural gas transport.

## 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 and 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, and potable and reclaimed water handling), fleet (onroad, nonroad vehicle use), solid waste and employee commuting.

## COMMUNITY INVENTORIES OVERVIEW

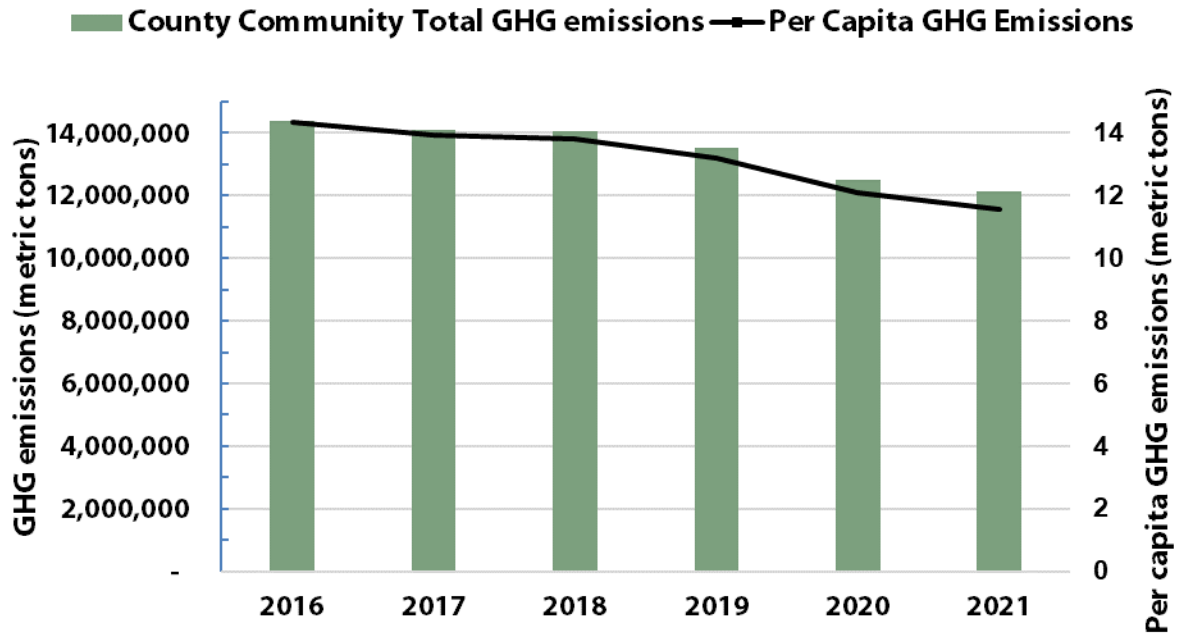
Generally, regional GHG emissions downward trends and sources follow those of the United States. Over the 2016-2021 period, national GHG emissions declined by 3.6% from 6,578 million metric tons annually in 2016 to 6,340 million metric tons in 2021. The 2021 per capita emissions were 19.06 metric tons, down from 20.36 metric tons in 2016 (USEPA, 2021, U.S. Census Bureau, 2021).

Over the same period, County Community GHG emissions declined by a greater percentage than the national trend. GHG emissions fell 15.6% from 14.4 million metric tons in 2016 to 12.1 million metric tons in 2021. Per capita emissions also remained lower than national levels and similarly declined due to a combination of a drop in emissions and population growth trends over this time, although regional emissions do not cover certain emission sources such as national defense operations, agriculture and product manufacturing (Figure ES-1). Eastern Pima County's 2021 per capita emissions were 11.58 metric tons, down from 14.35 metric tons in 2016, while the City Community 2021 per capita emissions were down to 9.58 metric tons from 13.57 metrics tons in 2016 (Appendix B).

Pandemic-related decreases in emissions occurred during 2020. Total emissions were down 9% nationally compared to 2019 and down 8% regionally. However, emissions rebounded 5% nationally in 2021 over 2020, while they continued to drop another 3% in our region (Table 2). Electricity production and transportation were the major U.S. GHG emission sources nationally and in eastern Pima County and the City of Tucson.

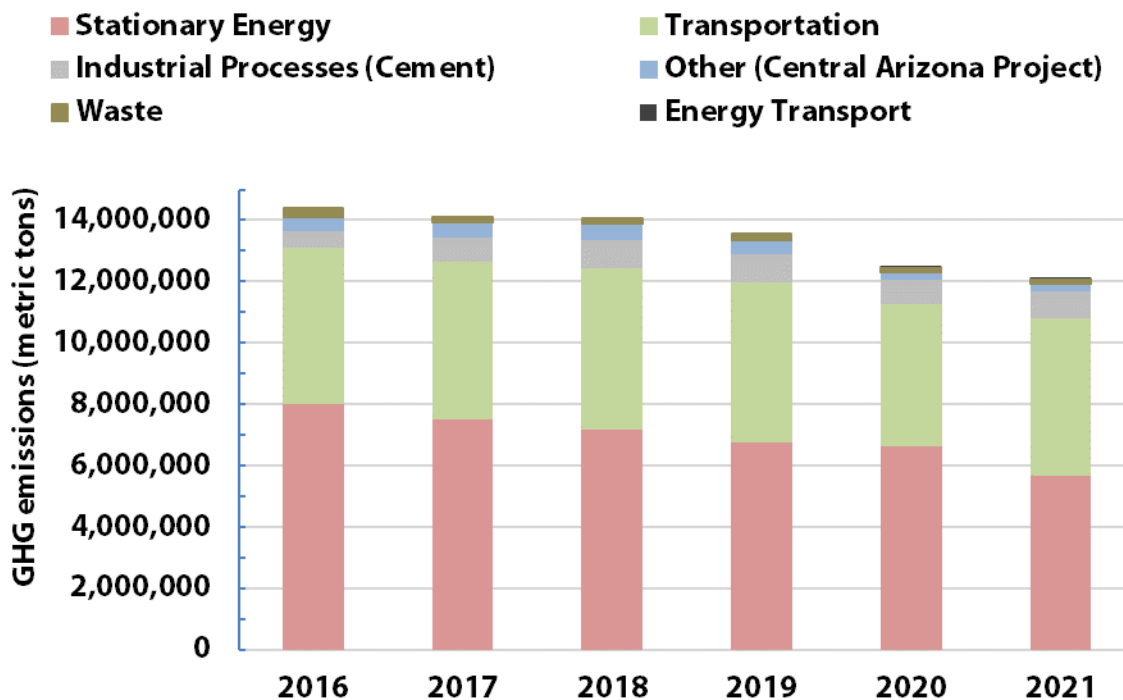


**Figure ES-1. County Community Greenhouse Gas and Per Capita Emissions 2016-2021**



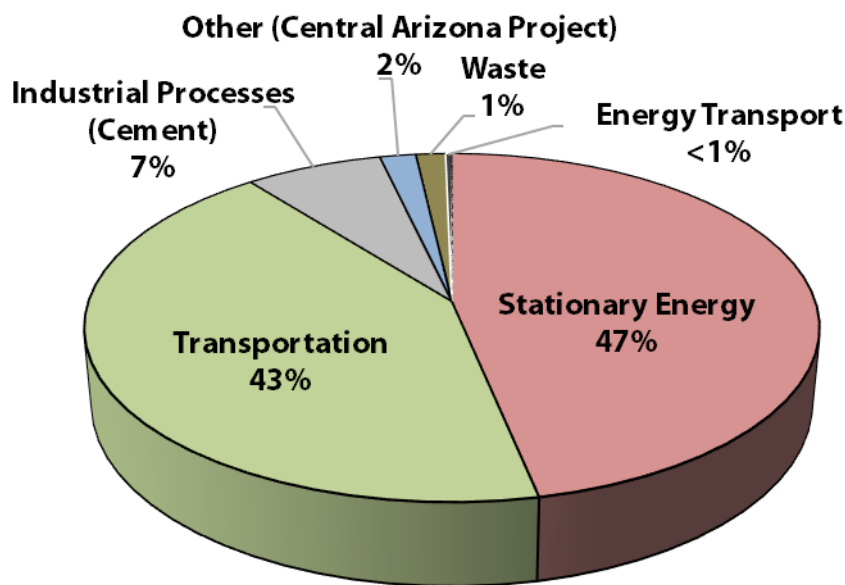
Over the inventory period, County Community emissions showed reductions in all categories except for transportation and industrial processes (Figure ES-2). Stationary energy use was the major source of County Community emissions, averaging 52% of total emissions. Within the stationary energy sector, residential energy use was the major contributor (47%). Electricity use was responsible for 88% of stationary energy emissions and 46% of total County Community emissions over the inventory period.

**Figure ES-2. County Community Greenhouse Gas Emissions 2016-2021**



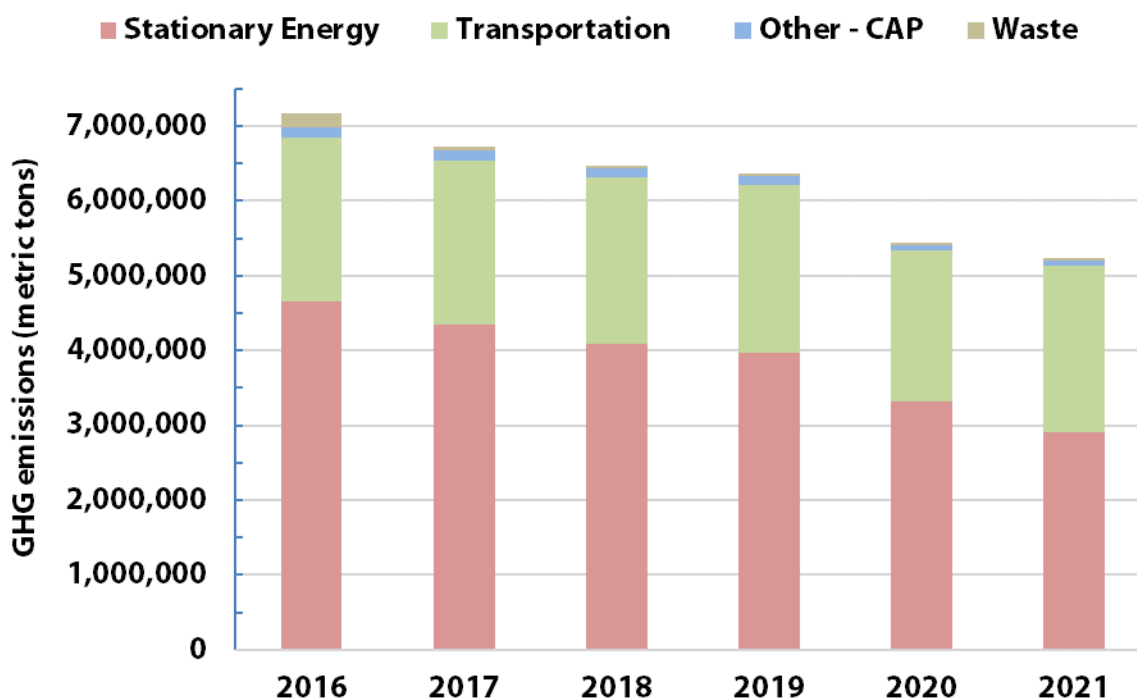
Transportation emissions were the other major source of emissions, averaging about 38% of total annual GHG emissions from 2016-2021. Onroad vehicle emissions comprised 79% of transportation emissions. Figure ES-3 shows the relative contributions of each sector to the 2021 total.

**Figure ES-3. 2021 County Community Greenhouse Emissions by Source**

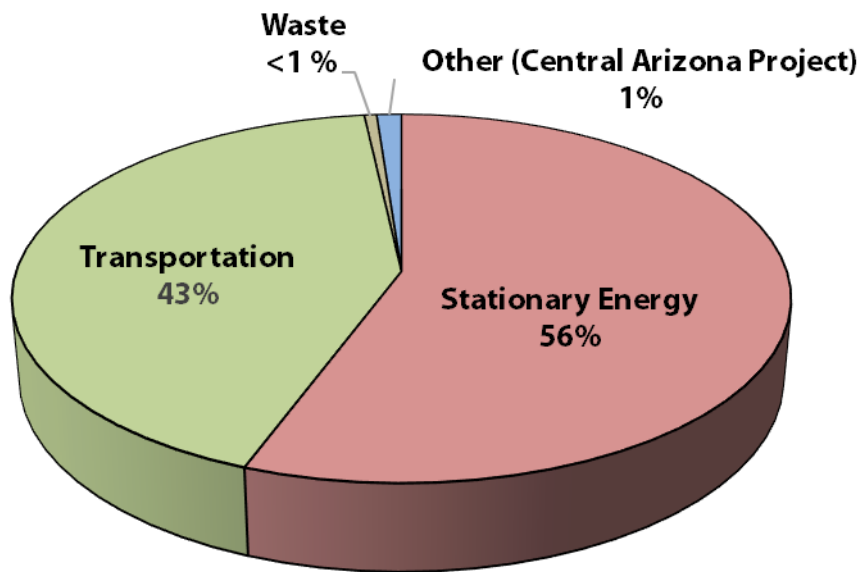


From 2016-2021, City Community emissions dropped by 27%. Emission reductions occurred in all sectors except for transportation (Figure ES-4). Energy use and transportation were the major sources of emissions in 2021 (Figure ES-5).

**Figure ES-4. City Community Greenhouse Gas Emissions 2016-2021**



**Figure ES-5. 2021 City Community Greenhouse Gas Emissions by Source**

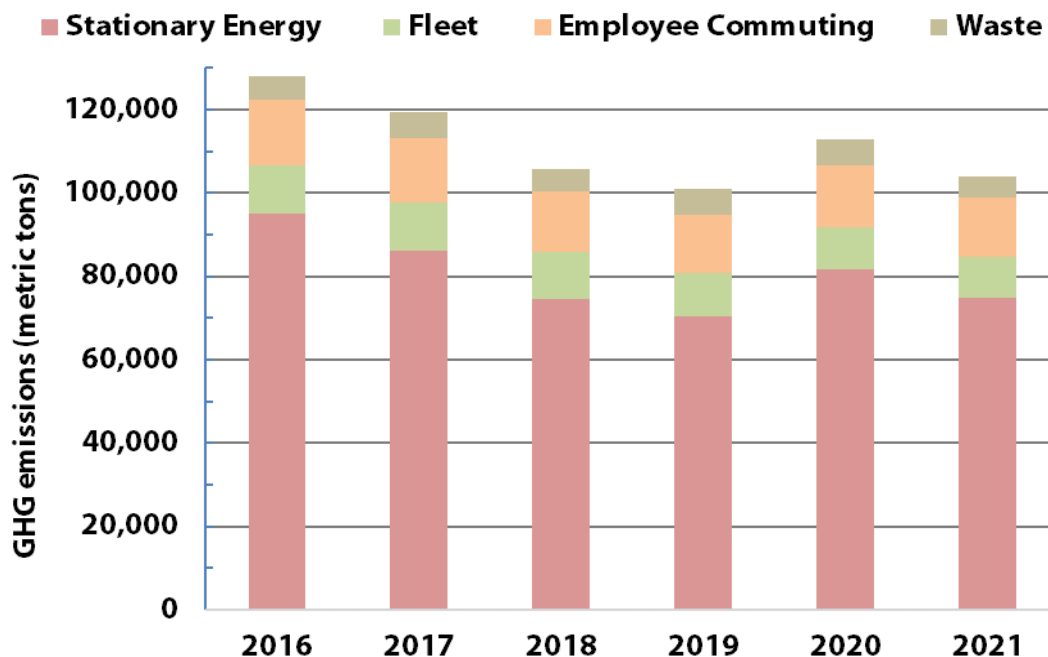


## GOVERNMENT OPERATIONS INVENTORIES OVERVIEW

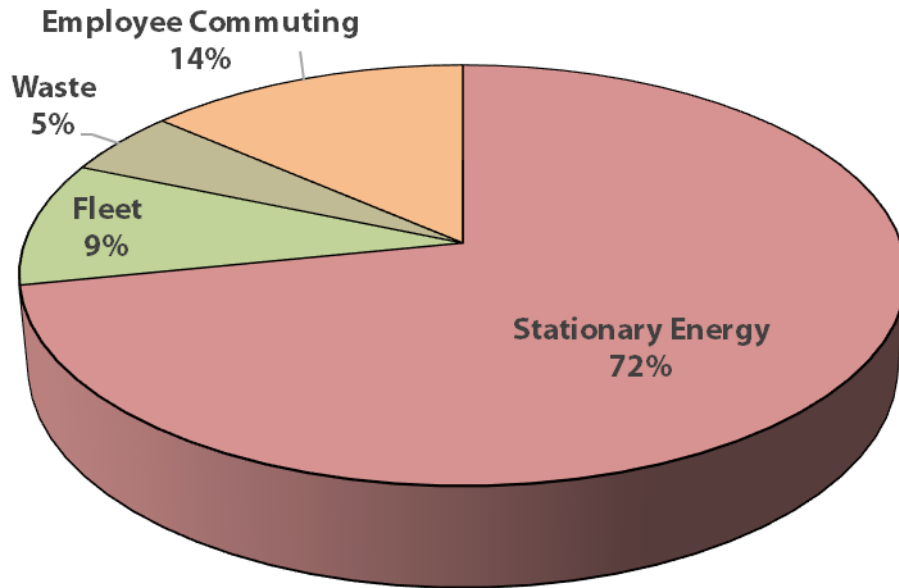
Government-generated emissions were a small portion of Community totals. Stationary energy, which is primarily electricity use, generated most of the County and City Governments' emissions.

From 2016-2021, County Government emissions declined by 19%, due to reductions in the stationary energy, fleet, employee commuting and waste sectors (Figure ES-6). Stationary energy use emissions made up the majority of County Government emissions in 2021, while the remaining emissions were attributed to employee commuting and fleet, followed by waste (Figure ES-7).

