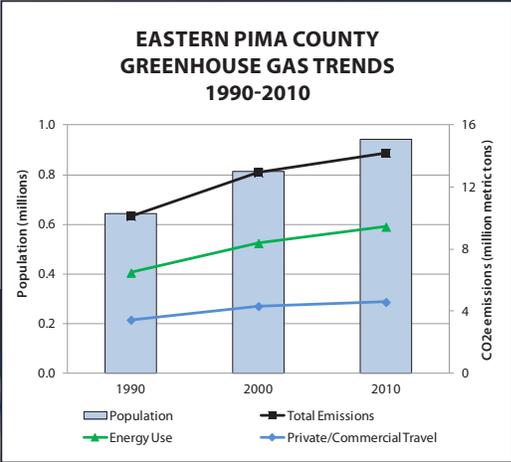


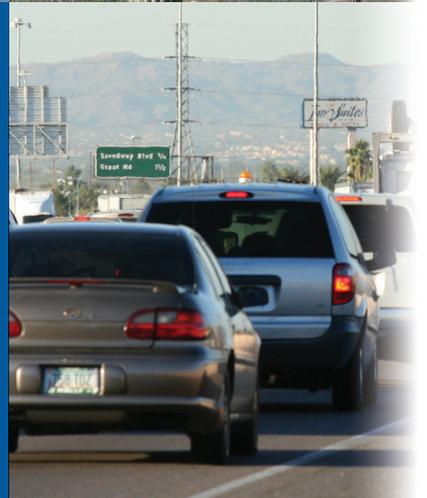
Regional Greenhouse Gas Inventory



1990 – 2010

- Eastern Pima County
- City of Tucson
- Pima County Government
- City of Tucson Government

Published November 2012



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November 2012

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In addition, we would like to especially thank Pima County Department of Environmental Quality for continued access to the greenhouse gas emissions model.

List of Acronyms

ADEQ	Arizona Department of Environmental Quality
APC	Arizona Portland Cement Co.
Btu	British thermal units
B-20	Biodiesel containing 20 percent vegetable oil and 80 percent
CACP	Clean Air and Climate Protection model
CAP	Central Arizona Project
CH ₄	Methane
CNG	Compressed natural gas
CO ₂	Carbon dioxide
CO ₂ e	Carbon dioxide equivalents
DOE	Department of Energy
EIA	Energy Information Administration (department within DOE)
GHG	Greenhouse gas
HFC	Hydrofluorocarbons
ICLEI	International Council for Local Environmental Initiatives
IPCC	Intergovernmental Panel on Climate Change
KWh	Kilowatt hours
LTO	Landings and Take-offs
MMBtu	Million British thermal units
N ₂ O	Nitrous oxide
PAG	Pima Association of Governments
PCRWRD	Pima County Regional Wastewater Reclamation Department
PDEQ	Pima County Department of Environmental Quality
PFC	Perfluorocarbons
RCI	Residential, Commercial and Industrial sectors
SF ₆	Sulfur hexafluoride
TEP	Tucson Electric Power Co.
TIA	Tucson International Airport
TRP	Travel Reduction Program
TW	Tucson Water
UPRR	Union Pacific Railroad
USEPA	U.S. Environmental Protection Agency
VMT	Vehicle Miles Traveled
WARM	EPA's Waste Reduction Model
WRFs	Wastewater Reclamation Facilities

Regional Greenhouse Gas Inventory – 1990 to 2010

Executive Summary

In October 2007, the PAG Regional Council approved a resolution to conduct a greenhouse gas (GHG) emissions inventory for eastern Pima County. The goal of this resolution is to provide a regional, broad-based GHG emissions inventory which provides baseline information on emissions and evaluates the region's overall progress in achieving GHG reductions.

Pima Association of Governments' (PAG) staff, on behalf of Pima County and the City of Tucson, developed this new edition of the *Regional Greenhouse Gas Inventory*. It serves as an update to the last GHG inventory published in April 2011 (PAG, 2011) and includes 2010 data for the Tucson metropolitan area. This report includes four inventories:

Eastern Pima County Regional GHG emissions inventory: (hereinafter referred to as the County Regional). It includes emissions generated by the communities and governments of Tucson, Marana, Oro Valley, Sahuarita, the Tohono O'odham Nation, the Pascua Yaqui Tribe and unincorporated eastern Pima County.

Subsets of the Eastern Pima County Regional GHG Inventory:

- Tucson Community GHG Emissions Inventory: (hereinafter referred to as the City Community). It includes GHG emissions generated within the Tucson city limits and by Tucson government operations.
- Pima County Government Operations GHG Emissions Inventory: (hereinafter referred to as the County Government). Inventory includes emissions from the County government operations only.
- Tucson Government Operations GHG Emissions Inventory: (hereinafter referred to as the City Government). Inventory includes emissions from City government operations only.

All inventories estimate the three major GHG emissions, carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O), and are expressed as carbon dioxide equivalents (CO₂e). Unlike the Arizona and national inventories, hydrofluorocarbons (HFCs) perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆) are not included; local fluorinated hydrocarbons emissions are expected to represent a very small proportion of the total of all greenhouse gases.

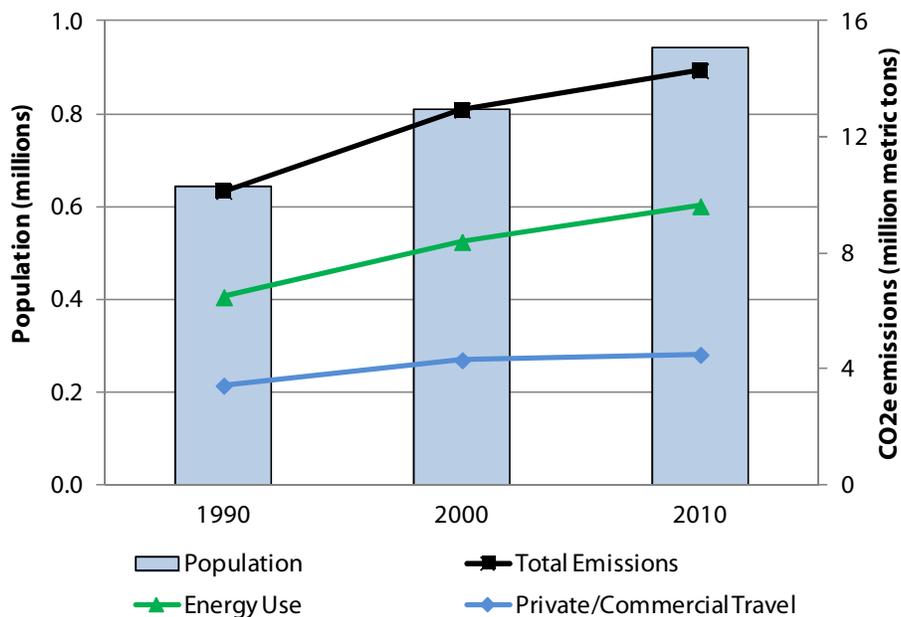
The regional/community inventories include three major emission sources: energy consumption (from residential, commercial and industrial), transportation (from private/commercial and public transit), and waste disposal. Additional sources are designated as "other" and include emissions from local cement production, a closed Tucson landfill, propane use and stationary diesel use, as well as aviation and locomotive fuel consumption. The government inventories include three major emission sources: energy consumption, (from water-handling activities, government facilities and public lighting) transportation (from vehicle fleets and employee commuting) and waste disposal.

Eastern Pima County Regional GHG Emissions Inventory

Overall, County Regional GHG emissions rose by 41 percent between 1990 and 2010. Most of this increase can be attributed to the 47 percent growth in population and the associated increases in County Regional energy use emissions (49 percent) and private and commercial vehicle travel (31 percent). From 2008 to 2010, total County Regional emissions dropped 3 percent, reflecting declines in commercial and industrial energy use, and waste disposal emissions. Slight emission increases occurred in transportation and residential energy use over this 2-year period. In 2010, the County Region generated 14.3 million metric tons of greenhouse gases with energy use and transportation continuing to generate the largest portion of emissions. Combined residential, commercial and industrial (RCI) energy use and transportation were responsible for 67 percent and 32 percent of 2010 emissions, respectively.

Regional GHG emission trends generally follow national trends. In the United States, GHG emissions increased by 11 percent from 1990 to 2010, but declined by 3 percent from 2008 to 2010 (USEPA, 2012a). However, County Regional GHG emissions per capita were low as compared to the nation. In 2010, U.S. per capita GHG emissions were 17.8 (PBL Netherlands Environmental Assessment Agency, 2012) metric tons while County Regional per capita emissions were 15.2 metric tons.

Eastern Pima County Regional Population and Energy Use and Private/Commercial Travel Emission Trends: 1990-2010



Tucson Community GHG Emissions Inventory:

Similar to the County Region, City Community GHG emissions grew by 30 percent from 1990 to 2010, reflecting the 27 percent population increase and the accompanying travel and energy use increases. Private/commercial vehicle travel emissions increased by 26 percent and the City Community's total energy use emissions increased by 35 percent over this 20-year period. From 2008 to 2010, the City Community emissions exhibited a 1 percent decline reflecting decreases in all sectors except residential energy use. The largest declines occurred in waste disposal emissions and industrial energy use. In 2010, the City Community generated over 7 million metric tons of GHG, representing 49 percent of the County Regional's emissions. As in

the County, City Community RCI energy use was responsible for two-thirds of emissions while regional travel produced about one-third of emissions.

Pima County Government Operations GHG Emissions Inventory

From 2000 to 2010, County Government emissions rose by 55 percent with the greatest increases occurring in wastewater reclamation facility (WRFs) energy use and employee commuting. Emissions from the other sectors (facility energy use and vehicle fleet) also showed modest increases over this same period. Electricity use emissions averaged 75 percent of the total for all survey years. From 2008 to 2010, County Government emissions rose by 6 percent. Emissions associated with waste disposal, WWR energy use and vehicle fleet all showed declines over this two-year period, while emissions from the other sectors increased. In 2010, facility and WRFs energy use were the major contributors. Electricity was the major form of energy consumed and was responsible for 63 percent of the County Government's 2010 total. County Government emissions represented 1 percent of the total County Regional emissions in 2010.

Tucson Government Operations GHG Emissions Inventory

Total City Government emissions dropped by 4 percent from 2000 to 2010, showing substantial reductions in building energy use and vehicle fleet emissions; employee commuting showed a slight decline. Emissions from waste disposal and water-related energy use, showed increases. Similar to the County Government, electricity use from all sources averaged about 75 percent of the City Government's emissions for the survey years.

Water-related energy use emissions averaged over 50 percent of the City Government's emissions during the 2000 to 2010 period. Energy-related emissions associated with the Central Arizona Project (CAP) water conveyance increased more than 8-fold from 2000 to 2010, reflecting the 7-fold increase in water volume deliveries.