**Figure ES-6. County Government Greenhouse Gas Emissions 2016-2021**

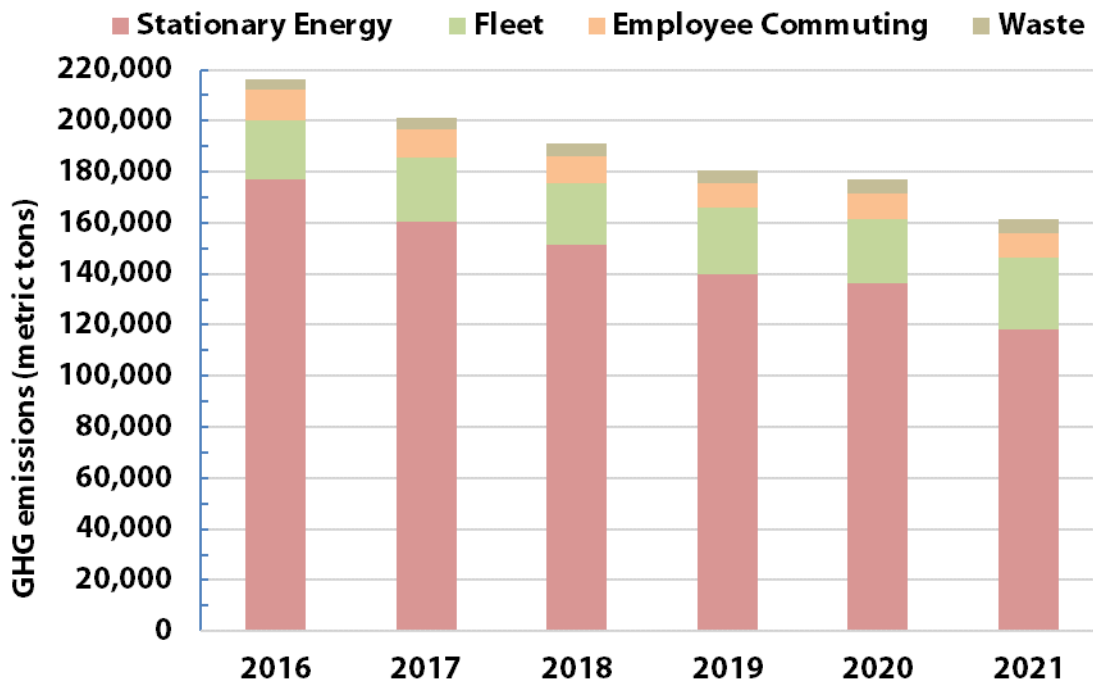


**Figure ES-7. 2021 County Government Greenhouse Gas Emissions by Source**

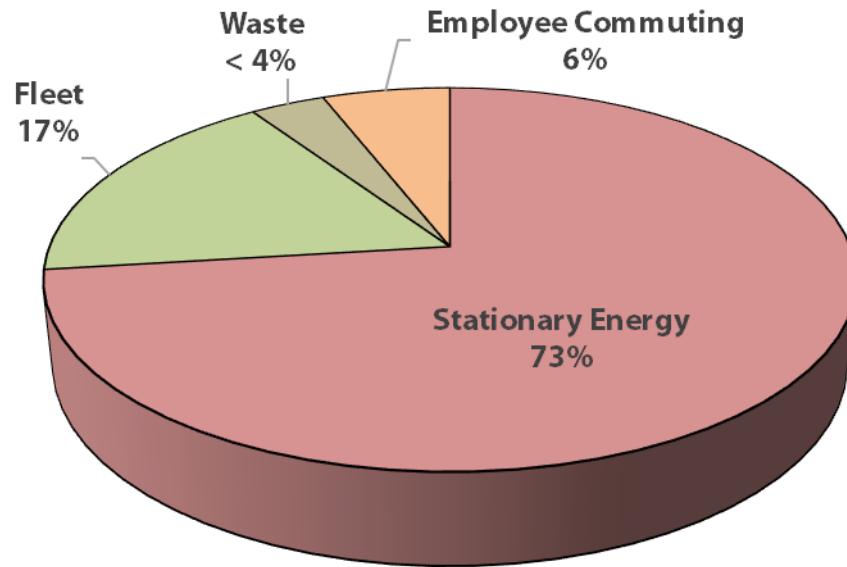


From 2016-2021, City Government emissions dropped by 25%, reflecting a decrease in the stationary energy sector (Figure ES-8). In 2021, stationary energy consumption was the major source of City government emissions (water-related energy use was the predominant contributor to stationary energy use emissions), followed by fleet, employee commuting and waste (Figure ES-9).

**Figure ES-8. City Government Greenhouse Gas Emissions 2016-2021**



**Figure ES-9. 2021 City Government Greenhouse Gas Emissions**



# REGIONAL BACKGROUND



## 2023

- The Pima County Department of Environmental Quality (PDEQ) was awarded the Climate Pollution Reduction Grant for the Tucson Metropolitan Statistical Area (MSA) in August, a noncompetitive grant from the U.S. Environmental Protection Agency (USEPA) in the amount of \$1 million used for planning to develop climate, energy or sustainability plans.
- The City of Tucson Mayor and Council adopted the Tucson Resilient Together Climate Action and Adaptation Plan (City of Tucson, 2023). The plan lays out steps and strategies to achieve carbon neutrality across City operations by 2030 and community-wide carbon neutrality by 2045.
- The Bipartisan Infrastructure Bill established the Carbon Reduction Program (CRP) and requires states to develop a carbon reduction strategy by November. PAG's Regional Council, Federal Highway Administration (FHWA) and Arizona Department of Transportation (ADOT) have approved PAG's Overall Work Program (OWP) for use of CRP funding for multiple programs and activities, including: development of multimodal components of PAG's Regional Mobility and Accessibility Plan (RMAP); pedestrian and bicycle count program activities; PAG Regional Bike Map update; Regional Active Transportation Plan; interactive web-based carpool, vanpool matching system and subsidies; Sun Rideshare marketing efforts and digital materials for Travel Reduction Program (TRP) employers' workforce education efforts; Sun Rideshare commuter program; quarterly newsletter for Sun Rideshare News; dial-a-ride/micro transit service area analysis; exploratory planning tool and its development report for uncertain future system and environment; dynamic traffic assignment (DTA) model development and its report for calibration/validation and sensitivity tests with regional congestion mitigation and air quality modeling support; household travel survey results; TransView.org website; traffic incident reporting system [TIRS]; traffic volume counts; real-time online GIS system-based interactive maps; orthophoto data extraction; development and management of the PAG regional transportation data archive system; regional multimodal performance assessment; and support and assistance with agency coordination and the performance-based planning efforts and congestion management process.

## 2022

- The Pima County Board of Supervisors (Board) passed Resolution 2022-25 to revise the Sustainable Action Plan for County Operations (SAPCO) into a multi-year Climate Action Plan for County Operations (CAPCO). This extends the plan to 2030 and increases carbon reduction targets to 50% to 52% below 2005 levels to conform with the United States' Nationally Determined Contribution to achieve its commitment to the Paris Agreement on Climate

Change (Pima County, 2022).

## **2021**

- The City of Tucson approved an Electric Vehicle (EV) Readiness Roadmap to increase citywide adoption of EVs (City of Tucson, 2021).

## **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.
- 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 greenhouse gas (GHG) vehicles (PAG, 2020). PAG's plan was used as a resource for the State's ADOT National Electric Vehicle Infrastructure Deployment Plan released in 2022 (ADOT, 2022).

## **2018**

- The Board approved the seven-year SAPCO 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, 2018). 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. The FY 2020/2021 Annual Report highlights progress toward targets such as having reduced carbon emissions from the County fleet by 10% in non-electric vehicles and replacing 97 gas sedan vehicles with EVs (Pima County, 2021).
- 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 organizations developed this agreement which makes them community partners in working collaboratively toward the goals of the District. The District's goals are to reduce building energy and water consumption and climate-changing emissions from transportation by 50% by the year 2030.

## **2017**

- The City of Tucson introduced a bike-share program which now includes over 300 bikes in 36 locations strategically located throughout the City. This program provides public access to

bicycles for short trips, thereby circumventing the need to use motor vehicles.

- The Board adopted Resolution 2017-39 and Resolution 2017-51, which directed the County government to align its operational efforts to meet the United States' commitment to the Paris Agreement, which sought to reduce global carbon emissions by 26% to 28% below 2005 levels by the year 2025 (Pima County, 2017a, 2017b).

## **2016**

- The City of Tucson began a project to upgrade existing government-owned lighting to LED. Facilities that were included in this conversion included street and traffic lights, parking garages and underpasses.
- The Tucson Mayor and Council approved funding for a neighborhood-scale stormwater harvesting program utilizing funds from the Water Conservation Fee. This program provides funding to the City's Wards 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.

## **2007**

- The PAG Regional Council adopted a resolution directing PAG staff to conduct a GHG emissions inventory for the Tucson region in consultation with PAG jurisdictions. 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 reduction goals. Pima County and the City of Tucson have continued to make commitments to reduce energy consumption, fuel use and GHG emissions.

PAG manages other programs that provide for reduction of GHG emissions. PAG's Green Infrastructure mapping and bike and pedestrian planning efforts help to encourage active modes of transportation. PAG's technical support of the region's rain and stormwater harvesting programs works at reducing the demand for imported CAP water and offsetting use of potable water for irrigation. The TRP promotes alternative transportation modes and carpooling to reduce single-occupancy vehicle travel, congestion and emissions.



# PROJECT OBJECTIVES



The goal of this report is to track regional GHG emissions, identify major emission sources to assist County and City 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 becomes 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 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 basis level emissions inventory for 2016-2021 County and City Communities and their respective government operations inventories. The *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, 2021). ICLEI's *U.S. Community Protocol for Accounting and Reporting of GHG Emissions* does not use scopes as a framework for categorizing emissions because the organization-related definitions of scopes for corporate accounting do not translate to the community scale in a manner that is clear and consistently applicable as an accounting framework. The central categorizations of emissions used in the Community Protocol are sources located within the community boundaries and community activities that result in creation of GHG emissions directly or indirectly. *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).

The *ClearPath* Global 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 2016, 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 (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O). These are expressed as carbon dioxide equivalents (CO<sub>2</sub>e). Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF<sub>6</sub>) emissions were not included since data were not available on these pollutants.

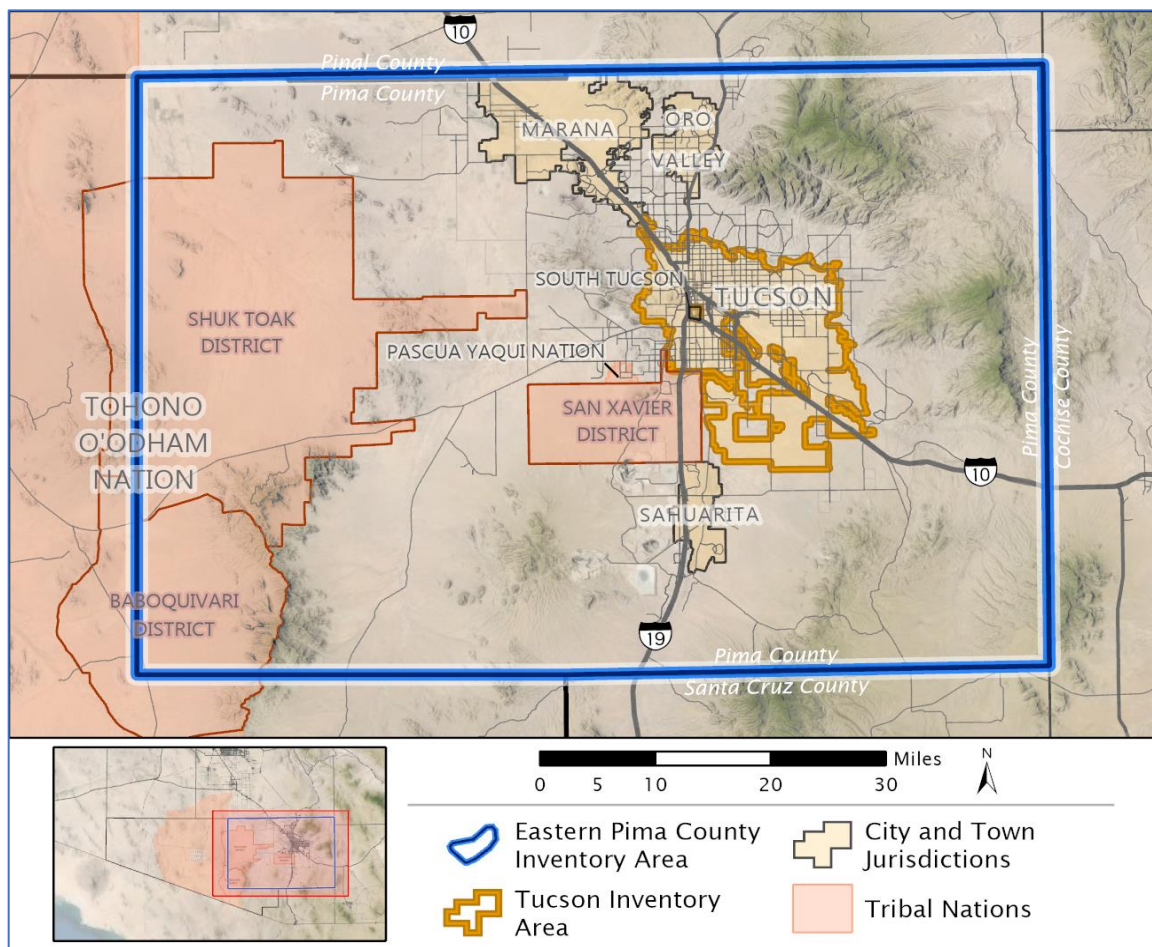
## COMMUNITY INVENTORIES

Separate County and City Community inventories were prepared for 2016 through 2021. These inventories do not track all 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 eastern 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 and natural gas), transportation (onroad, nonroad vehicle use, locomotives and aircraft), waste (solid and wastewater processing), industrial processes (cement production), Central Arizona Project (CAP) energy use (Other) and energy industry natural gas transport.

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 and 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**



## 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 and natural gas.

Southwest Gas Corporation (SWG) staff provided RCI natural gas use for eastern Pima County and for the City of Tucson from 2016 through 2021. SWG staff reaggregated energy use resulting in an overall shift from the industrial to commercial sector compared to the past inventory. The Tohono O'odham Nation and Pascua Yaqui Tribe's natural gas use is captured in the SWG totals. Emissions from fossil fuel combustion are calculated using fuel volumes and *ClearPath* emission factors for natural gas.

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 emissions released in the generation of electricity were incorporated into the electricity use totals and in the calculations of 2016-2021 TEP emission factors.

Electricity use data (2016-2021) 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 – generation (Table 2 and Table 4) but are not included in the County or City Community totals to avoid double counting. These emissions were included in the emission factor determination and the RCI sectors' electricity use emissions.

## TRANSPORTATION

### Onroad

Onroad vehicles include private and commercial vehicles such as motorcycles, cars, trucks, vans, SUVs, tractor trailers and transit buses. Previous inventories used modeling of regional vehicle miles traveled (VMT) and estimations of vehicle fuel economies to derive emissions, in which public transit historically has accounted for less than 1% of total emissions. In 2022, FHWA proposed a rulemaking for *Performance of the National Highway System, Greenhouse Gas Emissions Measure* in which state departments of transportation (DOTs) and metropolitan planning organizations (MPOs) would establish declining CO<sub>2</sub> targets and methods for the measurement and reporting of GHG emissions associated with transportation. The proposed methodology for estimating GHG emissions would measure tailpipe emissions on all public roads by utilizing the Fuels and Financial Analysis System – Highways (FUELS/FASH) records of motor fuel sales within the state and multiplying the total fuel type volumes by a CO<sub>2</sub> factor for each fuel type.

The approach of using fuel sales as a direct indicator of GHG emissions is more straightforward than the previous modeling approach and is utilized in the current report. ADOT tracks sales of onroad fuels by county as part of the Highway User Revenue Fund (HURF) program and provided fuel sales data in Pima County for the reporting period of 2016-2021. The geographic isolation of cities and towns within the boundaries of Pima County allows for accurate estimations using the fuel sales methodology for gasoline and diesel fuel.

Compressed Natural Gas (CNG) transportation fuel usage data was provided by SWG and assigned geographically to the corresponding County and City Communities. CNG, gasoline and diesel fuel GHG emissions were derived from *ClearPath* using emission factors for each respective fuel type. The proportion of gasoline and diesel fuel was assigned to the City Community using the modeled regional VMT factor of 52.44%. The total HURF fuel sales of onroad gasoline and diesel fuel were multiplied by 99% to account for the population of eastern Pima County.

### Nonroad

Nonroad vehicles include mining and construction equipment and offroad vehicles. The majority of fuel utilized by these vehicle types is red-dyed diesel fuel. Red-dyed diesel fuel is not taxed, and sales are tracked by the HURF program. The portion of red-dyed diesel fuel utilized for mining was assigned to the County Community and the remaining red-dyed diesel fuel was assigned to the City Community using the VMT factor of 52.44%.

### Locomotives

Emissions from locomotive travel within eastern Pima County were calculated using diesel consumption data submitted by Union Pacific Railroad (UPRR) staff and a diesel emission factor (0.01 metric tons CO<sub>2</sub>e/gallon) embedded in the *ClearPath* model. Only the County Community inventory contains locomotive emissions due to the difficulty in separating rail tracks by jurisdiction. UPRR's 2022 Climate Action Plan highlights GHG reduction opportunities of 75% when moving freight by rail instead of highway trucks (UPRR, 2022).

## **Aircraft**

Volumes of Jet A fuel use were collected from the various airport staff for the Marana Airport, Ryan Airfield, Tucson International Airport (TIA) and Davis-Monthan Air Force Base (Appendix A). Aviation gasoline (Avgas) sales are tracked through the HURF program and were provided by ADOT. Previous Avgas source-provided data was replaced with more accurate HURF data.

Emissions were calculated using the Avgas and Jet A fuel 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 the Los Reales, Sahuarita, Marana Regional and Speedway landfills (2016-2021, as applicable). Solid waste disposal totals and emissions for Los Reales (2016-2021) and Marana Regional (2018-2021) landfills were obtained from the EPA's Greenhouse Gas Reporting Program (USEPA, 2021a). Emission totals were 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 & Landfill facility (2016 -2021) 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 (2016-2017) and the Sahuarita (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 *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, 2021b). Emissions from landfills with gas collection systems tend to produce less GHG emissions than those that lack a gas collection system (USEPA, 2021c).

### **Wastewater Reclamation**

Pima County Regional Wastewater Reclamation Department (RWRD) staff provided data for all regional facilities (2016-2021), 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, as well as septic fugitive. Staff at the Towns of Marana and Sahuarita provided wastewater processing emissions data for their facilities (2016 through 2021).

For years 2016-2017 inventory data, 73% of County Government wastewater-associated process emissions were attributed to the City. For years 2018-2019, 76% of the County Government wastewater-associated process emissions were attributed to the City. For years 2020-2021, 75% 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 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 2021, updated September 2022 (USEPA, 2022). The model uses a lifecycle approach, accounting for emissions avoided in producing replacement materials (upstream) and disposal-related emissions (downstream). Calculations are based on the difference between the CO<sub>2</sub>e emitted and energy expended if materials were landfilled and the savings realized through alternate waste management practices such as recycling.

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 (Appendix H) (Cascadia, 2016).

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 (Appendix I).

### **INDUSTRIAL PROCESSES (CEMENT PRODUCTION)**

County Community emissions from the CalPortland Company Rillito Cement Plant (2016-2021) were obtained from the EPA GHG Reporting Program (USEPA, 2021a).

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 CO<sub>2</sub>e source. These emissions were included in the industrial SWG totals.

## OTHER (CENTRAL ARIZONA PROJECT)

Emissions from the electricity used to deliver CAP water to Tucson Water and various other customers within Pima County were listed as “Other.” CAP delivery volume data (2016-2021) was provided by Tucson Water and CAP staff. Electricity used for CAP pumping was predominantly from the Navajo Generating Station (NGS) up until it ceased operation in November 2019, whereafter the portfolio consists of a combination of market forward purchases, market daily/short-term purchases, Salt River Project (SRP)-supplied electricity, hydroelectric from the Hoover Dam and solar power purchase agreements (CAP, 2022). Electricity generation emission factors for the CAP were provided by CAP staff (Appendix E).

The calculation for CAP electricity use was previously made by Tucson Water staff by determining the kWh needed to pump water to individual pumping stations to deliver one acre-foot (AF) of water to each 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 and other CAP customers.

## ENERGY INDUSTRIES

The Kinder Morgan Inc. SGC Sierrita Compressor Station began operation in 2020, and the energy industry transport emissions resulting from natural gas combustion were obtained from the EPA’s Greenhouse Gas Reporting Program (USEPA, 2021a). The energy industry generation emissions resulting from natural gas combustion were provided for informational purposes only, since they were already captured in the RCI electricity use emission factors and emissions. County emissions (2016-2021) from energy generation (TEP’s H. Wilson Sundt, DeMoss Petrie power plants) were obtained from the EPA’s Greenhouse Gas Reporting Program (USEPA, 2021a). TEP 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 facilities are shown in the County Community inventory summary (Table 2).

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 2016 through 2021 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, 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, combined potable and reclaimed water pumping/delivery totals and street and traffic lighting. Electricity emissions associated with stored CAP water were placed in the Community inventories for this report, as opposed to the previous report where they were assigned to City Government. These emissions are assigned to the Communities due to the activity of sourcing Colorado River water for local use. 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 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.

## **FLEET**

### **Onroad**

Onroad vehicle fuel use data were provided by County and City Government staff for 2016-2021. Similar to the Community Inventories, GHG emissions were derived from *ClearPath* using the emission factor for each respective fuel type. VMT by fuel type was included for illustration (Appendices J and K).

### **Nonroad**

Nonroad vehicle fuel use data were provided by County and City Government staff for 2016-2021. Emissions were calculated using *ClearPath* fuel emission factors for each specific fuel type.

## **WASTE**

### **Solid Waste Disposal**

Government-generated solid waste totals (2016-2021) were supplied by County staff and City of Tucson staff.

Government solid wastes were characterized using the Default California Waste Characterization, Table 9.4, 2007-2009 (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 2016-2021 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.

### **Recycled Materials**

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 (2016-2021).

Recycling emission and energy reductions were estimated using the EPA's WARM Version 15 – May

2021, updated September 2022 (USEPA, 2022). 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, 2016) (Appendix H).

## **EMPLOYEE COMMUTE**

PAG's 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 and City Government employees' survey data for annual, roundtrip drive-alone and carpool commuting VMT for 2016 through 2021.

County and City Government employee commuting emissions (2016-2021) were estimated using a composite emission factor for each survey year (kilograms CO<sub>2</sub>e /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 EPA Motor Vehicle Emissions Simulator (MOVES) model 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 energy 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.

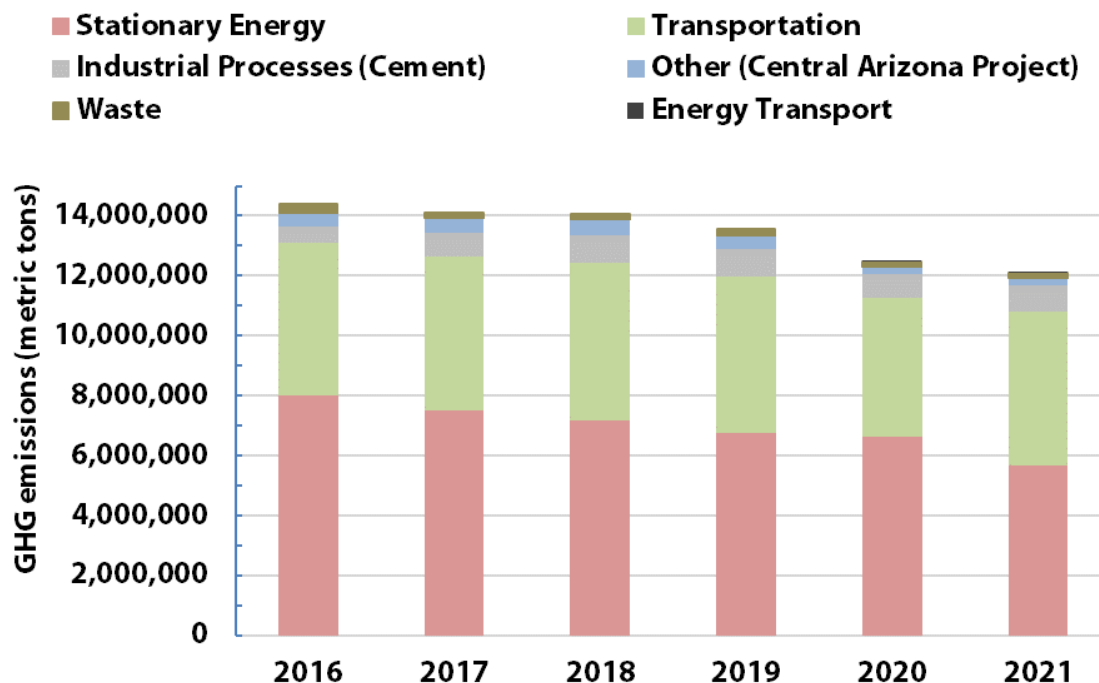
# COMMUNITY INVENTORY RESULTS



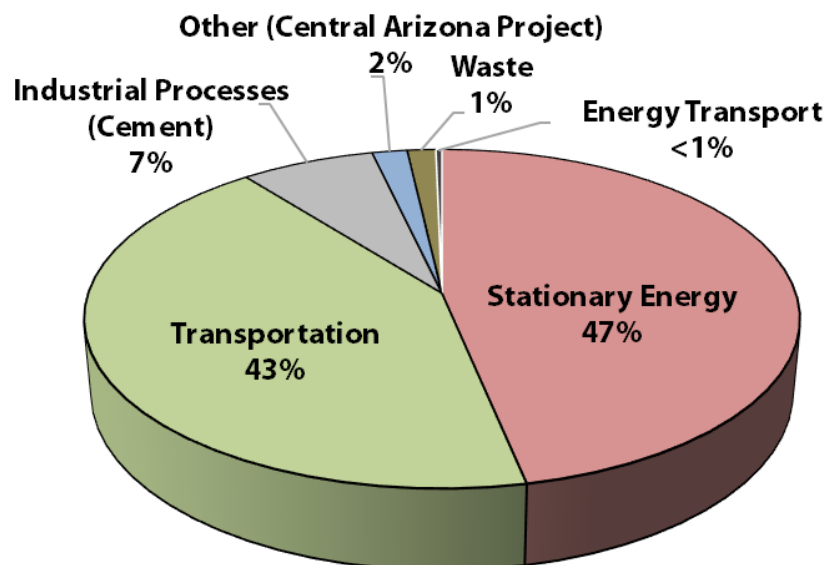
## EASTERN PIMA COUNTY REGIONAL INVENTORY OVERVIEW

From 2016-2021, County Community emissions dropped by 2.25 million metric tons, or 15.6% (Figure 2, Table 2). Emission reductions occurred in all categories except for transportation and industrial processes (cement production), which increased.

**Figure 2. County Community Greenhouse Gas Emissions 2016-2021**



**Figure 3. 2021 County Community Greenhouse Gas Emissions by Source**



For all inventory years, stationary energy use was the major contributor to GHG emissions, averaging 52% of annual total emissions (Figure 3). A bit over 88% of these stationary energy emissions resulted from electricity use, while natural gas use accounted for the other 12%.

Transportation emissions (onroad, nonroad vehicle use, aircraft and railroad) averaged 38% of total GHG emissions during the inventory years. Onroad vehicle travel was the largest component of these emissions, contributing about 79% of the total transportation emissions.

## STATIONARY ENERGY

In 2021, stationary energy was the largest source of County Community GHG emissions (Figure 3). From 2016-2021, total RCI energy use and emissions fell by 30%. All RCI sectors showed a drop in emissions (Table 2). The reductions are attributable to grid-supplied electricity, which fell 33% across the combined RCI sectors, from 7,255,386 metric tons CO<sub>2</sub>e in 2016 to 4,839,111 in 2021. Conversely, emissions from fossil fuel combustion of natural gas rose 5% across the combined RCI sectors, from 789,407 metric tons of CO<sub>2</sub>e in 2016 to 831,897 in 2021.

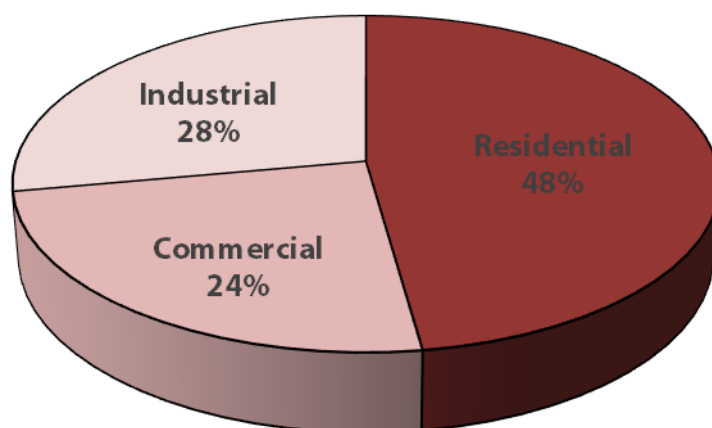
In 2021, stationary energy use generated 47% of annual emissions (Figure 3). As in other inventory years, residential energy use was the largest component (48%) of 2021 stationary energy use emissions (Figure 4). A more detailed discussion of each source follows.

### Residential

From 2016-2021, residential energy use emissions dropped by 26%, reflecting a shift toward lower and zero emissions sources of electricity generation despite a 5% increase in electricity use and 3% increase in natural gas use. Estimated 2021 County Community per household energy-associated emissions was approximately 6.55 metric tons per year, down 30% from 9.42 in 2016 (Appendix D).

Residential energy use contributed 22% to the 2021 County Community emissions total.

**Figure 4. 2021 County Community Stationary Energy Emissions**



### Commercial

Commercial energy use emissions fell by 33% over the inventory period, reflecting a shift toward low and zero emission sources and lower use of electricity, despite a 1% increase in natural gas use.

In 2021, commercial energy use produced 11% of the total County Community emissions.

## **Industrial**

Industrial energy use includes emissions from electricity use and fossil fuel combustion of natural gas. From 2016-2021, sector emissions declined by 32%, indicating a shift toward low and zero emission and lower use of electricity in spite of a 61% increase in natural gas use.

Industrial energy emissions contributed 13% to 2021 total County Community emissions.

## **TRANSPORTATION**

Transportation emissions increased from 35% of total County Community emissions in 2016 up to 43% in 2021. Transportation emissions increased 2% (Table 2) from 2016-2021, reflecting slight increases in onroad, nonroad and locomotive emissions while aircraft emissions dropped substantially in 2020 only to rebound back to 2016 levels in 2021.

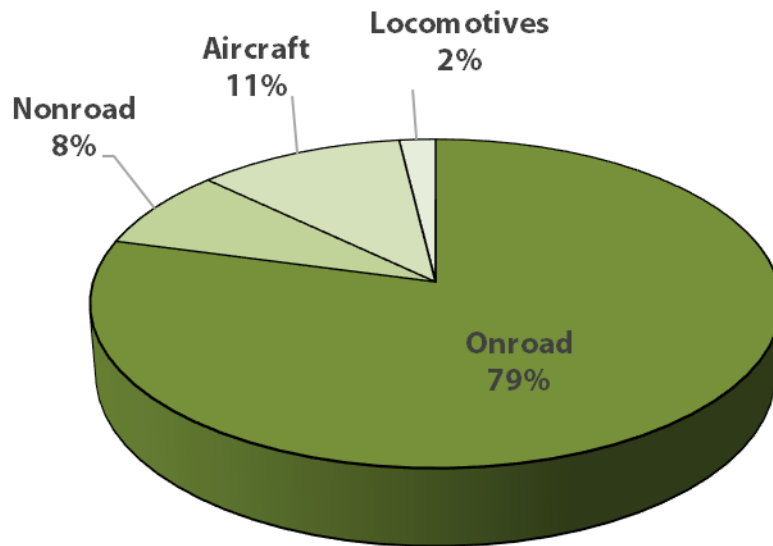
### **Onroad**

Onroad vehicle emissions constituted 79% of transportation emissions in 2021, the same as in 2016. In 2021, onroad vehicle emissions were 34% of the County Community total. The average fuel economy of passenger cars improved from 24.0 miles per gallon (mpg) in 2016 to 25.2 mpg in 2021, while the average fuel economy of passenger trucks improved from 17.4 mpg in 2016 to 17.9 mpg in 2021 (USDOE, 2016, 2021). Despite the improved average fuel economy, the increased ratio of trucks to cars has resulted in sustained fuel consumption.

Onroad gasoline fuel consumption in eastern Pima County decreased 2% from 394,763,305 gallons in 2016 to 387,115,725 gallons in 2021, while onroad diesel fuel consumption increased 28% during the same period up from 52,065,422 gallons to 66,448,886 gallons. Overall combined onroad gasoline and diesel consumption increased from 446,828,727 gallons in 2016 to 453,564,611 gallons in 2021. This compares to 3,028,880,527 gallons of gasoline sold, 1,075,428,062 gallons of diesel sold, and 4,104,308,589 gallons combined gasoline and diesel sold in the State of Arizona in 2021 (USDOT, 2021).

Onroad CNG consumption increased 95% from 1,952,116 therms in 2016 to 3,801,860 therms in 2021 and made up 0.48% of total onroad emissions in 2021 (Appendix F).

**Figure 5. 2021 County Community Transportation Emissions**



### **Nonroad**

Nonroad diesel emissions made up 8% of transportation emissions in 2021 and 3.4% of overall County Community emissions. Nonroad diesel consumption increased slightly from 38,973,750 gallons in 2016 to 39,988,623 gallons in 2021.

### **Locomotives**

Emissions from Union Pacific Railroad (UPRR) travel increased by 33% over the inventory period due to an increase in intermodal freight (UPRR, 2021).

In 2021, locomotive emissions were 2% of 2021 transportation emissions (Figure 5) and less than 1% of total County emissions.

### **Aircraft**

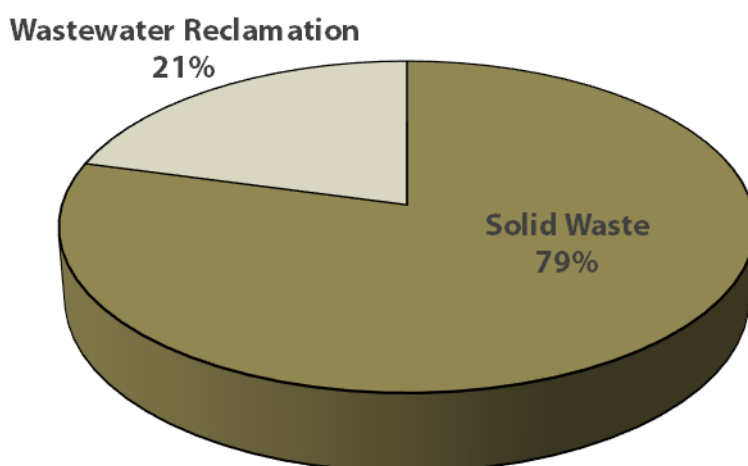
Aircraft emissions represent the combustion of Avgas and Jet A dispensed at the TIA, Marana and La Cholla Airports, Ryan Airfield and Davis Monthan Air Force Base. Aircraft emissions dropped 31% in 2020 compared to 2019 but rebounded in 2021. Overall, aircraft emissions decreased by 4.5% over the inventory period.