Between 2008 and 2010, City Government emissions rose by 2 percent showing the largest increases in public lighting and employee commuting. Emissions from facility energy use declined and the emissions from other sectors (water energy use, vehicle fleet and waste disposal) showed little change during these two years. From 2008 to 2010, CAP energy-related emissions declined reflecting a 26 percent reduction in water delivery volume. In 2010, emissions from water energy-related energy use were over half of total 2010 City Government emissions. Similar to the County Government, electricity was the major energy source for City operations and was responsible for 73 percent of the 2010 total. City Government emissions represent 3 percent of the City Community total.

Project Objectives

In October 2007, the PAG Regional Council approved a resolution to conduct a GHG emissions inventory for eastern Pima County. The goal of this resolution is to provide a regional, broad-based GHG emissions inventory which provides baseline information on emissions and evaluates the region's overall progress in achieving GHG reductions. This inventory is an update to the last version published in April 2011 (PAG, 2011) and includes 2010 data. The report provides estimates of regional GHG emissions and is not meant to be a precise accounting of emissions. These inventories serve as a resource for future regional planning.

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

This inventory continues to be a useful tool for County and City governments to evaluate their programs and progress toward reducing their GHG emissions. In addition to local governments' actions to reduce GHG emissions, several of PAG's Sustainable Environment's programs also serve to reduce GHG emissions. PAG's rainwater harvesting program works at reducing the demand for potable water for irrigation, and the SunRide Share program promotes the reduction of vehicle travel through alternate transportation modes and carpooling.

These inventories continue to be living documents and can be updated as new and more accurate data become available.

General Methodology

Regional/community and government operations inventories were conducted for the County and the City Community using the Clean Air and Climate Protection (CACCP) model. As designed, the model includes government emissions within the community inventory but provides the option of examining government operations separately for a more detailed analysis of government emissions.

The County Regional inventory includes community and government emissions from Tucson, and nearby cities and towns and tribal areas (Figure 1). The City Community inventory includes emissions generated within the Tucson boundaries. This report follows the same protocol as described in PAG's initial and subsequent Regional GHG Inventories (PAG, 2008, 2011).

The three major greenhouse gases are estimated in the inventories: carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O), and are expressed as carbon dioxide equivalents (CO₂e). Unlike the Arizona and national inventories, hydrofluorocarbons (HFCs) perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆) are not included. Local fluorinated hydrocarbons emissions are expected to represent a very small proportion of the total of all greenhouse gases.

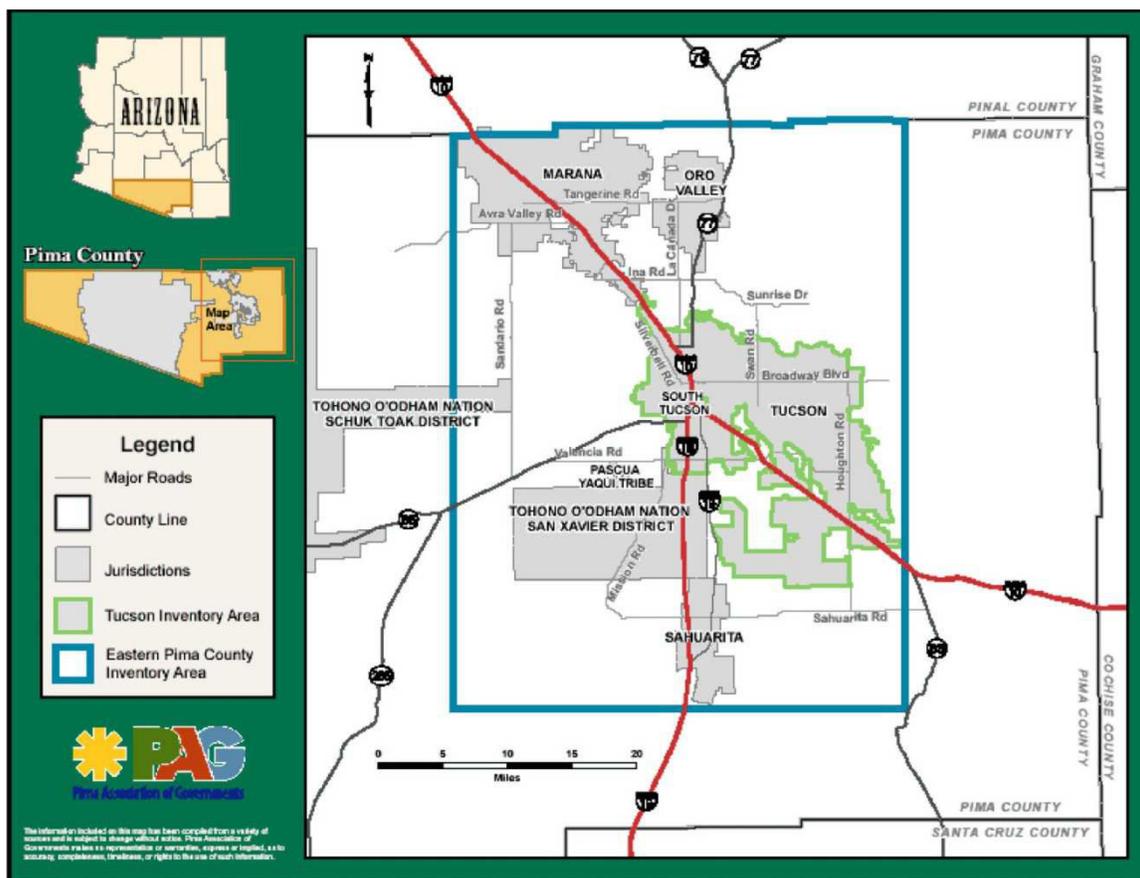
County Regional and City Community Inventories

The regional/community inventories include three major emission sources: energy consumption, transportation and waste disposal. Additional emission sources were presented in the report but are not included in the totals or figures due to the absence of 1990 data. These "other" sources include emissions from local cement production, a closed Tucson

landfill, propane use and stationary diesel use, as well as aviation and locomotive fuel consumption.

The regional/community inventories include emissions from government sources but the CACP model includes the option of examining government operations separately for a more detailed analysis. Separate County and City Government inventories were prepared for 2000, and survey years 2005 through 2010.

Figure 1. Greenhouse Gas Inventory Area



Residential, Commercial and Industrial (RCI) Sector Energy Use

Community Electricity Use

RCI electricity consumption totals for select years between 1990 to 2010 were submitted by Tucson Electric Power Co. (TEP) for eastern Pima County. Annual emission factor data were provided by TEP staff (Appendix C) and were applied to the corresponding annual County Regional consumption data to estimate emissions. TEP electricity use data are aggregated into customer classes based on average annual energy use, not necessarily by customer operations. Therefore, the industrial class may include some large commercial operations, and the commercial class may include some small industrial operations.

TEP staff provided City Community RCI electricity use data for 2002 to 2008 and 2010 only. City residential TEP usage for 1990 and 2000 were estimated using residential hookup data from PAG's Technical Services staff. City commercial and industrial electricity use for 1990 and 2000 were estimated using the proportion of City Community to County Regional use in the 2002

TEP data. As in the County, annual emission factors (Appendix C) were applied to the corresponding annual City Community consumption data to estimate emissions.

The Tohono O'odham Nation purchases its electricity from TEP and its emissions were determined using the annual TEP-supplied electricity coefficients. Electricity use data for 2000, and 2005 through 2010, were supplied by the Tohono O'odham Utility Authority staff.

Trico RCI electricity use information for eastern Pima County for years 1990, 2000 and 2005 to 2008 and 2010 were submitted by Trico staff. Annual electricity emission factors were supplied by Arizona Electric Power Cooperative staff (Appendix C). Electricity for the Pascua Yaqui Tribe is supplied by Trico and is included in the Trico residential and commercial data. Annual emission factors were applied to the use data to estimate emissions for all survey years.

Regional/Community Natural Gas Use

In 2012, Southwest Gas staff identified errors in the historic data they provided previously (RCI: 1990, 2000, and 2005 through 2008). After researching its archival files, Southwest Gas staff determined that revised data were available for 2007 and 2008 only. So care should be taken when making assumptions in comparing earlier use data with 2007 to 2010 data. County Regional RCI 2010 use data were provided for the current inventory by Southwest Gas staff.

Natural gas use by the Tohono O'odham Nation and the Pascua Yaqui Tribe are included in the County Regional totals. Natural gas emissions were estimated using coefficients embedded in the CACP model and were derived from the Department of Energy's Voluntary Greenhouse Gas Emissions Reporting Guidelines <http://www.eia.doe.gov/oiaf/1605/flash/flash.html>.

After discovering similar errors in its previously submitted Tucson Community's 2007 and 2008 data, Southwest Gas staff provided revised data for these years in 2012. Additionally, City Community natural gas use data were provided by SW Gas staff for 2010.

To estimate City Community RCI natural gas data for survey years 1990 through 2006, PAG staff held the revised 2007 City Community to County Regional use proportion constant and applied them to the respective years' County Regional use. Since the 2007 use data were used to estimate 1990, 2000, 2005 and 2006 City Community usage and emissions, the values are different from those previously reported (PAG, 2008, PAG, 2011). Caution should be taken when making assumptions of trends using pre-2007 natural gas use and emissions data. As with the County, City Community natural gas emissions were estimated using coefficients embedded in the CACP model.

TEP's natural gas use was removed from the County Regional and City Community industrial natural gas use volumes for all years. This was done to avoid double counting of the natural gas emissions produced in the generation of electricity (already accounted for in the annual TEP emission factors).

Emissions from natural gas and electric use are based on end-use energy consumption data, not on the emissions resulting from the production of that energy.

On-Road Transportation

Regional/Community Private and Commercial Vehicle Travel

Based on the ICLEI's staff recommendations, the U.S. average CACP model defaults were used to apportion the local private and commercial vehicle mix.¹ Specifically, 93 percent of the vehicles were assumed to be gasoline-powered and 7 percent were assumed to be diesel.

Data were entered as total VMT per year and were distributed by vehicle/fuel type as per the model default mix. Model default fuel economies for each vehicle/fuel combination were used and were based on the Energy Information Administration (EIA) Energy Data book and Tellus Institute research. Default emission factors depend on the type of fuel used and were derived from the Environmental Protection Agency (EPA) data and the International Panel on Climate Change (IPCC) guidelines.

County Regional and City Community transportation data from on-road private and commercial vehicle use were provided by PAG's Technical Services staff for 1990, 2005 through 2008, and 2010, using PAG's travel demand forecasting model.

Estimates for County Regional vehicle miles traveled (VMT) in 1990 were based on model runs conducted that year for transportation planning purposes. The 2000 VMT data were obtained from model runs performed in 2002 for a 2000 On-Road Emissions Inventory (PAG, 2004). In 2012, travel demand modeling was conducted for County private and commercial vehicle travel for 2005, 2008 and 2010, incorporating the most recent employment and socio-economic data (2008) and 2010 census data to estimate annual vehicle miles traveled; 2006 and 2007 County private and commercial VMT data were interpolated using the 2005 and 2008 data. (Appendix D).