In 2021, aircraft emissions represented an estimated 11% of transportation emissions (Figure 5).

## **WASTE**

From 2016-2021, total waste emissions dropped by 39%. In 2021, as in other years, solid waste disposal accounted for the majority of waste emissions and was 79% of total waste emissions (Figure 6). Waste remains a small component of the 2021 County Community emissions total at 1.5% (Figure 3).

**Figure 6. 2021 County Community Waste Emissions**



### **Solid Waste Disposal**

From 2016-2021, solid waste disposal emissions declined by 42% (Table 2). These emissions vary by waste composition and the handling of landfill gas. By 2021, only three County Community landfills, Los Reales, Marana Regional and Speedway Recycling & Landfill Facility, were open and receiving waste (Appendix F). Only Los Reales has a landfill gas recovery system that captures the gas, which was used as biogas for energy generation at the TEP H. Wilson Sundt Generating Station up until November 2019 and is currently flared. This recovery process is factored into the EPA's method of calculating landfill emissions (USEPA, 2021a) and generally results in lower emissions than facilities lacking a gas capture system, although 2016 was an anomalously high emission year related to landfill gas collection at Los Reales.

### **Wastewater Reclamation**

Emissions from wastewater reclamation decreased by 26% over the inventory period and contributed 21% of 2021 waste emissions (Table 2). Process emissions were tallied from the nine wastewater reclamation facilities owned by Pima County and the facilities owned by the Towns of Marana and Sahuarita. All of these facilities treat regional wastewater from residents and some from commercial and industrial activities. Totals represent the sum of nitrification/denitrification and lagoon treatments and the handling of wastewater digester gas.

Fugitive methane emissions from septic systems were calculated based upon the balance of the County Community population that is not serviced by municipal wastewater treatment systems (Appendix F). These emissions comprised 88% of total wastewater reclamation emissions over the inventory period and 89% in 2021. The septic system emissions are proportionately much higher than municipal treatment systems due to the lack of methane capture and conversion to CO<sub>2</sub> that occurs in treatment systems.

There are multiple non-municipal wastewater treatment systems with minor processing capacities serving relatively small populations whose emissions were excluded due to challenges in quantification.

The majority of GHG emissions from municipal wastewater treatment are from the processing of waste, but the County has addressed 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 for the SWG system was completed and operational in February 2022.

## Recycled Materials

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 City of Tucson collections. There was an 8% increase in recycling totals over this inventory period and 14% increase in emissions saved (Table 1).

**Table 1. County Community Recycled Material Totals and Emissions Saved 2016-2021**

	<b>Recycled totals (metric tons)</b>	<b>CO2e Saved (metric tons)</b>
<b>2016</b>	62,547	126,000
<b>2017</b>	84,311	170,623
<b>2018</b>	81,763	168,744
<b>2019</b>	76,272	158,269
<b>2020</b>	65,170	134,792
<b>2021</b>	67,325	144,190

## INDUSTRIAL PROCESSES

### CalPortland Company Rillito Cement Plant

According to the Portland Cement Association, Arizona cement production steadily increased over the inventory years and is expected to continue (Portland Cement Association, 2021). EPA-reported CalPortland Company Rillito Cement Plant emissions increased 54% from 2016-2021 (USEPA, 2021a).

Industrial process emissions were approximately 7% of the 2021 County Community total (Figure 3).

## OTHER

### Central Arizona Project (CAP)

Energy-related CAP water delivery emissions (Other) decreased by 46% over the inventory period due to the closure of NGS in 2019 and sourcing of less carbon intensive electricity. These emissions were about 1.8% of 2021 County Community totals (Figure 3).

## ENERGY INDUSTRIES

The Kinder Morgan Inc. SGC Sierrita Compressor Station began operation in 2020 and the natural gas combustion emissions from operation of the facility are included in this inventory. The 2021 emissions comprised 0.3% of the total County Community inventory.



TEP operates three electricity-generating facilities in eastern Pima County (H. Wilson Sundt, DeMoss Petrie and North Loop). The emissions from energy generation 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, and the relevant natural gas use was deducted from the SWG totals. From 2016-2021, there was a 6% decrease in the EPA-reported emissions.

## EASTERN PIMA COUNTY REGIONAL SYNOPSIS

From 2016-2021, County Community's GHG emissions fell by more than 2.25 million metric tons, or 16%. 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 52% of total emissions. All stationary energy sectors, residential, commercial and industrial, showed a decline in emissions over this time. Electricity use produces approximately 88.2% of stationary energy emissions; natural gas use contributed approximately 11.8% of stationary energy emissions.

Over the inventory period, transportation-related emissions averaged 38% of the County Community emissions and onroad vehicle use averaged 79% of total transportation emissions. From 2016-2021, GHG increases occurred in all transportation subcategories except for aircraft.

Solid waste disposal is the primary component of waste emissions and averaged about 1.1% of the County Community total. Over the inventory period, waste emissions declined by 39%.

Industrial processing emissions increased by 54% over the inventory period due to a reported increase in cement production emissions. These emissions were about 7% of total 2021 County Community total emissions.

From 2016-2021, CAP electricity-use emissions decreased by 46% with CAP emissions contributing approximately 2% of total 2021 County emissions.

**Table 2. County Community GHG Emissions (metric tons CO2e) 2016-2021**

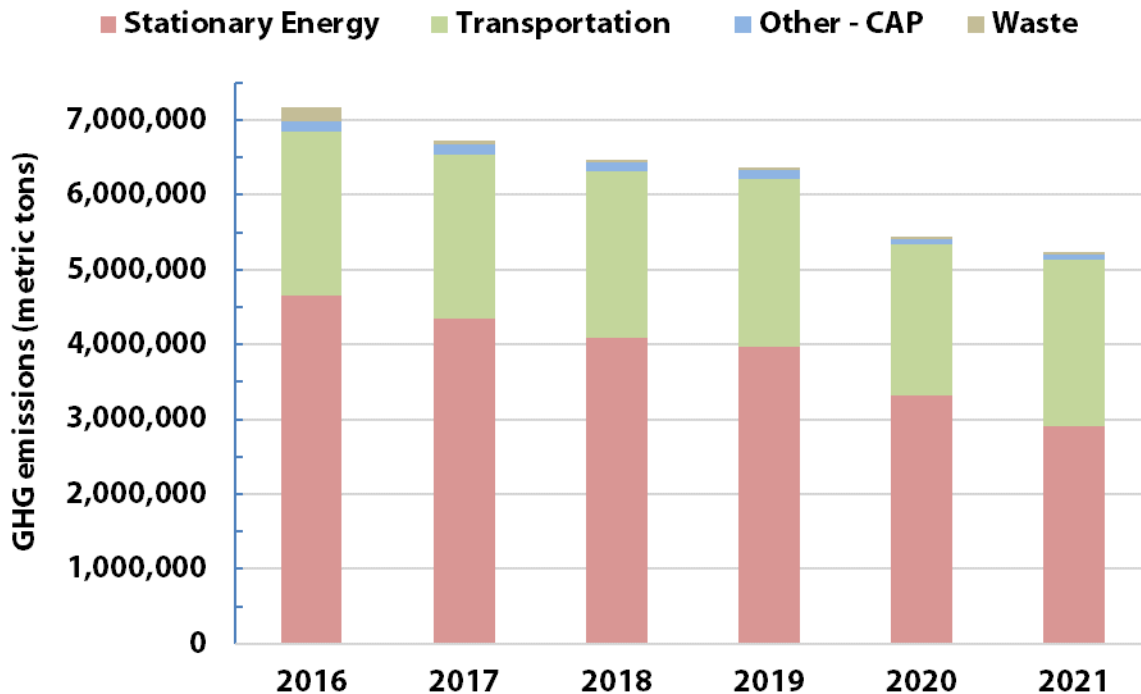
	2016	2017	2018	2019	2020	2021	CO2e % of total in 2021	CO2e % change 2016-2021
	CO <sub>2</sub> e (metric tons)							
<b>STATIONARY ENERGY</b>								
<b>Residential</b>								
Fossil fuel combustion	413,600	363,786	391,934	468,223	419,963	427,423		3
Grid-supplied electricity	3,237,245	3,073,543	2,900,831	2,679,347	2,831,247	2,281,472		-30
<b>Residential Subtotal</b>	3,650,845	3,437,329	3,292,765	3,147,570	3,251,210	2,708,895		-26
<b>Commercial</b>								
Fossil fuel combustion	335,147	332,506	335,498	327,332	338,562	338,886		1
Grid-supplied electricity	1,721,794	1,633,723	1,494,429	1,361,977	1,235,264	1,043,235		-39
<b>Commercial Subtotal</b>	2,056,941	1,966,229	1,829,927	1,689,309	1,573,826	1,382,121		-33
<b>Industrial</b>								
Fossil fuel combustion	40,660	50,499	41,875	51,715	102,144	65,588		61
Grid-supplied electricity	2,296,347	2,089,061	2,006,570	1,863,532	1,725,488	1,514,404		-34
<b>Industrial Subtotal</b>	2,337,007	2,139,560	2,048,445	1,915,247	1,827,632	1,579,992		-32
<b>STATIONARY ENERGY TOTAL</b>	<b>8,044,793</b>	<b>7,543,118</b>	<b>7,171,137</b>	<b>6,752,126</b>	<b>6,652,668</b>	<b>5,671,008</b>	<b>46.7</b>	<b>-30</b>
<b>TRANSPORTATION</b>								
<b>Onroad</b>	4,007,775	4,005,400	4,069,435	4,159,922	3,710,344	4,097,117		2
<b>Nonroad</b>	397,922	414,682	417,156	348,161	380,882	408,284		3
<b>Locomotives</b>	74,946	74,345	121,837	100,692	94,086	99,475		33
<b>Aircraft</b>	596,052	629,937	657,167	653,609	451,271	569,132		-5
<b>TRANSPORTATION TOTAL</b>	<b>5,076,695</b>	<b>5,124,364</b>	<b>5,265,595</b>	<b>5,262,384</b>	<b>4,636,583</b>	<b>5,174,008</b>	<b>42.6</b>	<b>2</b>
<b>WASTE</b>								
Solid waste disposal	245,889	92,819	123,806	134,360	140,711	143,380		-42
Wastewater reclamation process	51,107	51,987	37,937	39,477	38,215	37,618		-26
<b>WASTE TOTAL</b>	<b>296,996</b>	<b>144,806</b>	<b>161,743</b>	<b>173,837</b>	<b>178,926</b>	<b>180,998</b>	<b>1.5</b>	<b>-39</b>
<b>INDUSTRIAL PROCESSES - Cement</b>	<b>552,814</b>	<b>801,277</b>	<b>954,086</b>	<b>893,556</b>	<b>798,138</b>	<b>849,023</b>	<b>7</b>	<b>54</b>
<b>OTHER- Central Arizona Project</b>	<b>409,953</b>	<b>482,193</b>	<b>506,407</b>	<b>458,260</b>	<b>223,501</b>	<b>222,388</b>	<b>1.8</b>	<b>-46</b>
<b>ENERGY INDUSTRIES - Transport</b>	-	-	-	-	35,065	38,802	<b>0.3</b>	-
<b>E. PIMA COUNTY COMMUNITY TOTAL</b>	<b>14,381,251</b>	<b>14,095,758</b>	<b>14,058,968</b>	<b>13,540,163</b>	<b>12,524,881</b>	<b>12,136,227</b>	<b>100</b>	<b>-16</b>
<b>ENERGY INDUSTRIES - Generation*</b>	<b>570,100</b>	<b>552,155</b>	<b>958,198</b>	<b>1,114,990</b>	<b>880,679</b>	<b>535,211</b>		<b>-6</b>

\* Emissions accounted for in Stationary Energy

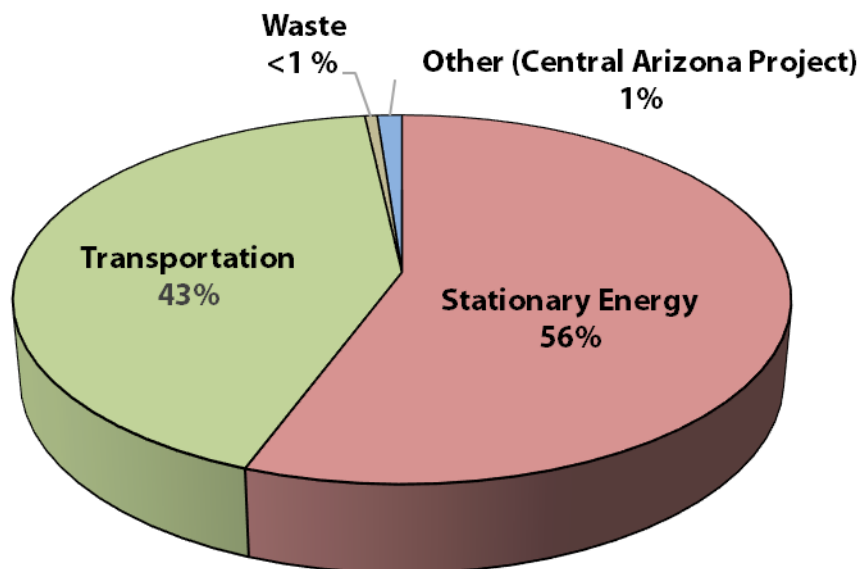
## TUCSON COMMUNITY INVENTORY OVERVIEW

From 2016-2021, City Community emissions dropped nearly 1.95 million metric tons, or 27% (Table 4 and Figure 7). Emission reductions occurred in stationary energy use (37%), waste (84%) and in CAP energy-related emissions (Other) 58%), while transportation emissions rose (1.4%). Stationary energy use was the major source of emissions and was 56% of the annual total in 2021; transportation was the second most significant GHG source comprising 43% of the annual total (Figure 8).

**Figure 7. City Community Greenhouse Gas Emissions 2016-2021**



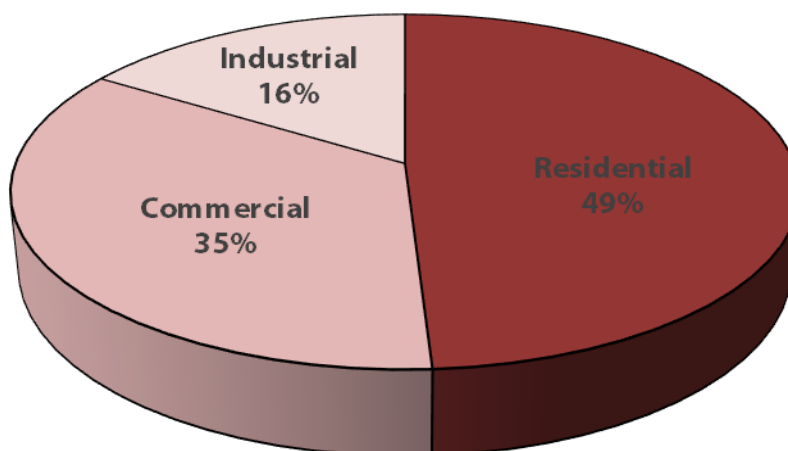
**Figure 8. 2021 City Community Greenhouse Gas Emissions by Source**



## STATIONARY ENERGY

From 2016-2021, total City Community RCI energy-related emissions declined by 37% and made up 56% of total City Community emissions in 2021. Reductions occurred in all sectors with industrial emissions showing the sharpest decline. Residential energy use was the major contributor, averaging 49% of total stationary energy emissions in 2021 (Figure 9).

**Figure 9. 2021 City Community Stationary Energy Emissions**



### Residential

From 2016-2021, total City Community residential energy use emissions dropped by 29%, resulting from a shift toward low and zero emission sources of and use of electricity and a minimal 1% decrease in natural gas use. In 2021, the estimated City per household energy-related emissions were approximately 6.53 metric tons per year, down 32% from 9.67 in 2016 (Appendix D).

Residential energy use was responsible for 27% of the 2021 City Community's total emissions.

### Commercial

From 2016-2021, City Community commercial energy use emissions fell by 32%, due to a shift toward low and zero emission sources and lower use of electricity, even with natural gas use emissions increasing 2%.

Commercial energy emissions were 35% of 2021 stationary energy emissions and represented 19% of the 2021 City Community total emissions (Figure 9).

### Industrial

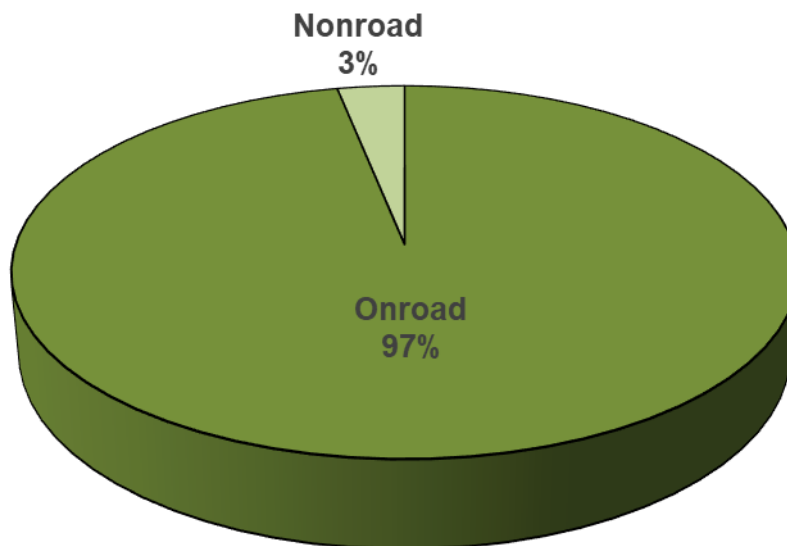
From 2016-2021, industrial electricity-use emissions declined by 59%, resulting from a shift toward low and zero emission sources and decreased electricity use, notwithstanding an 18% increase in natural gas use emissions.

Industrial energy use was responsible for 16% of stationary energy emissions and nearly 9% of the 2021 City Community annual emissions (Figure 9).

## TRANSPORTATION

From 2016-2021, total transportation emissions increased by 1.4% and were 43% of total City Community emissions in 2021 (Table 4). Onroad vehicle travel was the major contributor to transportation emissions (Figure 10).

**Figure 10. 2021 City Community Transportation Emissions**



### Onroad

For all inventory years, onroad vehicle use was responsible for the majority of the City Community transportation-related emissions, contributing 97% in 2021 (Figure 10). From 2016-2021, City Community onroad fuel use remained relatively steady with gasoline consumption decreasing 2% from 207,013,877 gallons in 2016 to 203,003,486 gallons in 2021 and diesel consumption increasing 28% from 27,303,107 gallons in 2016 to 34,845,796 gallons in 2021 (Appendix G). Combined onroad gasoline and diesel fuel consumption in 2021 was 237,849,282 gallons. Associated onroad GHG emissions increased by 2.2% over the inventory period (Table 4).

Onroad CNG fuel consumption increased 49% over the inventory period, up from 1,827,082 therms in 2016 to 2,725,869 therms in 2021. CNG emissions were 0.66% of the total onroad emissions in 2021.

### Nonroad

Nonroad vehicle emissions made up 3% of the City Community transportation emissions in 2021, with 71,380 gallons of diesel consumed. Over the inventory period, nonroad emissions decreased by 19%.

## WASTE

From 2016-2021, City Community total waste emissions declined by 84%, primarily due to unusually high reported emissions for Los Reales in 2016 related to the landfill gas treatment system (Table 4). Solid waste was the major component of waste emissions (Figure 11) but remains a small portion of annual City Community emissions at 0.6% in 2021 (Figure 8).

**Figure 11. 2021 City Community Waste Emissions**



### **Solid Waste Disposal**

Data represents emissions from Los Reales and Speedway landfills. The waste disposal volumes increased over the inventory period by 27% at Los Reales and 14.5% at Speedway landfill (Appendix G). Despite these increases, GHG emissions dropped by 84% from 2016-2021, reflecting declines in Los Reales emissions (USEPA, 2021a).

### **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 (73% in 2016-2017; 76% in 2018-2019; and 75% in 2020-2021). Emissions represent the sum of nitrification/denitrification and lagoon treatments and the handling of digester gas. Emissions decreased 3% during the inventory period and were 4.5% of the total waste emissions in 2021.

**Table 3. City Community Recycled Material Totals and Emissions Saved 2016-2021**

	Recycled totals (metric tons)	CO2e Saved (metric tons)
2016	28,797	56,790
2017	28,023	55,191
2018	25,031	52,397
2019	22,955	48,925
2020	20,100	42,364
2021	17,637	42,284

### **Recycled Materials**

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 39% over the inventory period, while emissions saved dropped by 26% (Table 3).

## OTHER

### Central Arizona Project (CAP)

CAP water delivery for direct use in the City Community decreased 12% over the reporting period from 77,700 AF in 2016 to 68,184 AF in 2021 (Appendix G). CAP water stored for future use is accounted for in the County Community inventory. Table 4 shows the electricity-use emissions proportional to the City of Tucson's CAP water use, estimated to be 27% of total CAP water delivered to Pima County in 2021. Over the 2016-2021 inventory period, CAP electricity-related emissions dropped by 58% and were 1.2% of the City Community total in 2021.

## TUCSON COMMUNITY SYNOPSIS

From 2016-2021, City Community emissions declined by nearly 1.95 million metric tons or 27%; stationary energy emissions were responsible for 56% of the City Community total emissions. Residential energy use was the largest component of stationary energy use and averaged around 46% of stationary energy emissions.

Transportation was the other major contributor to City Community emissions, averaging 35% of the City Community totals during the inventory period. From 2016-2021, overall transportation emissions increased by 1.4%. Onroad vehicle emissions increased by 2.2% and were responsible for 96.5% of the City Community's transportation emissions over the inventory period.

Waste emissions decreased by 84% and contribute less than 1% to total City Community emissions.

CAP water delivery electricity use emissions declined over this inventory period by 58% due to reduced direct use and less carbon intensive sourced electricity and represented 1.2% of the City Community emissions.

**Table 4. City Community GHG Emissions (metric tons CO<sub>2</sub>e) 2016-2021**

	2016	2017	2018	2019	2020	2021	CO2e % of total in 2021	CO2e % change 2016-2021
	CO2e (metric tons)							
STATIONARY ENERGY							55.7	
Residential								
Fossil fuel combustion	320,123	277,050	299,627	351,856	312,852	316,335		-1
Grid-supplied electricity	1,688,387	1,614,914	1,506,700	1,430,796	1,340,503	1,112,561		-34
Residential Subtotal	2,008,510	1,891,964	1,806,327	1,782,652	1,653,355	1,428,896		-29
Commercial								
Fossil fuel combustion	298,474	285,950	300,553	315,582	310,196	304,716		2
Grid-supplied electricity	1,202,964	1,143,849	1,047,791	977,053	818,117	710,970		-41
Commercial Subtotal	1,501,438	1,429,799	1,348,344	1,292,635	1,128,313	1,015,686		-32
Industrial								
Fossil fuel combustion	27,253	36,645	30,927	35,717	37,213	32,181		18
Grid-supplied electricity	1,108,636	992,666	902,939	861,552	500,083	436,145	-61	
Industrial Subtotal	1,135,889	1,029,311	933,866	897,269	537,296	468,326	-59	
STATIONARY ENERGY TOTAL	4,645,837	4,351,074	4,088,537	3,972,556	3,318,964	2,912,908	55.7	-37
							42.5	
TRANSPORTATION								
Onroad	2,105,870	2,104,012	2,137,688	2,185,292	1,949,041	2,152,355		2
Nonroad	87,909	81,115	83,869	54,028	72,723	71,380		-19
TRANSPORTATION TOTAL	2,193,779	2,185,127	2,221,557	2,239,320	2,021,764	2,223,735	42.5	1.4
							0.6	
WASTE								
Solid waste disposal	187,912	35,990	40,309	33,634	33,472	29,354		-84.4
Wastewater reclamation process	1,424	1,452	1,436	1,491	1,420	1,382		-2.9
WASTE TOTAL	189,336	37,442	41,745	35,125	34,892	30,736	0.6	-84
							1.2	
OTHER - Central Arizona Project	146,121	143,723	115,452	125,749	62,175	61,830		-58
TOTAL CITY OF TUCSON	7,175,073	6,717,366	6,467,291	6,372,750	5,437,795	5,229,209	100	-27
							-	
ENERGY INDUSTRIES - Generation*	569,234	550,859	952,876	1,107,010	880,193	534,384		-6

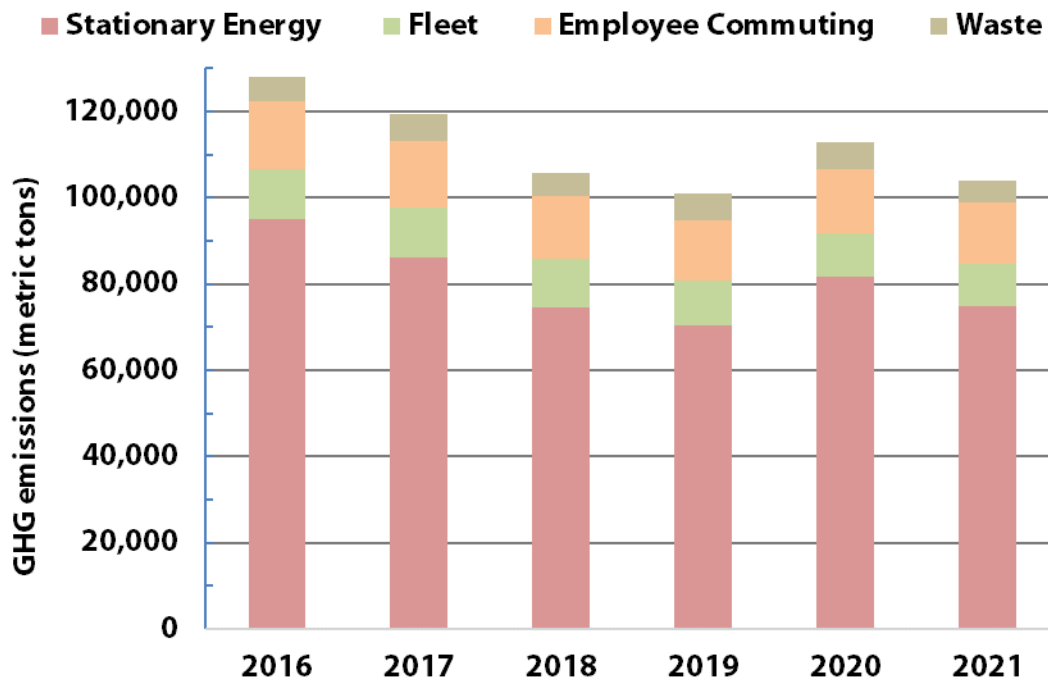
\* Emissions accounted for in Stationary Energy



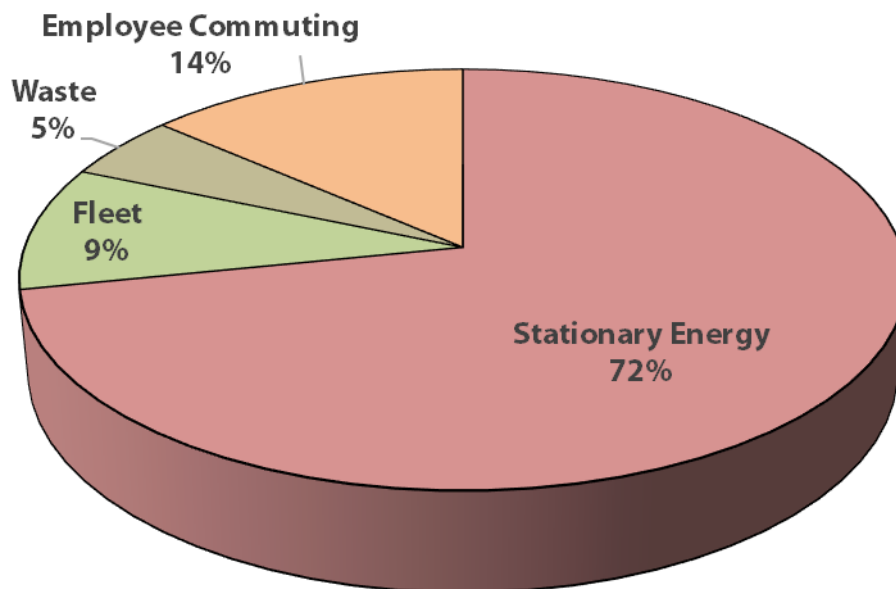
## PIMA COUNTY GOVERNMENT OPERATIONS INVENTORY OVERVIEW

County Government emissions were a small portion of the County Community total. From 2016-2021, total County Government emissions dropped by more than 24,000 metric tons, or 19% (Table 6, Figure 12). Over the inventory period, emission declines were evident in stationary energy use (21%), fleet (14%), employee commuting (10%) and waste (10%) (Table 6).

**Figure 12. County Government Greenhouse Gas Emissions 2016-2021**



**Figure 13. 2021 County Government Greenhouse Gas Emissions by Source**



Stationary energy use was the predominant source of emissions and, in 2021, was 72% of County Government emissions (Figure 13). Employee commuting was the next highest contributor at 14%, followed by fleet at 10% and waste at 5% for the 2021 County Government total.

## STATIONARY ENERGY

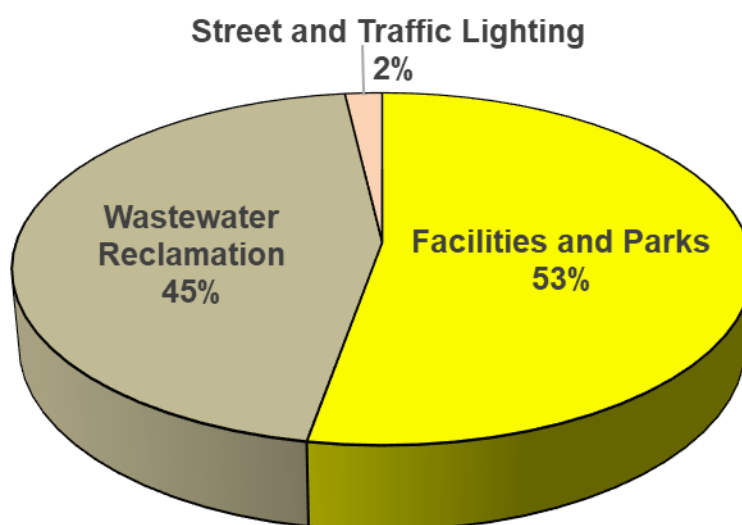
Emissions included purchased electricity and natural gas for all County-operated facilities and parks, wastewater reclamation and street and traffic lighting and the treatment of digester gas. From 2016-2021, total stationary energy emissions declined by 21%; these reductions were due to a shift toward low and zero emission sources of electricity despite increased energy usage (Appendix J). In 2021, 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 increased two and a half fold over the inventory period (Appendix J).

### Facilities and Parks

From 2016-2021, facility emissions fell by 23% due to a shift toward low and zero emission sources of electricity, despite a 10% increase in electricity use and 9% increase in natural gas use. In 2021, facility energy use was 38% of total County Government emissions.

**Figure 14. 2021 County Government Stationary Energy Use Emissions**



### Wastewater Reclamation

These emissions represent the total of purchased electricity and natural gas and the flaring and combustion of digester gas. From 2016-2021, wastewater-energy related emissions decreased by 19% (Table 6). Purchased electricity is the largest component, averaging over 98% 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 and flared, yet emissions were lower due to a shift toward low and zero emission sources of electricity (Appendix J). In 2021, wastewater-related emissions were 33% of total County Government emissions.

## Street and Traffic Lighting

From 2016-2021, street and traffic lighting emissions decreased by 31% and represent slightly less than 2% of the stationary energy use total (Figure 14).

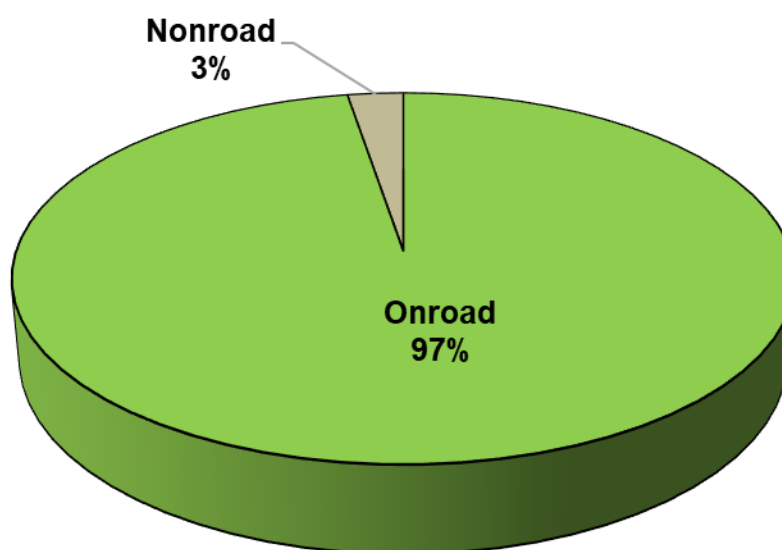
## FLEET

Over the inventory period, total fleet emissions decreased by 14%, with reductions in gasoline and diesel fuel use (Appendix J). Onroad fleet vehicles remain the major contributor to the 2021 fleet total (Figure 15). Fleet emissions represented 10% of the total 2021 County Government emissions (Figure 13). The County continues to make strides in reducing emissions from its passenger cars, primarily through increased replacement of gasoline vehicles with fully electric vehicles.

### Onroad

From 2016-2021, emissions from the County Government onroad fleet emissions decreased by 16%, reflecting a reduction from 1,284,258 combined gallons of gasoline and diesel in 2016 to 1,079,638 gallons in 2021. Onroad fleet emissions are approximately 10% of the 2021 County Government total.

**Figure 15. 2021 County Government Fleet Emissions**



### Nonroad

County Government nonroad equipment is used primarily in construction. From 2016-2021, emissions more than doubled but remained a small portion of fleet emissions at 3% (Figure 15).

### Employee Commuting

From 2016-2021, employee commuting emissions dropped by 10%. Commuter VMT declined nearly 2% during the inventory period (Appendix J). In 2021, County Government employee commuting emissions were 14% of the annual total (Figure 13).

## 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 2021, as in all other inventory years (Figure 16, Table 6). From 2016-2021, total waste emissions decreased by 10%. Waste contributed 5% to the total 2021 County Government emissions (Figure 13).