In the absence of historic City Community VMT information, PAG Technical Services staff recommended allotting a 49.2 percent share of County Regional VMT to the City Community for 1990 and 2000. This value was based upon a 2005 transportation model analysis. In 2012, travel demand modeling was conducted for City private and commercial vehicle travel for 2005, 2008 and 2010, incorporating the most recent employment and socio-economic data (2008) and 2010 census data to estimate annual vehicle miles traveled; 2006 and 2007 City private and commercial VMT data were interpolated using the 2005 and 2008 data (Appendix G).

Since recent employment, socio-economic and population data were used to update the County Regional and City Community VMT for 2005 through 2008, the travel and emissions data reported in the last report (PAG, 2011) have changed. This report reflects the most current and accurate transportation information available.

Other Transportation

Emissions from on-road public transit vehicle fuel use were calculated for gasoline, diesel, ethanol (E-85), biodiesel (B-20, B-5) and compressed natural gas (CNG). Data are entered as VMT per year for each type of transit vehicle by fuel type. Emissions were calculated using the model default fuel economies for each vehicle/fuel combination.

¹ Model default vehicle mix: **Gasoline:** auto (full size) = 8.5 percent; auto (mid-size) = 18.7 percent; auto (compact/subcompact) = 33 percent; light truck/SUV/pickup = 32.4 percent; motorcycle = 0.4 percent. **Diesel:** auto (compact/subcompact) = 0.3 percent; light truck/SUV/pickup = 1.3 percent; heavy truck = 5.2 percent; bus = 0.2 percent.

County Regional VMT data from Cat Tran, Coyote Run, Old Pueblo Trolley, Sun Shuttle (formally Rural Transit), Special Needs, Sun Tran, Sun Van and the Downtown Loop (formally TICET) are presented for select years during for the survey years between 1990 to 2010, as available. Emissions from all County Regional public transit appear as one total and are referred to as “Other Transportation” in Table 1; VMT from each public transit source are listed in Appendix D.

City Community VMT data from Cat Tran, Old Pueblo Trolley, Sun Shuttle (formally Rural Transit), Special Needs, Sun Tran, Sun Van and the Downtown Loop (formally TICET) are presented for select years from 1990 to 2010, as available. Emissions from all City public transit appear as one total and are referred to as “Other Transportation” in Table 3; VMT from each public transit source are listed in Appendix G.

Solid Waste and Recyclables

Emissions resulting from waste disposal depend on waste composition and the method of treatment. The waste emission factors used in this inventory were from an EPA evaluation contained in the CACP model. Both County Regional and City Community wastes were factored by disposal method and composition using California and Arizona waste characterization studies (Cascadia, 2003; Cascadia, 2004; Cascadia, 2006, 2006a) (Appendix E).

GHG emission and energy reductions, resulting from waste diversion, were estimated using EPA’s Waste Reduction Model Version 11 (WARM) (USEPA, 2010). The model uses a life-cycle approach accounting for emissions avoided in producing replacement materials (upstream) and disposal-related emissions (downstream). Calculations are based on a comparison of the CO₂e emissions and energy use that would be incurred if materials were landfilled and the savings realized through alternative waste management practices (e.g. source reduction, recycling, composting).

Waste Disposal

Waste tonnage from the Ina, Sahuarita, Tangerine and Los Reales landfills for 2000, 2005 through 2008 and 2010 were submitted by County and City staff (Appendix D); 1990 data were available for Los Reales only. County Regional waste totals reflect disposals at all landfills.

Waste totals for Los Reales only (survey years 1990 to 2010) were used to calculate disposal emissions for the City Community inventory (Appendix G).

Diverted (Recycled) Waste

County Regional recycled waste data were obtained from the Catalina, Ina, Sahuarita, Tangerine and Los Reales facilities, all County Regional and City Community collection activities and from private hauler programs for select years between 1990 and 2010, as available.

City Community recycling totals were obtained from Los Reales and all City programs (survey years 1990 through 2010) for the emission analyses.

Other

Locomotive Emissions

All locomotive emissions were allotted to the County Region due to the difficulty in isolating track sections and fuel usage within the City limits. Locomotive yard and line haul fuel use data for 2000 were provided by Envair (2001) and the data survey years from 2005 through

2010 were provided by Union Pacific Railroad (UPRR) staff. EIA's (2009) diesel emissions factors were used to evaluate GHG emissions.

Aviation Fuels: Aviation Gas and Jet A

All aviation fuel emissions were allotted to the County Region due to the difficulty in apportioning County Regional vs. City Community airshed emissions. Aviation gas and Jet A fuel use data were collected from Tucson International Airport (TIA), Ryan Airfield and Marana Airport for survey years 1990 to 2010, as available. Aviation gas totals from La Cholla Airport were provided for the survey years during 1990 to 2010. Davis-Monthan fuel use information was not available for public release.

Based upon other airport GHG studies and TIA staff guidance, only 10 percent of the total aviation fuels from the four airports were used to calculate emissions produced in the County Regional airshed. This 10 percent represents the fuel used during the landings and take-off (LTO) phase. Emissions were calculated using EIA's emission factors (EIA, 2009) for aviation gas and Jet A.

Propane

State propane sale volumes (gallons) for 2000 and 2005, and through 2008 and 2010, were obtained from the Arizona Department of Commerce, Energy Office, petroleum sales reports (Arizona Department of Commerce, 2012).

As suggested by the Arizona Department of Commerce, Energy Office staff, County Regional and City Community sales were allocated using annual population data and GHG emissions were estimated using the CACP model's propane emission factor (0.006 metric tons CO₂/gallon).

Industrial Processes

Arizona Portland Cement

Arizona Portland Cement (APC) participated in the Department of Energy's (DOE) EIA's 1605(b) Program, a voluntary GHG reporting system. The 2000 through 2008 APC emissions data reflect APC's submittals to DOE. APC staff provided the EIA reported emissions from cement production and onsite, non-transportation associated, fuel combustion for 2000, and 2005 through 2008. As is customary for GHG reporting by cement producers, emissions from the use of fuel in blasting operations are excluded from the total, since this work is performed by a contractor.

In 2009, the EPA promulgated a rule requiring large GHG generating sources (producing at least 25,000 metric tons CO₂e/year) to report their annual emissions. The deadline for reporting 2010 emissions was September 2011. The APC 2010 information represents emission data accessed from this mandatory reporting program. APC's process emissions are associated with cement production, and fuel emissions represent non-road vehicle and stationary combustion use (USEPA, 2012b).

Freeport McMoRan (formally Phelps Dodge Sierrita Mine)

ADEQ staff provided Freeport McMoRan's diesel use for 2000, and 2005 through 2007; Freeport McMoRan staff provided the 2008 and 2010 diesel use data (Appendix D). The CACP diesel emission factor (9.51 kg CO₂/gallon) was used to estimate GHG emissions for all years.

Harrison Landfill

As a result of EPA's new GHG reporting rule, 2010 emissions data from the City's Harrison Landfill is now available (USEPA, 2012b). This landfill accepted waste from 1972 until its closing in 1997. The data represents 2010 emissions from the wastes disposed during its 25 years in operation.

Government Operations Inventories

The regional/community inventories include emissions from government sources but the CACP model includes the option of examining government operations separately for a more detailed analysis. Separate County and City Government inventories were prepared for 2000, and select survey years from 2005 through 2010. Each government operations' inventory includes emissions from energy consumption, on-road vehicle use and waste generation. Electricity emissions represent use in government facilities, water pumping, distribution and treatment, and public lighting. Natural gas emissions represent use in government facilities, water pumping, distribution and treatment. On-road vehicle emissions are from government fleet travel and employee commuting. Waste emissions represent those from disposal of waste generated by government operations only.

Data from 2000 and survey years 2005 through 2010 were compiled and analyzed using the CACP software, as in the community inventories. Additionally, cost data for each category were compiled for all survey years.

Government Facility Energy Use

As in the community inventories, annual TEP and Trico emission factors were used to estimate government emissions from electricity use (Appendix C); natural gas emissions were estimated using the model's embedded emission factor.

Because County Government facility energy use data for 2000 and survey years 2005 through 2010 were not available, County staff provided total electricity and natural gas expenditures for the survey years. Facility energy usage was determined using information from the County's WRFs usage and expenditure data for each survey year (cost/MMBtu). Electricity and natural gas usage and expenditures for the combined County Government facilities are shown in Appendix H.

TEP electricity and natural gas use and expenditures data for individual facilities were provided by City Government staff for 2000, and survey years 2005 through 2010. Data were sorted and compiled by year and department; utility costs were similarly compiled. A more detailed list of energy use and expenditures by department is found in Appendix I.

In 2012, City staff provided energy use data for 11 additional buildings (2005, 2006, 2007, 2008 and 2010) which they inadvertently omitted from the data they provided in previous inventories. The emissions, energy use and cost are included for completeness (Appendix J) but were not incorporated into the City Government totals since 2000 data for these 11 facilities were not available.

Government Water-Related Energy Use

Wastewater Reclamation Facilities

The County Government is responsible for treating most wastewater in the eastern portion of Pima County.² Total TEP electricity and natural gas use and expenditures for the combined 11 facilities for 2000, and survey years 2005 through 2010 were submitted by County staff (Appendix H).

² The County's Regional Wastewater Reclamation Department (PCRWRD) operates three metropolitan facilities (Ina Road, Roger Road and Randolph Park) and several sub-regional facilities (Arivaca Junction, Avra Valley, Corona de Tucson, Pima County Fairgrounds, Green Valley, Marana, Mount Lemmon and Rillito Vista) (PCRWRD, 2012).

Potable Water System

Tucson Water is responsible for the pumping, treatment and delivery of potable water to the majority of eastern Pima County. TEP and Trico electricity and natural gas use and expenditures for all Tucson Water (TW) potable operations were submitted by TW staff for 2000, and survey years 2005 through 2010.

A detailed list of TEP electricity and natural gas consumption and expenditures and total Trico electricity use for the potable system are found in Appendix I.

Reclaimed Water System

Tucson Water distributes reclaimed water to approximately 800 sites in Pima County (Tucson Water, 2011). TEP and Trico electricity use and expenditures for TW's reclaimed operations were submitted by TW staff for 2000, and survey years 2005 through 2010.

Public Lighting

Total energy use and expenditure data for public lighting (combined street and traffic lights) were submitted by County Government staff for 2007 and 2010. Due to lack of historic information, all 2007 data were used for 2000, 2005 and 2006. County staff approximated 2008 energy use and expenditures to be 5 percent higher than the 2007 values, with solar use remaining unchanged from the 2007 value.

Streetlight and traffic light TEP electricity use and expenditures were provided by City staff for 2007, 2008 and 2010. Due to lack of historic information, the 2007 data were used for 2000, 2005 and 2006.

Government On-road Vehicle Use

On-road vehicle use included travel by government fleets and employee commuting and was disaggregated by vehicle and fuel type. Model default fuel economies for each vehicle/fuel combination were used and were based on the EIA Energy Data book and Tellus Institute research. Default emission factors depend on the type of fuel used and were derived from EPA data and the IPCC guidelines.