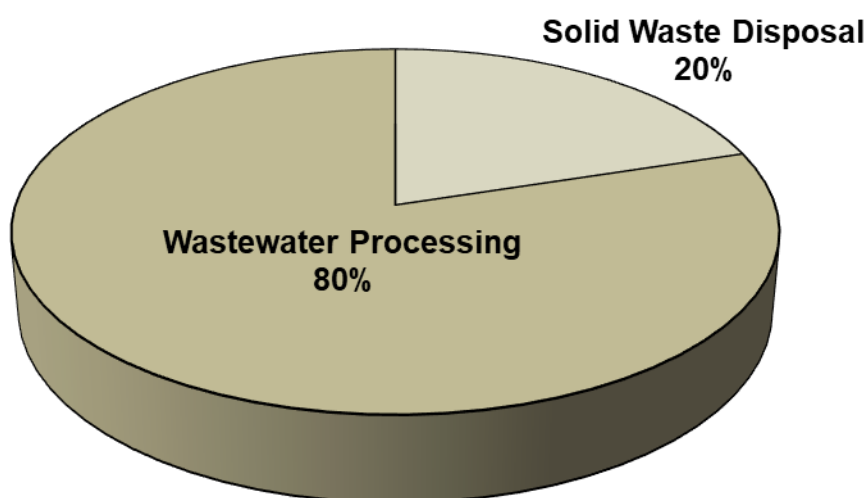
### Solid Waste Disposal

Solid waste disposal emissions decreased by 19% over the inventory period, reflecting a similar decrease in waste disposal volumes (31%). Solid waste disposal represents slightly more than 1% of total 2021 County Government emissions.

### Wastewater Processing

Total wastewater process emissions decreased 7% from 2016-2021. Wastewater processing emissions were slightly less than 4% of the total 2021 County Government emissions.

**Figure 16. 2021 County Government Waste Emissions**



**Table 1. County Government Recycled Material Totals and Emissions Saved 2016-2021**

	Recycled totals (metric tons)	CO2e Saved (metric tons)
<b>2016</b>	385	879
<b>2017</b>	418	956
<b>2018</b>	410	938
<b>2019</b>	407	930
<b>2020</b>	1,207	3,484
<b>2021</b>	1,062	3,065

### Recycled Materials

Emissions and energy savings data are presented for informational purposes and were not considered in computing the County Government totals. Recycling volumes nearly tripled during the inventory period and emissions savings more than tripled (Table 5).

## ENERGY GENERATION

Solar electricity generation does not contribute to GHG emissions but was included for informational purposes, as it reduces GHG emissions that would otherwise be emitted from fossil-fuel generation resources. From 2016-2021, the County Government more than doubled its solar energy production (Appendix J). Over 13% of County Government's energy needs are met using solar-generated electricity.

## PIMA COUNTY GOVERNMENT SYNOPSIS

The County Government's emissions were a small portion of the County Community's totals over the inventory period, making up less than 1% in 2021. From 2016-2021, County Government emissions dropped by more than 24,000 metric tons or 19%. Emission reductions were achieved over the inventory period in stationary energy use (21%), fleet (14%), employee commuting (10%) and waste (10%).

Stationary energy use was the major contributor to GHG production and in 2021 was 72% of the County Government's annual total. Electricity use averaged 94% of stationary energy emissions. County Government has continued to integrate renewable energy sources into its system and more than doubled its solar energy production over the inventory period.

Fleet emissions averaged about 10% of total County Government emissions (2016-2021). Onroad vehicle use accounted for 97% of fleet emissions, and from 2016-2021 onroad fleet fuel use decreased by 16%, resulting in a 14% reduction in emissions. Nonroad fleet fuel use increased from 2016-2021 but remained 3% of total fleet emissions (Appendix J).

Wastewater processing was the major component of waste emissions. From 2016-2021, wastewater processing emissions dropped by 10%, while solid waste emissions declined by 19%.

Waste emissions were a smaller component of total County Government emissions, averaging about 5% over the inventory period.

Employee commuting VMT decreased by 2% over the inventory period while emissions decreased by 10% from 2016-2021.

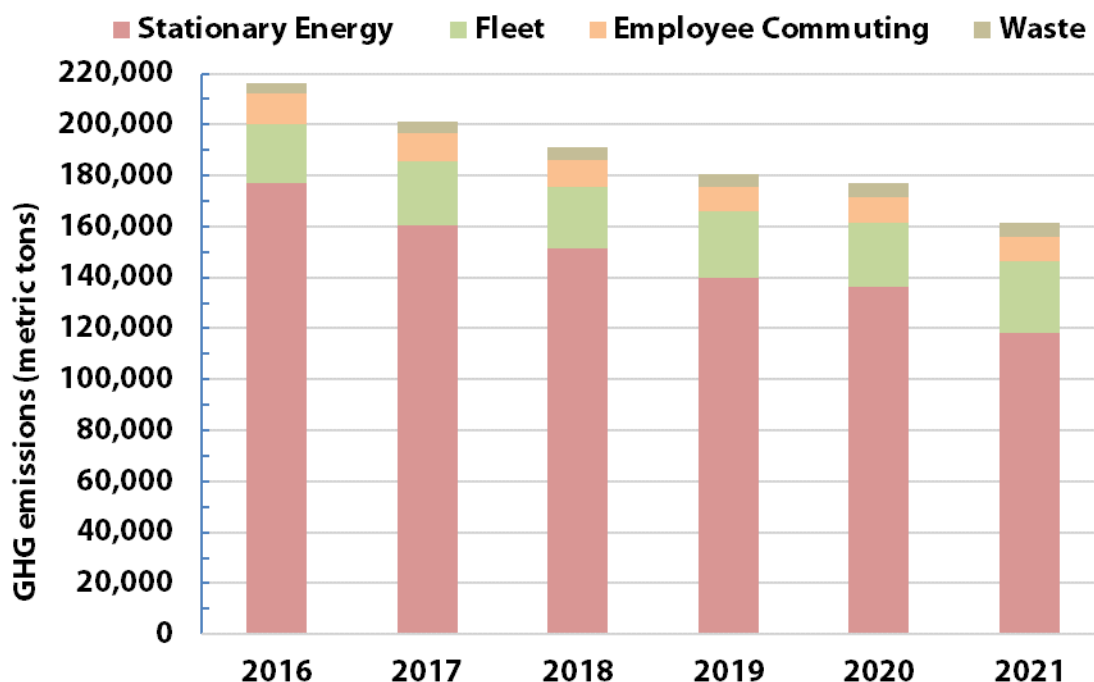
**Table 2. County Government GHG Emissions (metric tons CO<sub>2</sub>e) 2016-2021**

	2016	2017	2018	2019	2020	2021	CO <sub>2</sub> e % of total in 2021	CO <sub>2</sub> e % change 2016-2021
	CO <sub>2</sub> e (metric tons)							
<b>STATIONARY ENERGY</b>								
<b>Facilities and Parks</b>								
Fossil fuel combustion	4,054	3,913	3,919	4,783	4,620	4,422		9
Grid-supplied electricity	47,121	40,570	46,535	41,915	38,656	35,035		-26
<b>Facilities Subtotal</b>	51,175	44,483	50,454	46,698	43,276	39,457		-23
<b>Wastewater Reclamation</b>								
Fossil fuel combustion	32	11	21	444	842	2,248		6,925
Grid-supplied electricity	41,764	39,797	22,277	21,530	35,978	31,612		-24
Digester gas combustion for energy	7	6	11	8	7	-		-100
<b>Wastewater Reclamation Subtotal</b>	41,803	39,814	22,309	21,982	36,827	33,860		-19
<b>Street and Traffic Lighting</b>								
Grid-supplied electricity	2,035	1,858	1,856	1,688	1,661	1,401		-31
<b>STATIONARY ENERGY TOTAL</b>	<b>95,013</b>	<b>86,155</b>	<b>74,619</b>	<b>70,368</b>	<b>81,764</b>	<b>74,718</b>	<b>72</b>	<b>-21</b>
<b>FLEET</b>								
Onroad fleet	11,516	11,320	11,090	10,323	9,684	9,695		-16
Nonroad fleet	113	351	223	211	436	264		134
<b>FLEET TOTAL</b>	<b>11,629</b>	<b>11,671</b>	<b>11,313</b>	<b>10,534</b>	<b>10,120</b>	<b>9,959</b>	<b>10</b>	<b>-14</b>
<b>WASTE</b>								
<b>Solid Waste</b>	1,620	1,812	1,093	1,005	1,491	1,312		-19
<b>Wastewater Processing</b>								
Nitrification/denitrification	1,364	1,364	1,645	1,659	1,631	1,588		16
Lagoons	2,142	2,235	2,238	3,189	2,698	1,941		-9
Digester gas flaring	664	703	334	392	371	350		-47
<b>Wastewater Processing Subtotal</b>	4,170	4,302	4,217	5,240	4,700	3,879		-7
<b>WASTE TOTAL</b>	<b>5,790</b>	<b>6,114</b>	<b>5,310</b>	<b>6,245</b>	<b>6,191</b>	<b>5,191</b>	<b>5</b>	<b>-10</b>
<b>EMPLOYEE COMMUTE TOTAL</b>	<b>15,699</b>	<b>15,484</b>	<b>14,459</b>	<b>13,757</b>	<b>14,675</b>	<b>14,186</b>	<b>14</b>	<b>-10</b>
<b>TOTAL COUNTY GOVERNMENT GHG EMISSIONS</b>	<b>128,131</b>	<b>119,424</b>	<b>105,701</b>	<b>100,904</b>	<b>112,750</b>	<b>104,054</b>	<b>100</b>	<b>-19</b>
<b>SOLAR ENERGY GENERATION</b>	(5,472)	(7,647)	(9,477)	(10,126)	(10,052)	(9,027)	-	65

## CITY OF TUCSON GOVERNMENT OPERATIONS INVENTORY OVERVIEW

From 2016-2021, City Government emissions decreased by nearly 55,000 metric tons, or 25% (Table 8, Figure 17). Stationary energy use and employee commuting showed decreases in emissions over this period, while fleet and waste emissions increased. Stationary energy use was the largest contributor to City Government emissions, averaging 78% 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 2016-2021**



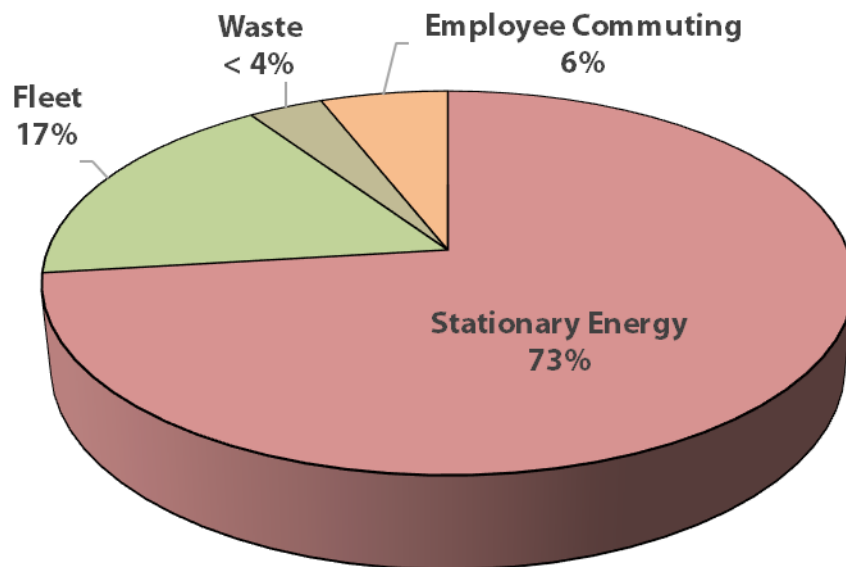
### STATIONARY ENERGY

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 potable and reclaimed water pumping, street and traffic lighting and natural gas used for district energy production.

From 2016-2021, total stationary energy emissions dropped by 33% (Table 8). This decline resulted from emission reductions in the categories within Stationary Energy, with the exception of increased water-related natural gas use. In 2021, stationary energy was responsible for 73% of 2021 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 again significantly increased its solar energy production by nearly doubling production (Appendix K). Solar energy provided 18% of the City Government electricity use in 2021.

**Figure 18. 2021 City Government Greenhouse Gas Emissions by Source**



### **Tucson 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 energy related to water pumping and delivery were responsible for 68% of the total stationary energy use in 2021 and 50% of the City Government emissions (Figure 19).

Over the inventory period, total water-related GHG emissions decreased by 22% despite an increase in emissions from natural gas usage, reflecting the greater influence of a shift toward lower and zero emission sources of electricity by TEP. Potable and reclaimed water energy use emissions averaged 50% of total City Government emissions over the inventory period.

### **Central Arizona Project (CAP)**

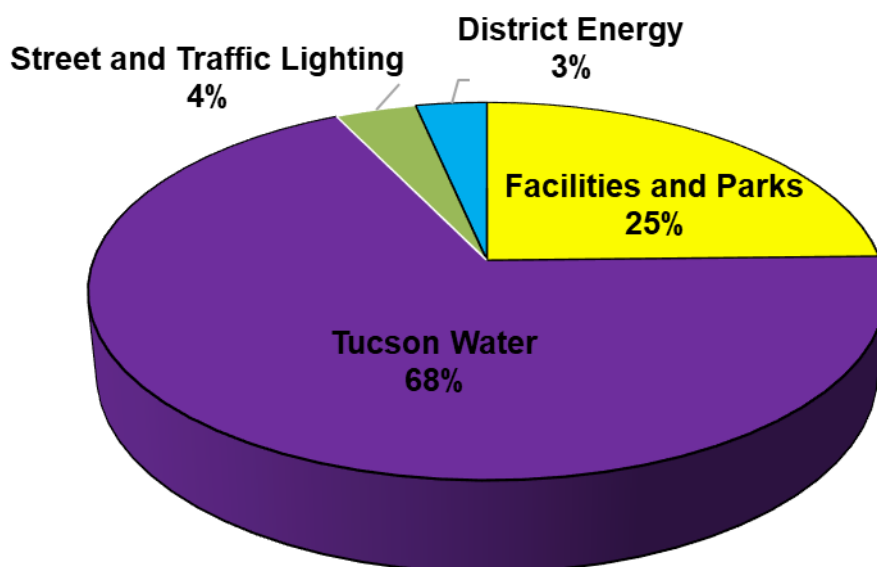
Most of the Colorado River water delivered to Tucson is directed into Tucson Water recharge basins in Avra Valley at the Clearwater Renewable Resource Facility. The water percolates into the ground and blends with the native groundwater in the aquifer. The blend is then recovered by a number of wells 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. Only emissions from the delivery of CAP water as potable water were included in the City Government inventory, while emissions from the CAP water that was pumped to the recharge basins for storage were accounted for in the County Community.

### **Facility and Parks**

Over the inventory period, facility and parks energy use emissions dropped by 47% reflecting a shift toward low and zero emission sources of electricity as well as declines in electricity and natural gas use. Facility and parks energy use was approximately 25% of the 2021 City Government stationary energy total (Figure 19).



**Figure 19. 2021 City Government Stationary Energy Use Emissions**



### **District Energy**

District energy emissions remained relatively flat over the inventory period and were a small component of the 2021 City Government stationary energy use emissions at 3% (Figure 19).

### **Street and Traffic Lighting**

From 2016-2021, public lighting emissions fell by 70% and contributed 4% to the 2021 City Government stationary energy emissions 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).

## **FLEET**

From 2016-2021, total fleet emissions increased by 22% and averaged 14% of total City Government emissions over the inventory period (Table 8). Onroad emissions constituted 97% of City Government fleet emissions in 2021 (Figure 20).

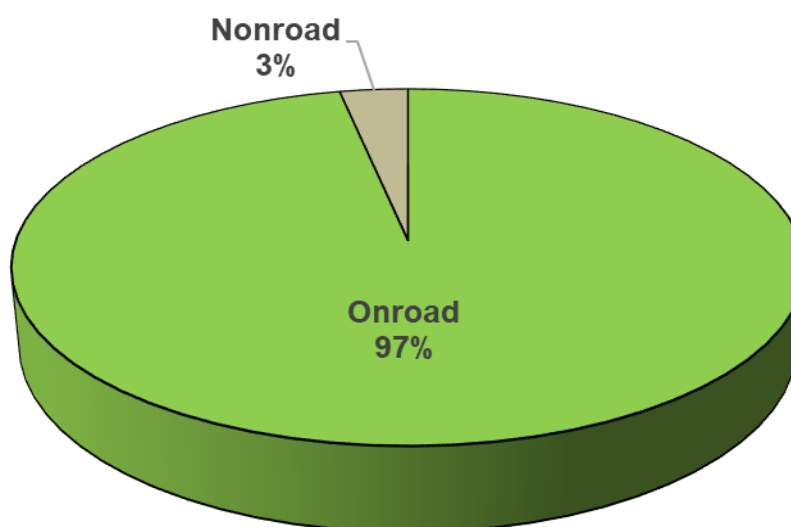
### **Onroad**

From 2016-2021, onroad fleet vehicle emissions increased by 31% (Table 8). Gasoline fuel use increased slightly from 1,201,940 gallons in 2016 to 1,220,254 gallons in 2021, diesel dropped from 341,421 gallons in 2016 to 256,764 gallons in 2021 and CNG doubled from 981,042 gasoline gallon equivalents (gge) in 2016 to 2,053,967 gge in 2021 (Table 8, Appendix K). Onroad fleet vehicle emissions contributed 17% to the 2021 overall City Government total.

### **Nonroad**

Nonroad emissions decreased by 59% over the inventory period due to decreases in diesel fuel usage, despite increases in gasoline and liquid petroleum gas (LPG, propane) (Appendix K). Nonroad fleet vehicle emissions contributed 0.6% to the 2021 City Government emissions total.

**Figure 20. 2021 City Government Fleet Emissions**



### **Employee Commuting**

From 2016-2021, City Government employees' emissions decreased by 20%. Employee commuting contributed 6% to the 2021 City Government emissions total, with total commutes decreasing by 2,274,984 miles over the inventory period (Figure 18, Appendix K).

## **WASTE**

### **Solid Waste Disposal**

City Government waste emissions result from the disposal of solid waste generated by government activities. Over the inventory years, waste volumes increased by approximately 13%, resulting in a 33% increase in emissions (Table 8, Appendix K).

#### 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 approximately 41%, with a resulting emissions savings of 79% (Table 7).

**Table 7. City Government Recycled Material Totals and Emissions Saved 2016-2021**

	Recycled totals (metric tons)	CO2e Saved (metric tons)
<b>2016</b>	1,338	3,060
<b>2017</b>	1,567	3,583
<b>2018</b>	1,751	4,004
<b>2019</b>	1,799	4,114
<b>2020</b>	1,872	5,454
<b>2021</b>	1,893	5,464

*\* Estimated values*

## Energy Generation

Solar energy production data were provided for informational purposes since no GHG emissions were produced (Table 8). Over the inventory period City Government solar energy production increased 82%.

## CITY OF TUCSON GOVERNMENT SYNOPSIS

The City Government's emissions were a small portion of the City Community's totals over the inventory period, making up 3% in 2021. From 2016-2021, City Government emissions dropped by nearly 55,000 metric tons, or 25%. Emission reductions occurred in stationary energy use and employee commuting, while increases took place in fleet and waste. In 2021, stationary energy emissions were 73% of the total City Community emissions, with the majority of stationary energy emissions attributed to water-related energy use (68%).

Electricity use from all sources generated 63% of City Government emissions over the inventory period. City Government has made advances in meeting its energy needs through renewable energy sources. From 2016-2021, the City's solar energy production nearly doubled.

Stationary energy emissions declined by 33% over the inventory period due to reductions in both electricity use and the shift to lower and zero carbon sources used in electricity generation. Stationary energy use emissions were 73% of 2021 City Government emissions.

Over the 2016-2021 period, fleet emissions increased by 22% primarily due to an increase in use of compressed natural gas fuel. Fleet emissions were 17% of the 2021 annual City Government total.

Waste emissions increased by 33% over the inventory period. City Government waste contributed 4% to total 2021 emissions.

Employee commuting VMT decreased by 8% over the inventory period and emissions decreased by 20% from 2016-2021.

**Table 8. City Government GHG Emissions (metric tons CO<sub>2</sub>e) 2016-2021**

	2016	2017	2018	2019	2020	2021	CO2e % of total in 2021	CO2e % change 2016-2021
	CO2e (metric tons)							
<b>STATIONARY ENERGY USE</b>								
<b>Facilities and Parks</b>								
Fossil fuel combustion	5,275	4,650	5,119	5,615	5,036	4,686		-11
Grid-supplied electricity	49,588	45,135	41,245	36,374	31,513	24,413		-51
<b>Facilities Subtotal</b>	54,863	49,785	46,364	41,989	36,549	29,099		-47
<b>Tucson Water</b>								
Fossil fuel combustion	11,308	21,861	15,926	20,503	22,825	22,365		98
Grid-supplied electricity	91,782	77,684	80,396	68,586	71,375	58,086		-37
<b>Tucson Water Subtotal</b>	103,090	99,545	96,322	89,089	94,200	80,451		-22
<b>Street and Traffic Lighting</b>								
Grid-supplied electricity	15,040	6,945	5,446	5,210	5,076	4,549		-70
<b>District Energy</b>								
Fossil fuel combustion	3,953	4,135	3,079	3,771	354	3,983		1
<b>STATIONARY ENERGY USE TOTAL</b>	<b>176,946</b>	<b>160,410</b>	<b>151,211</b>	<b>140,059</b>	<b>136,179</b>	<b>118,082</b>	<b>73</b>	<b>-33</b>
<b>FLEET</b>								
City fleet onroad	20,797	22,768	23,589	25,264	24,503	27,238		31
City fleet nonroad	2,187	2,301	751	608	914	903		-59
<b>FLEET TOTAL</b>	<b>22,984</b>	<b>25,069</b>	<b>24,340</b>	<b>25,872</b>	<b>25,417</b>	<b>28,141</b>	<b>17</b>	<b>22</b>
<b>WASTE TOTAL</b>	<b>4,277</b>	<b>4,559</b>	<b>4,832</b>	<b>4,923</b>	<b>5,615</b>	<b>5,678</b>	<b>4</b>	<b>33</b>
<b>EMPLOYEE COMMUTE TOTAL</b>	<b>12,134</b>	<b>11,290</b>	<b>10,612</b>	<b>9,521</b>	<b>9,922</b>	<b>9,678</b>	<b>6</b>	<b>-20</b>
<b>TOTAL CITY GOVERNMENT GHG EMISSIONS</b>	<b>216,341</b>	<b>201,328</b>	<b>190,995</b>	<b>180,375</b>	<b>177,133</b>	<b>161,579</b>	<b>100</b>	<b>-25</b>
<b>SOLAR ENERGY GENERATION</b>	(12,880)	(12,407)	(11,947)	(12,284)	(16,193)	(15,789)	-	23

# REPORT SUMMARY



Pima County and the City of Tucson Communities reduced greenhouse gas emissions over the 2016-2021 inventory period by 16% and 27%, respectively. Stationary energy use emissions were the major source of community greenhouse gas emissions, although the sector has seen the greatest overall reduction in emissions over the inventory period. County Community combined electricity use from stationary energy and CAP was 10,047,849 MWh in 2016 and decreased slightly by 0.2% to 10,031,868 MWh in 2021, while subsequent emissions were 7,665,339 MT CO<sub>2</sub>e in 2016 and decreased substantially by 34% to 5,061,499 MT CO<sub>2</sub>e in 2021. County Community natural gas use for stationary energy was 149,302,476 therms in 2016 and increased 4.9% to 156,579,103 therms in 2021, while resultant emissions were 789,407 MT CO<sub>2</sub>e in 2016 and increased proportionately by 5.4% to 831,897 MT CO<sub>2</sub>e in 2021. Both the County and City Communities exhibited substantial continued reductions in energy-use emissions over the inventory period due primarily to the shift away from coal toward lower emission natural gas and renewable sources of electricity. Stationary energy use made up 56% of total County Community emissions in 2016 and decreased to 47% of emissions in 2021.

Transportation emissions were the other major source of regional Community emissions, with onroad vehicle emissions contributing 79% of transportation emissions in 2021. Combined onroad gasoline and diesel consumption increased from 446,828,727 gallons in 2016 to 453,564,611 gallons in 2021, yielding 4,097,117 MT CO<sub>2</sub>e. Transportation made up 35% of total County Community emissions in 2016 and increased to 43% of emissions in 2021.

Industrial processes (cement production), CAP water pumping from Lake Havasu to the Tucson metro region, waste and intra-state natural gas transport combined to contribute the remaining 10% of 2021 County Community emission totals.

Pima County and the City of Tucson Governments exhibited GHG emission declines over the inventory period of 19% and 25%, 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, facility and wastewater reclamation energy use were the major contributors to GHG emission totals.

Opportunities are available for further GHG emission reductions in the stationary energy and transportation sectors through electrification of space and water heating systems and vehicles. An RMI study indicated that modern heat pumps used for space heating in Arizona reduce GHG emissions by 80% over a 15-year lifespan compared to natural gas furnaces, while heat pumps used for water heating reduce operational GHG emissions by 76% compared to natural gas water heaters (RMI, 2023). According to the USEPA, passenger EVs emit one-half to two-thirds less GHG emissions compared to gasoline vehicles (Argonne, 2022) (USEPA, 2023). Today's EVs will emit less GHG in the future as the electric grid continues to transition from coal and increase renewable energy resources.

# REFERENCES CITED



- Ameresco. 2016. Investment Grade Audit – City of Tucson LED Lighting Conversion Project.  
[https://www.tucsonaz.gov/files/sharedassets/public/government/departments/departments-of-transportation-and-mobility/documents/01.22.16\\_cot\\_iga\\_report\\_final.pdf](https://www.tucsonaz.gov/files/sharedassets/public/government/departments/departments-of-transportation-and-mobility/documents/01.22.16_cot_iga_report_final.pdf)
- Argonne National Laboratory. 2022. Cradle-to-Grave Lifecycle Analysis of U.S. Light-Duty Vehicle-Fuel Pathways: A Greenhouse Gas Emissions and Economic Assessment of Current (2020) and Future (2030-2035) Technologies.  
<https://publications.anl.gov/anlpubs/2022/07/176270.pdf>
- Arizona Department of Transportation. 2022. ADOT National Electric Vehicle Infrastructure Deployment Plan.  
<https://azdot.gov/planning/transportation-studies/arizona-electric-vehicle-program>
- Arizona Office of Economic Opportunity (AOEO). <https://population.az.gov/>
- Cascadia Consulting Group Inc. 2016. City of Tucson Waste Diversion Plan and Roadmap.
- Cascadia Consulting Group Inc. 2006. Detailed Characterization of Construction and Demolition Waste. Contractor's Report to the California Integrated Waste Management Board.  
<http://www2.calrecycle.ca.gov/publications/Documents/>
- Central Arizona Project. 2022. Fact Sheet CAP Power Portfolio.  
<cap-fact-sheet-power-portfolio.pdf> ([cap-az.com](http://cap-az.com))
- City of Tucson. 2021. Electric Vehicle Readiness Roadmap.  
<https://climateaction.tucsonaz.gov/pages/electricvehicles-roadmap>
- City of Tucson. 2023. Tucson Resilient Together Climate Action and Adaptation Plan.  
[https://assets.tucsonaz.gov/share/gis-docs/caap/TucsonResilientTogether\\_20230228.pdf](https://assets.tucsonaz.gov/share/gis-docs/caap/TucsonResilientTogether_20230228.pdf)
- ICLEI. 2010. Local Government Operations Protocol for the Quantification and Reporting of Greenhouse Gas Emissions Inventories. May 2010, Version 1.1.  
[https://s3.amazonaws.com/icleiusaresources/lgo\\_protocol\\_v1\\_1\\_2010-05-03.pdf](https://s3.amazonaws.com/icleiusaresources/lgo_protocol_v1_1_2010-05-03.pdf)
- ICLEI. 2021. (Local Governments for Sustainability) U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions. July 2021, Version 1.2.  
<https://iclei.usa.org/us-community-protocol/>
- Philbin, A. 2012. Formally of Tucson Water. Personal communication.
- Pima Association of Governments. 2020. Arizona I-10 Alternative Fuels Corridor Deployment Plan.  
<https://pagregion.com/sustainability/air-quality/i10-alt-fuels-deployment-plan/>

Pima County. 2017a. Resolution 2017-39.

<https://content.civicplus.com/api/assets/6b9a4b1f-b223-4d1d-b0d2-79ace0eea5fd>

Pima County. 2017b. Resolution 2017-51.

<https://content.civicplus.com/api/assets/1f45a294-1428-4dde-8677-b823bceb567a>

Pima County. 2018. Sustainable Action Plan for County Operations 2018-2025.

<https://content.civicplus.com/api/assets/d4e07208-6cf4-45a8-90da-4cb8733d906d?cache=1800>

Pima County. 2021. Sustainable Action Plan for County Operations Report Card: FY 2020/2021.

<https://content.civicplus.com/api/assets/f8794f0d-2818-46e9-ab55-237d78eb8a0f?cache=1800>

Pima County. 2022. Resolution 2022-25.

<https://content.civicplus.com/api/assets/f2d4732e-b314-4260-ac4d-d89d07cc95f3?cache=1800>

Portland Cement Association. 2021. California/Nevada/Arizona Regional Cement Outlook.

[https://www.cement.org/docs/default-source/market-economics-pdfs/californiaregionalconference2021two.pdf?sfvrsn=f4c6e3bf\\_2](https://www.cement.org/docs/default-source/market-economics-pdfs/californiaregionalconference2021two.pdf?sfvrsn=f4c6e3bf_2)

RMI. 2023. Now Is the Time to Go All In on Heat Pumps.

<https://rmi.org/now-is-the-time-to-go-all-in-on-heat-pumps/>

Union Pacific Railroad. (UPRR) 2021. Pima County Fuel Consumption Data Report.

UPRR. 2022. Climate Action Plan.

[https://www.up.com/cs/groups/public/@uprr/@corprel/documents/up\\_pdf\\_nativedocs/pdf\\_up\\_2022\\_climate\\_action\\_pln.pdf](https://www.up.com/cs/groups/public/@uprr/@corprel/documents/up_pdf_nativedocs/pdf_up_2022_climate_action_pln.pdf)

U.S. Census Bureau. 2021 Quick Facts.

<https://www.census.gov/quickfacts/fact/table/US/PST045217>

U.S. Department of Energy (USDOE). 2016. Table VM-1 Highway Statistics 2016.

<https://www.fhwa.dot.gov/policyinformation/statistics/2016/vm1.cfm>

USDOE. 2021. Table VM-1 Highway Statistics 2021.

<https://www.fhwa.dot.gov/policyinformation/statistics/2021/vm1.cfm>

U.S. Department of Transportation (USDOT). 2021. FHWA Monthly Motor Fuel Reported by States, December 2021. <https://www.fhwa.dot.gov/policyinformation/motorfuel/dec21/dec21.pdf>

U.S. Environmental Protection Agency (USEPA). 2013. Subpart HH Rule Training.

<https://www.epa.gov/sites/production/files/2015-07/documents/subparthhruletraining2013.pdf>

USEPA. 2021a. Greenhouse Gas Reporting Program for Calendar Years 2016 through 2021.

<https://ghgdata.epa.gov/ghgp/main.do#>

USEPA. 2021b. Benefits of Landfill Gas Energy Projects.

<https://www.epa.gov/lmop/benefits-landfill-gas-energy-projects#one>

USEPA. 2021c. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021. EPA-430-R-21-005.

<https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2021>

USEPA. 2022. WARM model, May 2021, updated November 2020 and September 2022; Version 15.

<https://www.epa.gov/warm/versions-waste-reduction-model-warm#15>

USEPA. 2023. Comparison: Your Car vs. an Electric Vehicle.

<https://www.epa.gov/greenvehicles/comparison-your-car-vs-electric-vehicle>



# APPENDICES



- A. Inventory Data Sources
- B. Per Capita Greenhouse Gas Emissions
- C. Population Estimates, 2016-2021
- D. Number of Households in eastern Pima County and City of Tucson 2016-2021
- E. Emissions Factors for PAG GHG Inventory Electricity Use
- F. Eastern Pima County Community Inventory Data Inputs
- G. City of Tucson Community Inventory Data Inputs
- H. Waste & Recycling Characterizations
- I. EPA's WARM Model Emission Factors
- J. Pima County Government Operations Inventory Data Inputs
- K. City of Tucson Government Operations Inventory Data Inputs

## APPENDIX A. INVENTORY DATA SOURCES

Community Inventories		
Category	Data type	Contact
<b>STATIONARY ENERGY</b>		
<b>Electricity</b>	Residential, commercial, industrial use; annual emission factors data	Catherine Schladweiler, TEP
	Residential, commercial use	Laree St. Onge, Trico
	Residential, commercial use	Joe Mease, Tohono O'odham Utility Authority
<b>Fossil fuel combustion</b>	Residential, commercial, industrial natural gas use	Noreen Litty, Southwest Gas
<b>TRANSPORTATION</b>		
<b>Onroad &amp; Nonroad</b>	VMT modeling inputs; EPA MOVES	Hyunsoo Noh, Ryan Hatch, PAG
	HURF Fuel Sales in Pima County - gallons of gasoline, diesel	Barbara Budde, John Shown, ADOT
<b>Aviation Jet A</b>	Gallons of Jet A dispensed at DMAFB, ANG, TIA, Marana, Ryan	Sarah Simmons, TAA; Sarah Reitmeyer, DMAFB; Peter Barbier, Marana Airport; Tim Amalong, Ryan Airfield
<b>Aviation Avgas</b>	HURF Fuel Sales in Pima County - gallons of Avgas	Barbara Budde, John Shown, ADOT
<b>Locomotives</b>	Gallons of diesel in line haul and yard operations in Pima County	Tom Cappucci, UPRR
<b>WASTE</b>		
<b>Solid waste</b>	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
<b>Wastewater reclamation</b>	Electricity, natural gas use; process and digester gas data by facility	Sandra Rosales, Pima County Regional Wastewater Reclamation Department; Mike Osborne, Town of Marana
<b>Recycling</b>	Pima County	Kurtis Wahl, Tucson Waste Recycling & Waste; Jennifer Lynch, Pima County
	City of Tucson	Frank Bonillas, City of Tucson
<b>INDUSTRIAL PROCESSES</b>	Cement production emissions	EPA reported emission totals
<b>OTHER</b>	Central Arizona Project (CAP) electricity use & water delivery	Nolie Templeton, CAP; Jaimie Galayda, Tucson Water
<b>ENERGY INDUSTRIES</b>	Electricity generation emissions	EPA reported totals; Catherine Schladweiler, TEP
Government Operations Inventories		
Category	Data type	Contact
<b>STATIONARY ENERGY</b>		
<b>Facilities</b>		
Electricity use	Pima County	Sandra Rosales, Pima County
	City of Tucson	Michael Catanzaro, City of Tucson
Fossil fuel combustion	Pima County	Sandra Rosales, Pima County
	City of Tucson	Michael Catanzaro, City of Tucson
<b>Water &amp; Wastewater reclamation</b>		
Electricity use	Pima County	Sandra Rosales, Pima County Wastewater Reclamation
	City of Tucson	Jaimie Galayda, Tucson Water
Fossil fuel combustion	Pima County	Sandra Rosales, Pima County Wastewater Reclamation
	City of Tucson	Jaimie Galayda, Tucson Water
<b>Public lighting</b>	Pima County	Sandra Rosales, Pima County
	City of Tucson	Michael Catanzaro, City of Tucson
<b>FLEET</b>	Pima County	Sandra Rosales, Pima County
	City of Tucson	Michael Catanzaro, City of Tucson
<b>WASTE</b>		
<b>Solid waste, Recycling totals</b>	Pima County	Sandra Rosales, Pima County
	City of Tucson	Frank Bonillas, City of Tucson
<b>Wastewater treatment process</b>	Pima County	Sandra Rosales, Pima County Wastewater Reclamation
<b>EMPLOYEE COMMUTING</b>	Pima County and City of Tucson Government Employee VMT	Mary Carter, PAG

## APPENDIX B. PER CAPITA GREENHOUSE GAS EMISSIONS (METRIC TONS CO<sub>2</sub>E)

	CO <sub>2</sub> e (metric tons per capita)		
	United States	Eastern Pima County	City of Tucson
<b>2016</b>	20.36	14.35	13.57
<b>2017</b>	20.18	13.96	12.59
<b>2018</b>	20.76	13.82	12.00
<b>2019</b>	20.16	13.19	11.77
<b>2020</b>	18.16	12.10	10.01
<b>2021</b>	19.06	11.58	9.58

## APPENDIX C. POPULATION ESTIMATES, 2016-2021

	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>
City of Tucson	528,931	533,694	538,883	541,288	543,136	546,061
Eastern Pima County*	1,002,179	1,009,950	1,017,227	1,026,815	1,035,222	1,047,617

Data represents July population estimates for each year.