Government Fleets

County Government staff provided VMT and expenditure data by vehicle and fuel type for fiscal years 2000, and survey years 2005 through 2010. VMT and cost information for fiscal year 2006 were interpolated using the FY2005 and FY2007 data.

Due to lack of City Government VMT data for 2000, fleet emissions were approximated using gasoline and diesel use. Fuel usage for 2000 was estimated by subtracting the average rate of increase in fleet fuel use and cost from 2001 to 2005 from the 2001 data. City staff provided fleet fuel costs and VMT segregated by fuel and vehicle type for 2005 through 2008. As recommended by City Government staff, the 2008 vehicle fleet composition was used to estimate emissions for 2000, and 2005 through 2008.³

³ 2008 City fleet composition: **Gasoline** - Auto: full-size (32 percent); Auto: mid-size (30 percent); Heavy truck (8 percent); Light truck (5 percent); Motorcycle (5 percent). **Diesel** - Heavy truck (19 percent); Bus (1 percent).

City staff was not able to provide complete 2010 VMT data for all fleet vehicles. As a result, City staff recommended that 2010 VMT data for CNG, E-85 fueled vehicles and 2008 gasoline and diesel fleet VMT data be used for the 2010 inventory.

Employee Commute

The Travel Reduction Program (TRP) started in 1989 to reduce carbon monoxide levels and traffic congestion in the Tucson metropolitan area. From 1989 through 2005 and in 2007, employee surveys were conducted and included all of the region's largest employers. Starting in 2010, and in subsequent years, 25 percent of the employers complete the survey on a rotating basis.

As recommended by ICLEI staff, a model default vehicle mix was used to characterize County and City employees' commuting patterns.⁴

County employees' weekly drive-alone, one-way VMT survey data were used to calculate annual round-trip miles for 2000, 2005, 2007 and 2010. County Government commuter data for 2006 was interpolated using 2005 and 2007 data and 2008 data was interpolated using 2007 and 2010 survey data.

City employees' weekly drive-alone, one-way VMT survey data were used to calculate annual round-trip VMT for 2000, 2005, 2007 and 2011. (City employees were not scheduled to complete the survey in 2010). City Government commuter data for 2006 data was interpolated using 2005 and 2007 data and 2008 VMT was interpolated using 2007 and 2011 survey data.

Government Solid Waste Generation

Government-generated waste data were collected and factored by disposal method and characterized using data from a 1993 Tucson government waste study (Hughes, et al, 1993) (Appendix E).

County staff submitted waste data for 2007, 2008 and 2010; earlier years' data were not available. Based upon County staff recommendations, the 2007 totals were used for 2000 and 2005 and 2006.

City staff provided government-generated solid waste totals for 1993 and 2007, 2008 and 2010. Waste data for 2000, 2005 and 2006 were interpolated using the 1993 and 2007 totals. Specifically, a 3.5 percent decrease per year was applied to the 2007 total and progressively to each preceding year to estimate historic waste totals.

Other

Central Arizona Project (CAP) Water Pumping Energy Use

Emissions from the electricity used in the delivery of water from the CAP to TW facilities, listed as "Other" were included for 2000, and survey years 2005 through 2008 and 2010 (Appendix I, Table 6). CAP energy use emissions were excluded from the City Government totals to preserve the relationship between City Community and City Government emissions. CAP emissions were not included in the City Community emissions (1990 to 2010) since CAP water delivery did not start until 1992.

⁴ Commuter vehicle fleet mix: **Gasoline** - Auto: full-size/SUV/Pickup (36.4 percent); Auto: mid-size (18.8 percent) Auto: compact/subcompact (44.8 percent).

To estimate electricity use, data from individual pumping stations were used to compute the energy needed to deliver an acre-foot⁵ (AF) of water to every location used by TW (Philbin, A. personal communication with CAP staff, 2009). 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) (Appendix I). CAP water deliveries for 2000, and survey years 2005 through 2008 and 2010 for each facility were obtained from CAP Water Use Accounting Reports. CAP expenditures were calculated using the cost per AF⁶ and the total volume of water delivered to TW.

Location-Specific Results

Eastern Pima County Regional Inventory

Residential, Commercial and Industrial (RCI) Sectors Energy Use

The residential sector evaluation is based on household energy use for activities such as heating, cooling and lighting. The commercial sector encompasses electricity and natural gas used in non-residential buildings such as schools, hospitals, retail, institutional and government-owned facilities. The industrial sector includes energy used in mining and agriculture and includes manufacturing and factory operations. Energy use emissions include electricity and natural gas use only.

From 1990 to 2010, total RCI energy-related emissions rose by 49 percent. The residential (77 percent) and commercial sectors (63 percent) energy use emissions had the largest upsurge, while the industrial emissions experienced a more modest increase (13 percent) (Table 1). Electricity averages about 90 percent of RCI total emissions over the survey years; estimated natural gas use emissions averaged about 10 percent over this period.

From 2008 to 2010, RCI emissions decreased 6 percent, primarily due to the drop in natural gas use. Combined RCI energy use was responsible for 67 percent of total County Regional emissions in 2010 (Figure 4). In 2010, electricity was the major source of regional GHG emissions.

Residential Energy Use

From 1990 to 2010, residential electricity-related emissions almost doubled while estimated natural gas use increased by 9 percent. From 2008 to 2010, residential energy use emission remained relatively unchanged. Residential energy use is a major contributor to County Regional emissions, contributing 29 percent to the 2010 total (Figure 4).

Commercial Energy Use

Commercial energy use emissions grew by 63 percent from 1990 to 2010 (Table 1). Commercial natural gas use emissions exhibited a 31 percent increase and electricity use experienced a larger, 71 percent increase over these 20 years.

⁵ An acre-foot (AF) equals 325,851 gallons, approximately the amount of water used by a family of four for one year

⁶ Cost per AF of water: **2000**: \$54.00/AF; incentive water: \$44.00/AF; **2005**: \$85.00/AF; 2006: \$85.00; **2007**: \$87.00/AF; **2008**: \$91.00/AF; **2010**: \$118/AF; <http://www.cap-az.com/Portals/1/Skins/cap/files/5-b-ii-Revised-Rate-Schedule-Combined.pdf>.

Figure 2. Comparison of Eastern Pima County Regional GHG Emissions by Sector 1990, 2008 and 2010

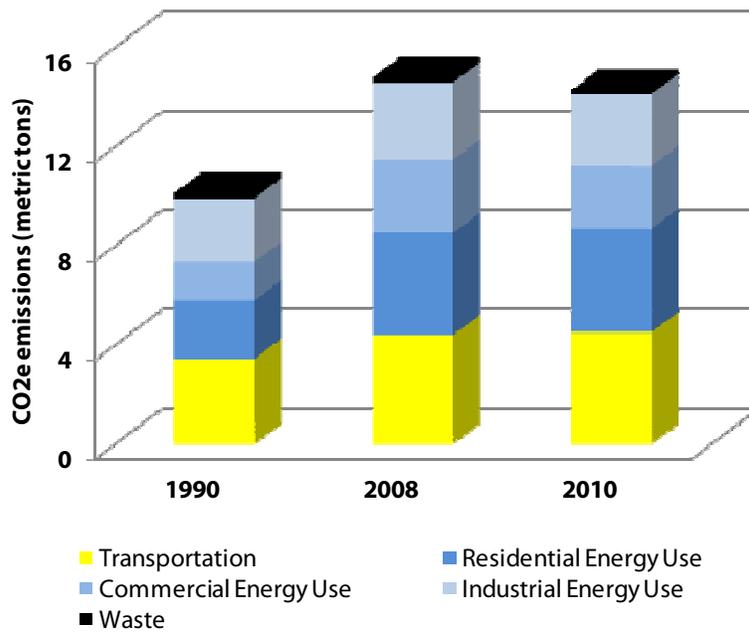
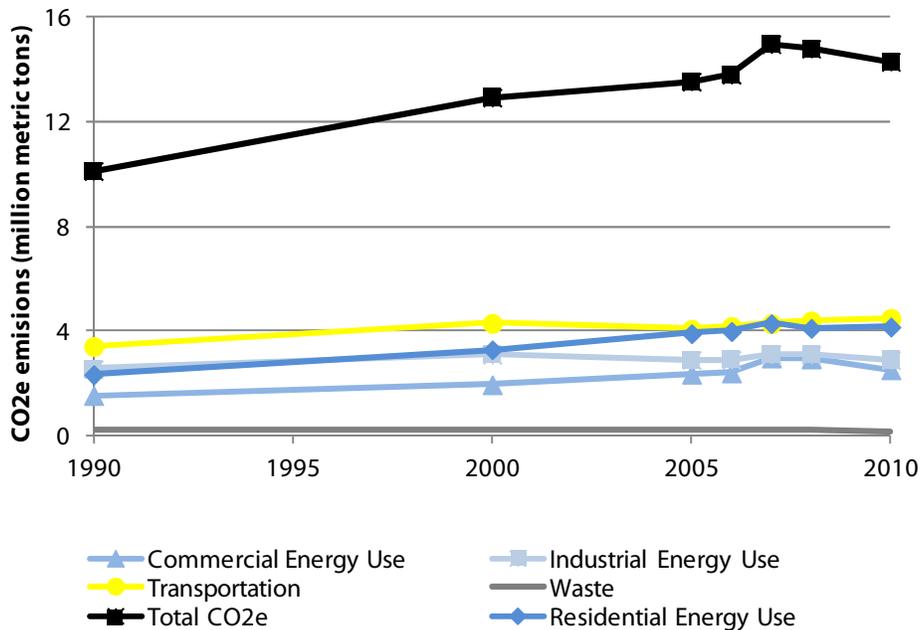


Figure 3. Eastern Pima County Regional GHG Emissions 1990 to 2010



Industrial Energy Use

Over the 20-year survey period, industrial natural gas emissions declined by 42 percent. From 2008 to 2010, a 69 percent drop in industrial natural gas use/emissions occurred. SW Gas staff indicated that several of its larger customers switched to a different natural gas provider.

On-road Transportation

It wasn't until 2000 that essentially all of the County's public transportation systems were operational. Therefore, comparing emissions from 2000 to 2010, would more accurately present a comprehensive assessment of transportation emission trends. From 2000 to 2010, total VMT from all sources increased by 12 percent and transportation emissions increased by 4 percent (Table 1).

From 2008 to 2010, total transportation emissions increased by 2 percent, with an associated 3 percent rise in total VMT.

Transportation-related emissions were responsible for 32 percent of 2010 emissions (Figure 4). Gasoline was the major fuel used in the region and was responsible for 26 percent of all 2010 emissions, with diesel use contributing 5 percent (Figure 5).

Private and Commercial Vehicle Travel

From 1990 to 2010, travel by private and commercial vehicles increased by 60 percent, resulting in a 31 percent increase in emissions. Private and commercial vehicle use was responsible for essentially all of transportation-related emissions over the survey period (Table 1).