\* Calculation: Eastern Pima County is estimated by using 99% of Pima County population.

**Data Source:** Arizona Office of Economic Opportunity (AOEO). <https://www.azcommerce.com/oeo/population/>

## APPENDIX D. NUMBER OF HOUSEHOLDS IN EASTERN PIMA COUNTY AND CITY OF TUCSON 2016-2021

	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>
Number of Households - City of Tucson	207,661	209,906	210,816	212,491	215,943	218,790
Residential Stationary Energy GHG emissions/household (metric tons)	9.67	9.01	8.57	8.39	7.66	6.53
Number of Households - Eastern Pima County*	387,597	390,675	393,005	396,762	406,868	413,262
Residential Stationary Energy GHG emissions/household (metric tons)	9.42	8.80	8.38	7.93	7.99	6.55

\* Calculation: Eastern Pima County data is estimated using 99% of Pima County population.

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

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

## APPENDIX E. EMISSIONS FACTORS FOR PAG GHG INVENTORY ELECTRICITY USE

	<b>2016</b>			<b>2017</b>			<b>2018</b>			<b>2019</b>			<b>2020</b>			<b>2021</b>		
	Lbs / MWh			Lbs / MWh			Lbs / MWh			Lbs / MWh			Lbs / MWh			Lbs / MWh		
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
Tucson Electric Power (TEP)	1,684.78	0.1689	0.0243	1,570.38	0.1552	0.0224	1,483.77	0.1305	0.0187	1,391.21	0.1545	0.0205	1,295.98	0.1058	0.02	1,128.81	0.0895	0.0126
*TEP Emission Factors also used for Trico Electric Cooperative (Trico) and Tohono O'odham Utility Authority (TOUA)																		
	Lbs CO <sub>2</sub> e / MWh			Lbs CO <sub>2</sub> e / MWh			Lbs CO <sub>2</sub> e / MWh			Lbs CO <sub>2</sub> e / MWh			Lbs CO <sub>2</sub> e / MWh			Lbs CO <sub>2</sub> e / MWh		
Central Arizona Project (CAP)	1,615.1			1,913.7			1,883.8			1,723.1			766.1			778.8		

# APPENDIX F. EASTERN PIMA COUNTY COMMUNITY INVENTORY DATA INPUTS

	2016	2017	2018	2019	2020	2021	% change 2016-2021
STATIONARY ENERGY							
Residential							
Fossil fuel combustion	Therms / year						
SWG	77,764,127	68,398,233	73,690,460	88,034,269	78,960,407	80,363,060	3
Grid-supplied electricity	MWh / year						
TEP	3,724,044	3,785,635	3,766,234	3,698,302	4,170,494	3,820,049	3
Trico	480,465	497,820	514,132	516,732	586,194	579,209	21
TOUA	29,012	28,679	29,643	30,870	33,964	33,614	16
Commercial							
Fossil fuel combustion	Therms / year						
SWG	63,877,478	61,406,961	63,332,084	66,950,123	64,603,559	63,858,289	0
Grid-supplied electricity	MWh / year						
TEP	2,169,275	2,209,377	2,136,449	2,076,799	2,004,856	1,939,535	-11
Trico	25,288	26,201	27,060	27,196	30,852	30,485	21
TOUA	57,120	56,511	56,891	54,303	54,438	56,973	0
Industrial							
Fossil fuel combustion	Therms / year						
SWG	7,660,871	9,514,757	7,889,861	9,743,875	19,245,362	12,357,754	61
Grid-supplied electricity	MWh / year						
TEP	3,003,057	2,930,921	2,981,330	2,953,099	2,919,637	2,942,468	-2
TRANSPORTATION							
Gallons / year							
OnroadGasoline	394,763,305	395,298,140	399,822,388	408,298,697	354,464,225	387,115,725	-2
Diesel	52,065,422	51,046,905	53,168,095	54,553,211	56,828,702	66,448,886	28
Therms / year							
CNG	1,952,116	2,591,082	3,101,023	3,470,246	3,442,688	3,801,860	95
Gallons / year							
NonroadDiesel	38,973,750	40,615,317	40,857,619	39,653,907	37,304,829	39,988,623	3
Locomotives							
Diesel	7,275,362	7,217,037	11,827,309	9,774,695	9,656,506	9,133,374	26
Aircraft							
Avgas	358,398	354,733	369,319	346,606	393,335	498,217	39
Jet A	60,623,736	64,097,156	66,861,724	66,517,418	45,794,258	57,752,859	-5
WASTE							
Metric tons disposed/year							
Solid waste							
Los Reales Landfill	527,388	708,235	761,501	644,840	666,998	669,801	27
Sahuarita Landfill	3,240	0-closed	0-closed	0-closed	0-closed	0-closed	
Marana Regional Landfill	302,745	332,348	339,658	349,887	384,968	392,691	30
Speedway Recycling & Landfill Facility	58,018	49,529	52,814	48,754	58,364	66,439	15
Solid waste total	891,390	1,090,112	1,153,973	1,043,481	1,110,330	1,128,931	27
Wastewater reclamation							
Population served							
Pima County nitrification/denitrification	588,561	588,561	709,233	713,338	721,919	732,074	24
Marana nitrification/denitrification	6,271	7,483	8,680	9,409	10,625	14,958	139
Sahuarita nitrification/denitrification	15,902	16,298	16,707	17,128	17,562	18,000	13
Septic fugitive	385,838	391,981	276,961	281,217	279,424	277,058	-28
Varies by treatment facility							
Standard cubic feet/day							
Digester gas flared	565,098	601,678	597,794	701,185	679,265	654,740	16
Digester gas combustion for energy	112,806	94,564	203,467	150,318	121,312	-	
INDUSTRIAL PROCESSES							
EPA reported emissions 2016-2021							
Cement production (CalPortland Rillito)							
OTHER							
MWh / year							
Grid-supplied electricity							
Central Arizona Project	559,588	555,496	592,650	586,321	643,172	629,535	12
Acre-feet / year							
Water deliveries	220,214	223,026	235,967	235,153	257,344	249,774	13
ENERGY INDUSTRIES							
* Energy Generation (TEP - Irvington, DeMoss Petrie, North Loop; UArizona)	EPA reported emissions 2016-2021						
Energy Transport (Kinder Morgan Inc. - SGC Sierra)							

\*Emissions accounted for in Stationary Energy.

*Italic numbers – estimated values*

## APPENDIX G. CITY OF TUCSON COMMUNITY INVENTORY DATA INPUTS

	2016	2017	2018	2019	2020	2021	% change 2016-2021
STATIONARY ENERGY							
Residential							
Fossil fuel combustion (therms)	60,188,772	52,090,295	56,335,086	66,155,208	58,821,730	59,476,641	-1
Grid-supplied electricity (MWh)							
TEP	2,022,532	2,078,975	2,030,136	2,065,731	2,134,516	1,961,341	-3
Trico	185,463	186,725	195,638	185,827	204,948	200,351	8
Commercial							
Fossil fuel combustion (therms)	56,118,326	53,763,639	56,509,197	59,335,058	58,322,352	57,292,033	2
Grid-supplied electricity (MWh)							
TEP	1,563,420	1,594,975	1,537,554	1,527,750	1,377,269	1,370,861	-12
Trico	9,761	9,828	10,297	9,780	10,787	10,545	8
Industrial							
Fossil fuel combustion (therms)	5,134,818	6,904,513	5,827,134	6,729,538	7,011,472	6,063,390	18
Grid-supplied electricity (MWh)							
TEP	1,449,823	1,392,696	1,333,868	1,355,772	846,172	847,425	-42
TRANSPORTATION	Gallons / year						
Onroad Gasoline	207,013,877	207,294,345	209,666,860	214,111,837	185,881,040	203,003,486	-2
Diesel	27,303,107	26,768,997	27,881,349	28,607,704	29,800,971	34,845,796	28
	Therms / year						
CNG	1,827,082	2,044,626	2,329,801	2,552,655	2,443,636	2,725,869	49
	Gallons / year						
Nonroad Diesel	46,397	42,864	44,430	28,481	38,155	37,206	-20
WASTE							
Solid waste disposal	Metric tons disposed/year						
Los Reales Landfill	527,388	708,235	761,501	644,840	666,998	669,801	27
Speedway Recycling & Landfill Facility	58,018	49,529	52,814	48,754	58,364	66,439	15
Solid waste totals	585,406	757,764	814,315	693,594	725,362	736,240	26
Wastewater reclamation	Calculated City fraction of County's wastewater emission totals						
OTHER - Central Arizona Project							
Grid-supplied electricity (MWh)	199,456	165,572	135,114	160,890	178,922	175,028	-12
Water deliveries (acre-feet)	77,700	64,500	52,635	62,680	69,701	68,184	-12
Energy Industries							
* Energy generation (TEP Irvington, DeMoss Petrie, UArizona)	EPA reported emissions 2016-2021						

\*Emissions accounted for in Stationary Energy.

## APPENDIX H. WASTE & RECYCLING CHARACTERIZATIONS

WASTE	Waste Type	Percent Composition
<b>Construction and Demolition</b> Source: Cascadia, 2006	Paper products	3
	Food	0
	Plant debris	1
	Wood/textiles	20
	Other (not included - nonorganic)	76
<b>Government-generated (2016-2021)</b> Source: ICLEI, 2010	Newspaper	1.7
	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
<b>County &amp; City 2016-2021 (Community and Government)</b> Source: Cascadia, 2014	OCC and other paper	25.4
	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 EMISSION FACTORS - (VERSION 15) PER TON ESTIMATES OF BASELINE AND ALTERNATIVE MANAGEMENT SCENARIOS

Material	GHG Emissions per Ton of Material Source Reduced (MTCO <sub>2e</sub> )	GHG Emissions per Ton of Material Recycled (MTCO <sub>2e</sub> )	GHG Emissions per Ton of Material Landfilled (MTCO <sub>2e</sub> )	GHG Emissions per Ton of Material Combusted (MTCO <sub>2e</sub> )	GHG Emissions per Ton of Material Composted (MTCO <sub>2e</sub> )
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	(142)	(0.76)	0.02	129	NA
LDPE	(180)	NA	0.02	129	NA
PET	(2.17)	(104)	0.02	124	NA
LLDPE	(158)	NA	0.02	129	NA
PP	(152)	(0.79)	0.02	129	NA
PS	(2.50)	NA	0.02	165	NA
PVC	(193)	NA	0.02	0.66	NA
Mixed Plastics	(187)	(0.93)	0.02	126	NA
PLA	(2.45)	NA	(164)	(0.63)	(0.09)
Desktop CPUs	(20.86)	(149)	0.02	(0.66)	NA
Portable Electronic Devices	(29.83)	(106)	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	120	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)	(183)	0.02	(159)	NA
Copper Wire	(6.72)	(4.49)	0.02	0.03	NA
Mixed Metals	(3.65)	(4.39)	0.02	(102)	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

	2016	2017	2018	2019	2020	2021	% change 2016-2021
<b>STATIONARY ENERGY</b>							
Facilities and Parks							
Fossil fuel combustion (therms)	762,133	735,760	736,830	899,294	868,719	831,338	9
Grid-supplied electricity (kWh)	61,622,742	56,918,835	69,141,493	66,421,510	65,407,916	68,073,101	10
Wastewater							
Fossil fuel combustion (therms)	5,933	2,087	3,959	83,530	158,261	422,620	7023
Grid-supplied electricity (kWh)	54,617,617	55,834,290	33,098,611	34,118,049	60,877,117	61,422,535	12
Digester gas flared	565,098	601,678	597,794	701,185	679,265	654,740	16
Digester gas combusted for energy	112,806	94,564	203,467	150,318	798,507	814,748	622
Street and Traffic Lighting (kWh)	2,660,867	2,606,577	2,757,138	2,675,569	2,809,616	2,722,944	2
<b>FLEET</b>	<b>Miles/year</b>						
Onroad (total)	10,780,342	15,362,188	15,378,193	14,767,679	13,318,006	13,818,822	28
Gasoline	9,620,759	14,378,622	14,380,286	13,849,226	12,303,734	12,525,373	30
Diesel	1,159,583	983,349	989,819	824,219	836,195	900,494	-22
Electric	-	217	8,088	94,234	178,077	392,955	
	<b>Gallons/year</b>						
Gasoline	1,116,539	1,088,174	1,057,537	1,013,201	929,727	928,655	-17
Diesel	167,719	172,904	176,810	139,746	148,952	150,983	-10
Nonroad	<b>Gallons/year</b>						
Gasoline	-	41	3,214	329	558	491	
Diesel	10,986	34,362	19,084	20,237	42,231	25,407	131
<b>WASTE</b>	<b>Metric tons disposed/year</b>						
Solid Waste	3,528	3,944	2,382	2,190	2,754	2,423	-31
Wastewater Treatment	<b>Population served</b>						
Nitrification/denitrification	588,561	588,561	709,233	713,338	721,919	732,074	24
Lagoons (BOD5/day)	Varies by facility						
<b>EMPLOYEE COMMUTING</b>	<b>Miles/year</b>						
	38,635,126	37,911,970	37,042,772	36,074,584	41,284,048	37,940,864	-2
<b>ENERGY GENERATION</b>	<b>kWh</b>						
Solar	7,156,618	10,728,263	14,080,529	16,046,468	17,009,362	17,540,023	145



## APPENDIX K. CITY OF TUCSON GOVERNMENT OPERATIONS INVENTORY DATA INPUTS

	2016	2017	2018	2019	2020	2021	% change 2016-2021
<b>STATIONARY ENERGY</b>							
Facilities and Parks							
Fossil fuel combustion (therms)	991,806	874,222	962,544	1,055,628	946,938	881,062	-11
Grid-supplied electricity (kWh)							
TEP	64,848,978	63,324,305	60,929,110	57,239,141	53,321,505	47,434,657	-27
Tucson Water (Potable and Reclaimed)							
Fossil fuel combustion (therms)	2,126,157	4,110,216	2,994,363	3,855,013	4,291,417	4,205,095	98
Grid-supplied electricity (kWh)							
TEP, Trico, BIA	120,028,027	108,989,694	118,765,796	107,930,435	120,771,930	112,861,155	-6
Street and Traffic Lighting							
TEP (kWh)	19,668,391	9,743,843	8,045,104	8,198,177	8,589,351	8,838,927	-55
District Energy							
Fossil fuel combustion (therms)	743,240	777,520	578,920	709,070	66,646	748,840	1
<b>FLEET</b>	<b>Miles/year</b>						
Onroad (Total)	19,796,712	17,977,228	18,297,482	17,261,487	18,325,860	16,589,918	-16
Diesel	3,054,663	2,777,589	2,030,584	1,582,073	1,550,472	1,482,845	-51
Gasoline	14,837,051	12,994,980	14,464,208	13,606,202	13,624,569	11,774,463	-21
E-85	1,054,807	1,137,580	409,668	406,541	1,763,111	1,729,298	64
CNG	844,592	1,060,403	1,386,500	1,659,541	1,335,965	1,549,194	83
LPG	5,599	6,676	6,522	7,130	51,743	54,118	867
Electric	-	-	3,490	3,490	4,352	4,352	
	<b>Gallons/year</b>						
Gasoline	1,201,940	1,181,528	1,162,794	1,210,789	1,260,240	1,220,254	2
Diesel	341,421	319,514	298,713	286,616	265,573	256,764	-25
E-85	21,962	26,378	32,529	38,529	25,686	21,003	-4
CNG	981,042	1,331,080	1,502,148	1,701,734	1,571,335	2,053,967	109
LPG	3,270	3,074	3,557	2,282	2,709	2,046	-37
Nonroad	<b>Gallons/year</b>						
Diesel	211,006	222,149	59,533	46,467	70,826	70,781	-66
Gasoline	593	598	12,896	12,627	19,720	18,679	3050
LPG	1,602	1,527	4,195	3,093	3,048	2,748	72
<b>WASTE</b>	<b>Metric tons disposed/year</b>						
Solid waste	9,320	9,935	10,531	10,728	10,384	10,500	13
<b>EMPLOYEE COMMUTING</b>	<b>Miles/year</b>						
	28,158,504	26,653,947	27,185,881	24,964,992	27,912,976	25,883,520	-8
<b>ENERGY GENERATION</b>	<b>kWh</b>						
Solar	16,843,462	17,406,202	17,648,151	19,331,066	27,398,958	30,678,604	82

*Italics – estimated values*