From 2008 to 2010, County Regional private and commercial vehicle travel and emissions increased by 3 percent and 2 percent, respectively.

Other Transportation

From 2000 to 2010, County Regional public transit emissions increased by 22 percent, while VMT increased by 40 percent over this 10 years.

From 2008 to 2010, public transportation VMT increased by 8 percent with GHG emissions increasing by 27 percent. This increase may be explained by several factors. Most of the public transit carriers showed VMT increases from 2008 to 2010. Sun Shuttle doubled its VMT, Special Needs increased travel by 26 percent, additionally Sun Tran and Sun Van experienced modest increases in their VMT, 5 percent and 6 percent, respectively. In addition to the increase in transit VMT, fuel use choice impacts emissions. Sun Shuttle and Sun Van both increased the proportion of miles driven by diesel-fueled vehicles and Sun Tran switched from B-20 to B-5 in 2010, which produces more GHG emissions per gallon than B-20.⁷

⁷ The emissions factor for B-5 is 20 percent higher than the emissions factor for B-20.

Table 1. Eastern Pima County Regional GHG Emissions (metric tons CO₂e) and Energy Consumption (million Btu) 1990 to 2010

	1990		2000		2005		2006		2007		2008		2010		Percent Change 1990-2010
	CO ₂ e (metric tons)	MMBtu	CO ₂ e (metric tons)	MMBtu	CO ₂ e (metric tons)	MMBtu	CO ₂ e (metric tons)	MMBtu	CO ₂ e (metric tons)	MMBtu	CO ₂ e (metric tons)	MMBtu	CO ₂ e (metric tons)	MMBtu	
Residential Energy Use															
Natural Gas	451,025	8,047,134	503,455	8,982,587	469,901	8,383,912	459,469	8,197,794	495,455	8,839,854	494,699	8,826,367	490,324	8,748,310	
Electricity	1,901,924	7,373,084	2,801,674	11,114,183	3,446,426	13,439,430	3,542,602	14,024,024	3,804,655	14,929,776	3,625,126	14,449,183	3,681,548	14,282,650	
Residential Total	2,352,949	15,420,218	3,305,129	20,096,770	3,916,327	21,823,342	4,002,071	22,221,818	4,300,110	23,769,630	4,119,825	23,275,550	4,171,872	23,030,960	77
Commercial Energy Use															
Natural Gas	319,789	5,705,634	347,013	6,191,368	330,103	5,889,666	337,429	6,020,365	781,941	13,951,304	781,728	13,947,500	418,054	7,458,871	
Electricity	1,235,612	4,787,865	1,617,714	6,413,811	2,036,099	7,822,904	2,080,283	8,245,709	2,202,813	8,638,002	2,173,019	8,603,070	2,116,972	8,216,800	
Commercial Total	1,555,401	10,493,499	1,964,727	12,605,179	2,366,202	13,712,570	2,417,712	14,266,074	2,984,754	22,589,306	2,954,747	22,550,570	2,535,026	15,675,671	63
Industrial Energy Use															
Natural Gas	109,298	1,950,082	99,020	1,766,703	146,822	2,619,585	128,413	2,291,125	216,922	3,870,298	204,628	3,650,952	62,878	1,121,855	
Electricity	2,454,013	9,517,092	3,009,036	11,924,148	2,768,660	10,835,382	2,792,468	11,127,712	2,901,334	11,433,643	2,900,434	11,557,057	2,844,307	11,055,133	
Industrial Total	2,563,311	11,467,174	3,108,056	13,690,851	2,915,482	13,454,967	2,920,881	13,418,837	3,118,256	15,303,941	3,105,062	15,208,009	2,907,185	12,176,988	13
Transportation															
Private & commercial vehicle use ⁸	3,415,256	43,660,650	4,298,737	55,000,983	4,070,036	52,299,108	4,175,495	53,684,496	4,285,562	55,123,233	4,389,323	56,474,809	4,486,221	57,740,354	31
Other Transportation	14,540	185,018	14,673	195,283	13,534	195,307	15,475	229,200	13,708	218,069	14,044	223,461	17,858	253,904	
Transportation Total	3,429,796	43,845,668	4,313,410	55,196,266	4,083,570	52,494,415	4,190,970	53,913,696	4,299,270	55,341,302	4,403,367	56,698,270	4,504,079	57,994,258	
Waste Disposal Total ⁹	224,689		238,610		258,024		274,245		262,752		214,027		175,006		
Total	10,126,146	81,226,559	12,929,932	101,589,066	13,539,605	101,485,294	13,805,879	103,820,425	14,965,142	117,004,179	14,797,028	117,732,399	14,293,168	108,877,877	41
Other															
Locomotives ¹⁰	n.a.	n.a.	89,632	1,216,198	84,657	1,148,674	86,620	1,175,733	90,343	1,225,840	89,032	1,208,034	75,713	1,026,892	
Aviation Gas ¹¹	84	1,190	475	6,717	510	6,279	520	7,363	853	12,073	467	6,611	347	4,539	
Jet A ¹¹	38,682	540,000	31,415	438,534	35,569	496,555	33,859	472,723	39,379	549,702	39,223	547,561	30,805	430,620	
Propane	n.a.	n.a.	86,242	1,282,001	92,717	1,378,254	84,343	1,253,772	91,431	1,359,141	88,710	1,318,687	67,393	1,001,818	
Harrison Landfill	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	28,081	n.a.	
Other Total			207,764	2,943,450	213,453	3,029,763	205,342	2,909,591	222,006	3,146,756	217,432	3,080,893	202,339	2,463,869	
Industrial Processes	n.a.	n.a.													
AZ Portland Cement (process)			645,956	0	740,823	0	615,937	0	681,032	0	508,336	0	358,935	n.a.	
AZ Portland Cement (fuel)			450,056	n.a.	504,533	n.a.	574,360	n.a.	544,640	n.a.	364,586	n.a.	239,408		
Freeport-McMoRan (fuel)			2,400	33,364	2,021	28,089	1,911	26,567	2,202	30,604	2,806	39,004	2,365	32,874	
Industrial Processes Total			1,098,412	33,364	1,247,377	28,089	1,192,208	26,567	1,227,874	30,604	875,728	39,004	600,708	32,874	

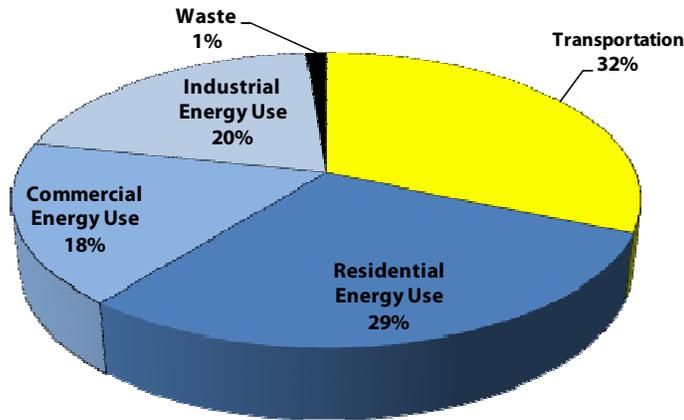
⁸ Private and commercial VMT for 1990 and 2000 were estimated using a different PAG transportation model than the model used for 2005 through 2010

⁹ Waste disposal information for 1990 is from Los Reales only; 2000 through 2010 waste data represents all Pima County landfills

¹⁰ 2000 locomotive fuel use data are taken from the *Emissions Inventories for the Tucson Planning Area*. Envair, 2001; fuel data from 2005 to 2008 and 2010 data were supplied by UPRR staff

¹¹ Aviation gasoline total for 1990 reflects Ryan Airfield and La Cholla use; 1990 Jet A totals represents TIA use only; 2000 through 2010 data represents the County Region's four airports' use

Figure 4. 2010 Eastern Pima County Regional GHG Emissions by Sector



Waste and Recyclables

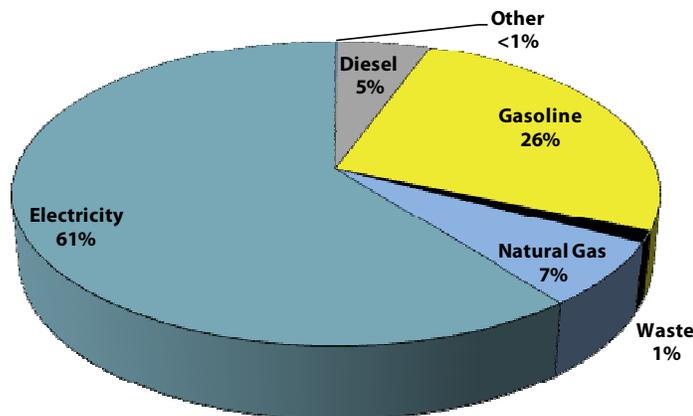
Waste

From 2000 to 2010, waste totals dropped by 22 percent which was reflected in the 27 percent drop in emissions.

Recent trend in waste disposal totals (2008 to 2010) showed an 18 percent decline. This trend could be a result of increased recycling throughout the region (Table 2), and could be linked to the economic downturn where residents tend to limit their consumption of disposable items (Hughes, W. Personal communication, 2009).

Wastes continued to be a minor source of County Regional emissions, contributing about 1 percent to the 2010 total (Figure 4).

Figure 5. 2010 Eastern Pima County Regional GHG Emissions by Source



Other- CNG and Biodiesel

Recyclables

County Regional recycling activities from 1990 to 2010 lack a clear pattern due to the inconsistency in the 1990 and 2000 data. Consequently, these historic emissions and energy savings cannot be compared with the more recent data which include comprehensive information from County Regional and City Community recycling programs. However from 2008 to 2010, there was a 13 percent increase in tonnage, resulting in a 3 percent increase in GHG emission savings.

Table 2. Summary of County Recycled Waste Activity and Emissions and Energy Savings 1990 to 2010

All Pima County Facilities and Collection ¹²	Recycled Waste (metric tons)	CO ₂ e Saved (metric tons)	MMBtus Saved
1990	51,710	255,792	1,004,291
2000	30,744	50,984	505,703
2005	86,157	196,986	1,545,956
2006	97,183	259,791	2,174,543
2007	95,097	255,578	2,202,797
2008	72,577	175,444	1,513,218
2010	81,944	180,735	1,304,111

Shading: Indicates incomplete data

Other

Locomotive Emissions

From 2000 to 2010, locomotive emissions declined by 14 percent from 2000 to 2010 (Table 1). Much of this decline occurred between 2008 and 2010.

Aviation Fuels: Aviation Gasoline and Jet A

Aviation gasoline emissions vary by year depending on travel demand. From 2000 to 2010, emissions declined by 27 percent (Table 1), showing a steady downward trend from the peak in 2007.

Jet A emissions remained relatively constant from 2000 to 2010, dropping about 2 percent over the 10 years. However, from 2008 to 2010, GHG emissions dropped by 21 percent. Tucson International Airport staff attributes these recent declines in aviation fuels' consumption/emissions to the economic downturn.

Propane

County Regional propane emissions exhibited a somewhat erratic pattern over the 2000 to 2010 period but overall County Regional emissions declined by 22 percent. A similar decline occurred from 2008 to 2010.

¹² 1990 data represents only voluntary drop-offs at Los Reales; 2000 data represents limited City curbside pickups and drop-offs; 2005 through 2010 data represents comprehensive pick-up service, commercial collections and voluntary drop-offs.

Industrial Processes

Arizona Portland Cement (APC) [CalPortlandCement]

Cement production emissions fell by 44 percent from 2000 to 2010, largely due to the 29 percent decline that occurred between 2008 and 2010 (Table 1). This trend reflects Arizona's cement consumption which dropped significantly from 2008 to 2010 (Portland Cement Association, (PCA) 2011). This same downward pattern occurred nationally and was linked initially to the mortgage foreclosure crisis and decreased residential construction. However, according to the PCA, the continued decline in cement consumption can be attributed to the collapse of the U.S. banking system, leading to construction spending declines for nonresidential and public construction (PCA, 2009).

From 2000 to 2010, APC fuel combustion emissions decreased by 47 percent largely due to the 34 percent drop in emissions from 2008 to 2010, most probably linked to the reduction in cement production.

Freeport McMoRan Sierrita Mine (formally Phelps Dodge)

From 2000 to 2010, diesel emissions declined slightly (1 percent) but from 2008 to 2010, emissions dropped significantly (15 percent).

Eastern Pima County Regional Synopsis

County Regional GHG emissions rose by 4.2 million metric tons from 1990 to 2010, representing a 41 percent increase. Energy use by the RCI sectors is the largest generator of County Regional GHG emissions over the entire survey period. Residential and commercial energy use emissions have shown the largest rate of growth over these 20 years, 77 percent and 63 percent, respectively, while industrial energy emissions increased by 13 percent. In 2010, RCI energy emissions were responsible for 67 percent of the County Region's total emissions.

Electricity is the major source of energy and averaged approximately 58 percent of total emissions across all survey years. In 2010, electricity was responsible for 61 percent of County Regional emissions, while natural gas use contributed 7 percent to the County Region's total.

On-road vehicle travel produced a large portion of the County Regional's emissions. From 1990 to 2010, private and commercial VMT increased by 60 percent which can essentially accounts for all of all of transportation emissions. In 2010, transportation emissions contributed 32 percent to the County Region's total.

Waste-related emissions continue to be a minor source of community emissions; in 2010 waste disposal accounted for 1 percent of the County Region's emissions.

Tucson Community Inventory

Residential Commercial and Industrial (RCI) Sectors Energy Use

From 1990 to 2010, total City Community RCI energy-related emissions rose by 35 percent. The commercial and residential sectors had the largest upsurge during this period, 67 percent and 38 percent, respectively, while industrial energy emissions had no net gain over this 20-year period. Combined RCI energy use was responsible for 68 percent of the City Community's emissions in 2010 (Figure 8). In 2010, RCI electricity use contributed 59 percent to the City Community total and natural gas use was responsible for 9 percent. The combined 2010 RCI emissions were virtually unchanged from the RCI 2008 emissions (Table 3).

Residential

From 1990 to 2010, City's residential electricity use emissions grew by 49 percent, while natural gas use exhibited a 3 percent increase. Over the 2008 to 2010 period, electricity related emissions rose by 8 percent, while natural gas use emissions declined by 5 percent. In 2010, total residential energy use was responsible for 30 percent of the City Community's total emissions (Figure 8).

Commercial

From 1990 to 2010, commercial electricity use emissions grew by 62 percent and natural gas emissions are estimated to have doubled. From 2008 to 2010, emissions from commercial electricity use increased by 2 percent while natural gas use decreased by 24 percent. In 2010, commercial energy use was responsible for 23 percent of the City Community's emissions (Figure 8).

Industrial

From 1990 to 2010, industrial electricity use emissions grew by 3 percent while natural gas use emissions declined by 82 percent. From 2008 to 2010 emissions from industrial electricity use declined slightly (1 percent) while natural gas use dropped by 88 percent. SW Gas staff indicated that several of its larger customers switched to a different natural gas provider. In 2010, total industrial energy use was responsible for 15 percent of the City Community's emissions (Figure 8).

Figure 6. Comparison of Tucson GHG Emissions by Sector 1990, 2008 and 2010

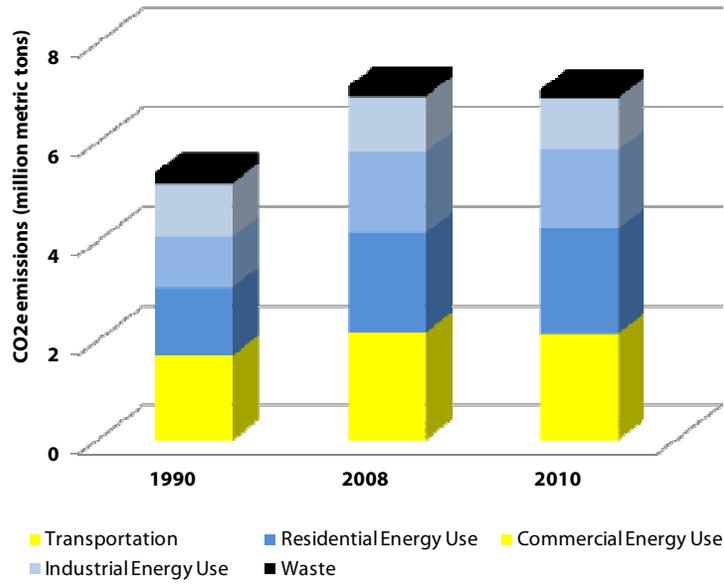
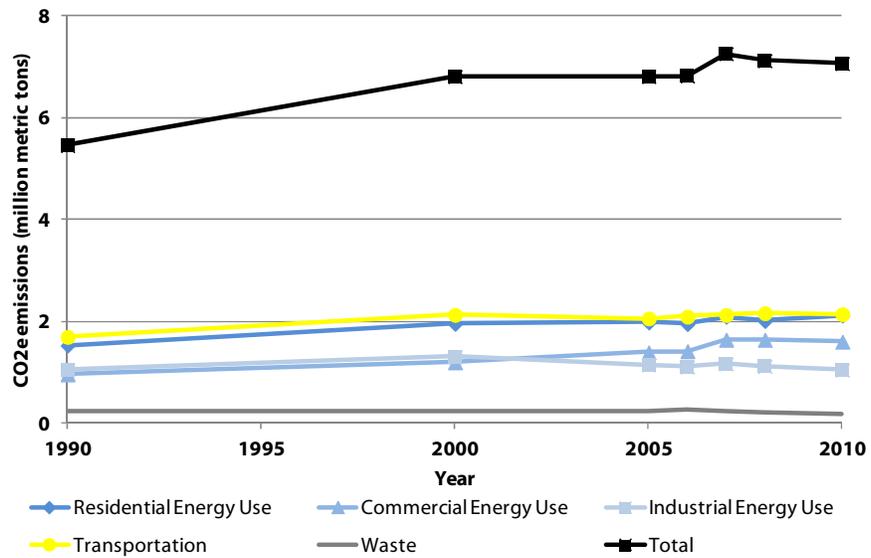


Figure 7. Tucson GHG Emissions 1990 to 2010



On-road Transportation

Starting in 2000, when all City public transit were operational, and comparing the data with 2010, transportation emissions dropped by less than 1 percent. From 2008 to 2010, transportation emissions also showed a slight decline (1 percent). In 2010, transportation emissions were responsible for 30 percent of City Community emissions (Figure 8) and gasoline was the major fuel consumed (Figure 9).

Private and Commercial Vehicle Travel

From 1990 to 2010, VMT by private and commercial vehicles increased by 54 percent, resulting in a 26 percent increase in these GHG emissions (Table 3). For all survey years, private and commercial vehicle use was responsible for essentially all of transportation-related emissions (99 percent).

Over the 2008 to 2010 period, City Community private and commercial vehicle emissions declined slightly (1 percent).

Other Transportation

From 2000 to 2010, VMT from City public transit increased by 28 percent with a 15 percent increase in emissions.¹³ This relatively small emission increase as compared to the VMT increase might be explained by the gradual shift from traditional fuels (diesel and gasoline) which average more GHG emissions/gallon to fuels which generally produce less CO₂ emissions per unit volume (CNG, B-20, and E85).

However, from 2008 to 2010, public transit VMT increased by 1 percent with an associated 24 percent increase in GHG emissions (Appendix G). This disproportionate increase in emissions relative to the VMT growth could be attributed to a combination of factors: 50 percent more miles were driven by diesel-fueled vehicles in 2010 than in 2008, and Sun Tran diesel buses used B-5 instead of the B-20 used in 2008.¹⁴

¹³ All seven City public transportation services were not functional until 2000.

¹⁴ B-5 has a 20 percent greater CO₂ emission factor per gallon than B-20.

Table 3. Tucson Community GHG Emissions (metric tons CO₂e) and Energy Consumption (million Btu) 1990 to 2010

	1990		2000		2005		2006		2007		2008		2010		Percent Change 1990-2010
	CO ₂ e (metric tons)	MMBtu													
Residential Energy Use															
Natural Gas ¹⁵	367,153	6,550,699	409,833	7,312,195	382,518	684,849	374,027	6,673,342	403,321	7,196,005	399,675	7,130,962	379,203	6,765,705	
Electricity ¹⁶	1,159,530	4,485,563	1,541,177	6,103,652	1,596,105	6,250,003	1,571,870	6,253,955	1,683,662	6,638,158	1,607,768	6,409,357	1,732,853	6,736,512	
Residential Total	1,526,683	11,036,262	1,951,010	13,415,847	1,978,623	6,934,852	1,945,897	12,927,297	2,086,983	13,834,163	2,007,443	13,540,319	2,112,056	13,502,217	38
Commercial Energy Use															
Natural Gas ¹⁵	114,688	2,046,250	124,452	2,220,452	118,387	2,112,251	121,014	2,159,124	280,433	5,003,451	305,887	5,457,603	232,754	4,152,764	
Electricity ¹⁷	844,324	3,266,212	1,071,749	4,244,539	1,272,901	4,984,404	1,293,813	5,147,660	1,356,546	5,348,442	1,332,215	5,310,869	1,364,828	5,305,807	
Commercial Total	959,012	5,312,462	1,196,201	6,464,991	1,391,288	7,096,655	1,414,827	7,306,784	1,636,979	10,351,893	1,638,102	10,768,472	1,597,582	9,458,571	67
Industrial Energy Use															
Natural Gas ¹⁵	44,016	785,327	39,877	711,478	59,128	1,054,947	51,714	922,671	87,358	1,558,628	66,405	1,184,787	7,770	138,623	
Electricity ¹⁷	1,002,743	3,879,044	1,263,460	5,003,788	1,086,654	4,255,102	1,053,015	4,189,603	1,074,612	4,236,863	1,048,439	4,179,595	1,034,337	4,021,012	
Industrial Total	1,046,759	4,664,371	1,303,337	5,715,266	1,145,782	5,310,049	1,104,729	5,112,274	1,161,970	5,795,491	1,114,844	5,364,382	1,042,107	4,159,635	-0.4
Transportation															
Private/commercial vehicle use ¹⁸	1,680,306	21,481,039	2,114,978	27,060,478	2,045,755	26,287,516	2,078,924	26,728,799	2,113,555	27,185,700	2,147,399	27,629,302	2,125,238	27,353,089	26
Other Transportation	14,314	182,115	13,183	175,554	11,822	171,037	13,658	203,107	11,947	191,884	12,235	196,620	15,146	217,093	
Transportation Total	1,694,620	21,663,154	2,128,161	27,236,032	2,057,577	26,458,553	2,092,582	26,931,906	2,125,502	27,377,584	2,159,634	27,825,922	2,140,384	27,570,182	
Waste Disposal Total	224,689		227,483		237,108		259,163		242,932		199,045		172,140		-23
	0.041214007		0.033422948		0.034815689		0.038016059		0.0334877		0.02795942		0.0243677		
Total	5,451,763	42,676,249	6,806,192	52,832,136	6,810,378	45,800,109	6,817,198	52,278,261	7,254,366	57,359,131	7,119,068	57,499,095	7,064,269	54,690,605	30
Other															
Propane	n.a.	n.a.	51,535	766,081	53,135	789,868	47,609	707,720	51,090	759,456	49,289	762,831	36,988	549,839	
Harrison Landfill	n.a.	n.a.	28,081												

0 – no use; n.a. – data not available

¹⁵ The ratio of Tucson: Eastern Pima County Regional natural gas use is assumed to be constant from 1990 through 2006 and is based on 2007 Tucson use data supplied by Southwest Gas; 2008 and 2010 natural gas use data were supplied by Southwest Gas staff

¹⁶ Tucson residential energy use for 1990 and 2000 are based on PAG's Technical Services Division historical data on the number of estimated TEP hookups

¹⁷ The ratio of Tucson: Eastern Pima County Regional commercial and industrial electricity use for 1990 and 2000 is assumed to be the same as that of 2002 City Community use from data supplied by TEP

¹⁸ Private and commercial VMT from 1990 and 2000 were estimated using a different PAG transportation model than the model used for 2005 through 2010

Figure 8. 2010 Tucson Community GHG Emissions by Sector

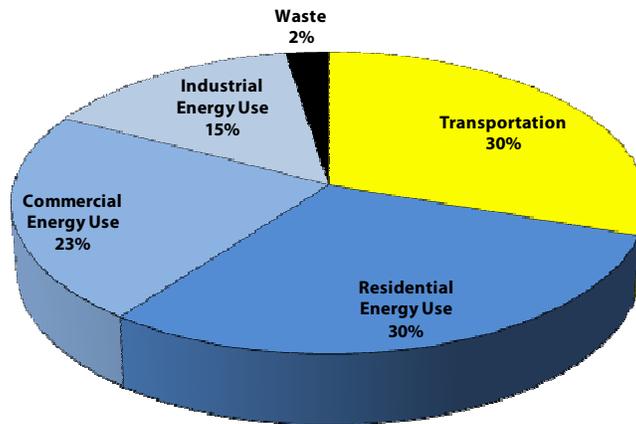
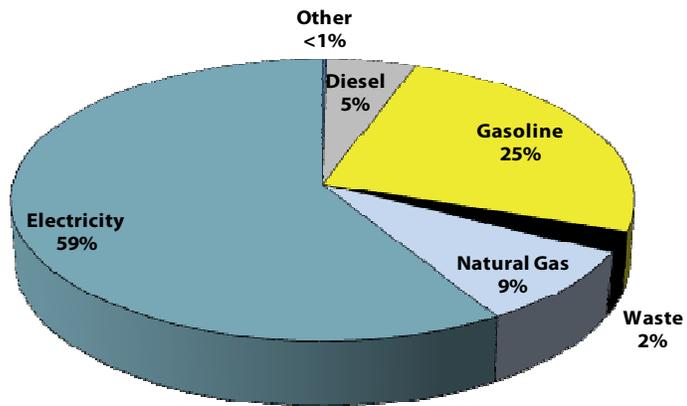


Figure 9. 2010 Tucson Community GHG Emissions by Source



Other- CNG and Biodiesel (B5)

Waste and Recyclables

Waste

From 1990 to 2010, Los Reales waste totals decreased by 6 percent, as reflected in the 23 percent reduction in emissions. Wastes continue to be a minor source of City Community emissions, averaging about 3 percent of City emissions over the survey years.

From 2008 to 2010, wastes tonnage declined by almost 14 percent, as evidenced by a similar decline in disposal emissions (Table 3). This decline could be linked to recycling programs and the economic downturn where residents tend to limit their consumption of disposable items (Hughes, W. Personal communication, 2009).

Recyclables

City Community recycling trends over the past 20 years lack a clear trend due to the inconsistency in data availability for 1990 and 2000 (Table 4). As a result, these historic emissions and energy savings cannot be compared with subsequent years which have complete information from all City recycling programs. However, there has been a downward trend in recycled tonnage since the peak in 2006.

Table 4. Summary of City Recycled Waste Activity and Emission and Energy Savings 1990 to 2010

City Collections ¹⁹	Recycled Waste (metric tons)	CO₂e Saved (metric tons)	MMBtus Saved
1990	51,710	255,792	1,004,291
2000	18,189	47,449	504,920
2005	45,430	73,649	828,583
2006	67,074	127,570	1,331,365
2007	66,728	127,027	1,283,265
2008	38,946	79,817	854,867
2010	34,011	49,088	599,966

Shading: Indicates incomplete data

Other

City Community fuel use emissions from locomotive and aviation fuels are included with the County Regional inventory due to the difficulty in isolating the Tucson airshed from the surrounding areas. Data for City industrial process emissions were not collected at this time.

City Community propane use (2000 to 2010) and Harrison Landfill emissions (2010) are included in the "Other" category but are not included in the City totals due to lack of 1990 data.

¹⁹ Data for 1990 represents only voluntary drop-offs at Los Reales; 2000 data denotes limited City curbside pickup and drop-offs; 2005 through 2010 totals include comprehensive curbside pick-ups, commercial collections and voluntary drop-offs.

Propane

From 2000 to 2010, City Community propane use and emissions dropped by 28 percent and experienced a similar decline (25 percent) from 2008 to 2010. Values reflect state sales scaled by City population levels.

Harrison Landfill

Due to the EPA's mandatory GHG reporting rule, 2010 emissions from the closed Harrison landfill appear in the City Community inventory for the first time this year. Due to lack of historic data, these emissions are not included in the City Community total.

Tucson Community Synopsis

City Community GHG emissions increased by 1.6 million metric tons from 1990 to 2010, representing a 30 percent increase. Over these past 20 years, City Community emissions represent a declining proportion of County Regional emissions, ranging from 54 percent of County Regional emissions in 1990 to 49 percent in 2010. This may be attributed to the slower rate of population increase in the City (27 percent) vs. the growth in the suburban areas of the County over this period.

Energy use by the RCI sectors is the largest generator of City Community GHG emissions. Commercial and residential energy use emissions have shown the largest rate of growth in these 20 years, 67 percent and 38 percent respectively, while industrial energy emissions did not show a net increase. In 2010, RCI energy emissions were responsible for 68 percent of the City Community's total emissions.

Electricity is the major source of energy and averaged about 56 percent of total emissions in all survey years. In 2010, electricity was responsible for 59 percent of City Community emissions, while natural gas use contributed 9 percent to the City Community's total.

Similar to the County, on-road vehicle travel was a major contributor to the City Community's emissions. From 1990 to 2010, private and commercial VMT increased by approximately 54 percent, which essentially accounted for the rise in total City community transportation emissions. In 2010, transportation emissions contributed 30 percent to the City Community's total.

Waste-related emissions continue to be a minor source of community emissions; in 2010, waste disposal accounted for 2 percent of the City Community's emissions.

Pima County Government Operations Inventory

County Government emissions showed a 55 percent increase from 2000 to 2010, with the largest increases occurring in WRFs energy use and employee commuting emissions (Figure 10, Table 5).

Energy Use

Emissions from County facilities, wastewater reclamation facilities (WRFs) and public lighting energy use are presented separately in Table 5 and in Figures 10 to 12, but are combined when comparing emissions by energy source (Figure 13). Total energy emissions from these three County Government sectors grew by 66 percent from 2000 to 2010, with WRFs exhibiting the greatest increase (Table 5). Electricity was the major source of energy and was responsible for 63 percent of the County

Government's 2010 emissions while natural gas use contributed 14 percent to the 2010 total (Figure 13).

Facility Energy Use

From 2000 to 2010, facility energy use emissions increased by 37 percent, with the largest increase in natural gas use (Table 5). Electricity was the chief source of energy consumed, averaging over 90 percent of facility energy use over the survey years.

From 2008 to 2010, facility energy use emissions rose by 12 percent, primarily due to the increase in natural gas use. Facility energy use emissions remain the predominant component of County Government emissions, generating 49 percent of the 2010 total (Figure 12).

Water-related Energy Use

WRFs energy use emissions increased significantly from 2000 to 2010, (Table 5). This is due in large part to upgrades at the Green Valley, Avra Valley, Corona de Tucson, Marana, and Ina Road wastewater treatment plants. The upgrades were necessitated by the County's rapidly growing population during this period. The plant upgrades not only increased capacity, they also significantly increased the quality of the effluent released from these plants (Nelson, E. 2012). Despite this overall increase, 2010 emissions were 8 percent lower than the 2008 emissions. WRFs energy-related emissions remain a major contributor to the 2010 County Government total (Figures 9 and 11).

Public Lighting

It is not possible to determine the 2000 to 2010 public lighting emission trends since the 2007 consumption data were used for 2000 to 2006. However, from 2008 to 2010, there was a 40 percent increase in emissions.

Public lighting emissions remain a minor source of government emissions, contributing about 2 percent to the 2010 total (Figure 12).

Figure 10. Comparison of County Government Emissions by Sector 2000, 2008 and 2010

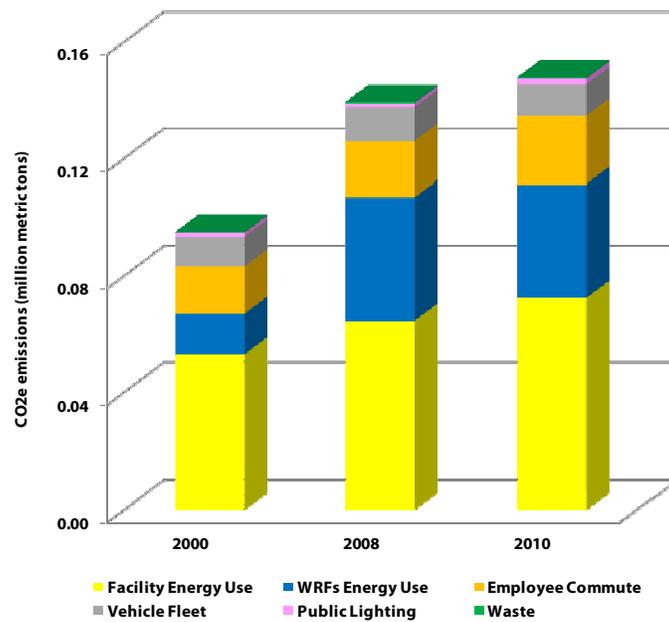
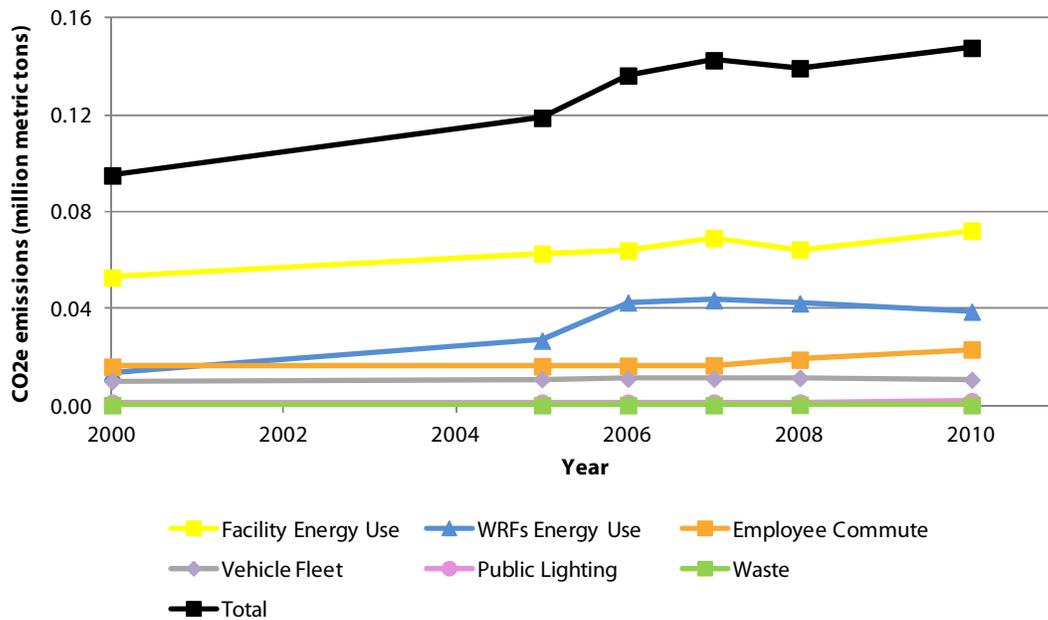


Figure 11. County Government GHG Emissions, 2000 to 2010



Government-generated Solid Waste

It is not feasible to estimate a 10-year emission trend for solid waste disposal since the 2007 value was held constant for all prior survey years. However, a 14 percent decline occurred in waste emissions between 2008 and 2010. Waste generation constitutes a small percentage of County Government emissions, contributing less than 1 percent to the 2010 total (Figure 12).

Figure 12. 2010 County Government GHG Emissions by Sector

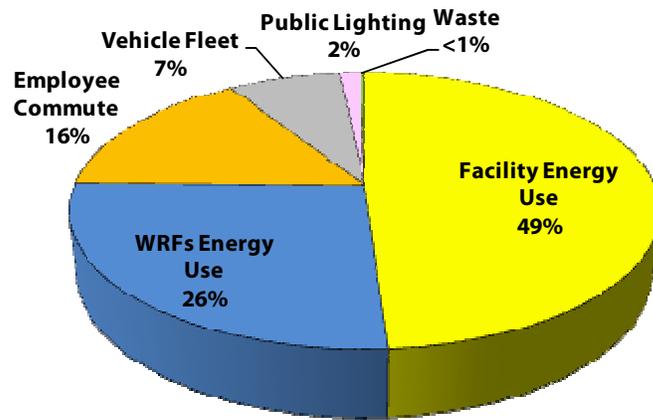


Figure 13. 2010 County Government GHG Emissions by Source

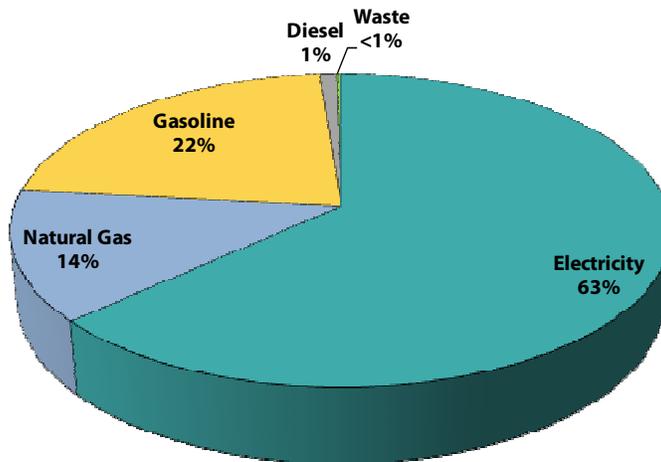


Table 5. Pima County Government GHG Emissions (metric tons CO₂e) and Energy Consumption (million Btu) 2000 to 2010

	2000		2005		2006		2007		2008		2010		Percent change 2000-2010
	CO ₂ e (metric tons)	MMBtu	CO ₂ e (metric tons)	MMBtu	CO ₂ e (metric tons)	MMBtu	CO ₂ e (metric tons)	MMBtu	CO ₂ e (metric tons)	MMBtu	CO ₂ e (metric tons)	MMBtu	
Facilities Energy Use													
Electricity (TEP)	49,848	197,418	57,049	223,391	55,870	222,289	63,184	249,116	60,157	239,814	65,566	254,890	
Natural Gas	3,136	55,953	5,686	101,450	8,200	146,305	6,086	108,580	4,317	77,020	6,788	121,107	
Facilities Total	52,984	253,371	62,735	324,841	64,070	368,594	69,270	357,696	64,474	316,834	72,354	375,997	37
Wastewater Reclamation Energy Use													
Electricity (TEP)	5,769	22,848	15,347	60,094	29,471	117,257	29,928	117,998	27,985	111,561	25,804	100,314	
Natural Gas	8,191	146,134	11,607	207,097	13,233	236,095	13,736	245,082	14,287	254,910	13,058	232,974	
Wastewater Reclamation Total	13,960	168,982	26,954	267,191	42,704	353,352	43,664	363,080	42,272	366,471	38,862	333,288	178
Vehicle Fleet													
Gasoline	8,951	115,007	9,299	120,081	9,451	122,126	9,704	125,457	10,005	129,406	9,451	122,277	
Diesel	1,268	16,109	1,744	22,144	1,785	22,674	1,595	20,251	1,519	19,288	1,367	17,361	
Vehicle Fleet Total ²⁰	10,219	131,116	11,043	142,225	11,236	144,800	11,299	145,708	11,524	148,694	10,818	139,638	6
Employee Commute Total ²¹	16,210	207,488	16,394	211,135	16,592	213,898	16,702	215,448	19,115	246,691	23,295	300,872	44
Public Lighting													
Electricity (TEP)	1,381	5,469	1,397	5,469	1,375	5,469	1,387	5,469	1,440	5,743	2,021	7,855	
Solar	0	1	0	1	0	1	0	1	0	1	0	1	
Public Lighting Total ²²	1,381	5,470	1,397	5,470	1,375	5,470	1,387	5,470	1,440	5,744	2,021	7,856	
Government Solid Waste Total ²³	269		269		269		269		446		384		
Grand Total	95,023	766,427	118,792	950,862	136,246	1,086,114	142,591	1,087,402	139,271	1,084,434	147,734	1,157,651	55

Shading indicates estimated data

²⁰ 2006 vehicle fleet data were interpolated using FY05/06 and FY06/07 data supplied by Pima County staff.²¹ 2006 data were interpolated and 2008 data were extrapolated using 2005 and 2007 PAG TRP survey data; 2008 data were interpolated using 2007 and 2011 data.²² 2007 public lighting energy use data were also used for 2000, 2005 and 2006.²³ 2007 waste totals were also used for 2000, 2005 and 2006.

County Government Synopsis

From 2000 to 2010, County Government emissions rose by almost 53,000 metric tons (55 percent) with the greatest increases occurring in wastewater reclamation facilities' (WRFs) energy use (178 percent) and employee commuting emissions (44 percent). Emissions from other sectors (facility energy use, and vehicle fleet travel) exhibited more modest increases over this same period. Electricity use was the major contributor to County Government emissions, averaging 75 percent of the total for all survey years.

From 2008 to 2010, County Government emissions rose by 6 percent. Emissions associated with waste disposal, WRFs energy use and vehicle fleet use declined by 14 percent, 8 percent, and 6 percent, respectively. However, emissions from the other sectors increased: public lighting (40 percent), employee commuting (22 percent), and facility energy use (12 percent).

In 2010, facility and wastewater reclamation energy use were the major GHG sources, contributing 49 percent and 26 percent, respectively, to the annual total. Electricity was the major form of energy consumed contributing 63 percent to the 2010 total, with gasoline and natural gas use producing 22 percent and 14 percent, respectively of the annual total. Diesel use and waste disposal were responsible for about 1 percent each of total 2010 emissions. Despite these increases, County Government emissions represent only 1 percent of the County Regional's total emissions in 2010.

City of Tucson Government Operations Inventory

From 2000 to 2010, City Government emissions declined by 4 percent. The largest declines occurred in facility energy use (35 percent) and in vehicle fleet emissions (27 percent) while water-associated energy use emissions increased by 13 percent (Table 6).

Energy Use

Emissions from City Government facilities, potable and reclaimed water handling and public lighting energy use are presented separately in Table 6 and in Figures 14 to 16, but are combined when comparing emissions by energy source (Figure 17).

From 2000 to 2010, emissions from the combined energy use in facilities, water handling and public lighting remained virtually unchanged, declining by 1 percent. From 2008 to 2010, these emissions remained relatively constant (1 percent increase).

Electricity was the major source of energy and was responsible for 73 percent of City Government emissions in 2010 (Figure 17). Over 60 percent of the electricity emissions can be attributed to water use. Emissions from natural gas use contributed 13 percent to the 2010 total (Figure 17).

Facility Energy Use

Facility energy use emissions decreased by 35 percent from 2000 to 2010, reflecting a 38 percent drop in electricity and an 8 percent decline in natural gas use (Table 6). Electricity is the chief source of energy and is responsible for over 90 percent of facility energy use for all survey years.

From 2008 to 2010, facility energy use emissions dropped by 5 percent (Figures 14 and 15). Despite this decline, facility emissions remain an important component of City Government's emissions, making up 18 percent of the 2010 total (Figure 16).

Figure 14. Comparison of City Government GHG Emissions by Sector 2000, 2008 and 2010

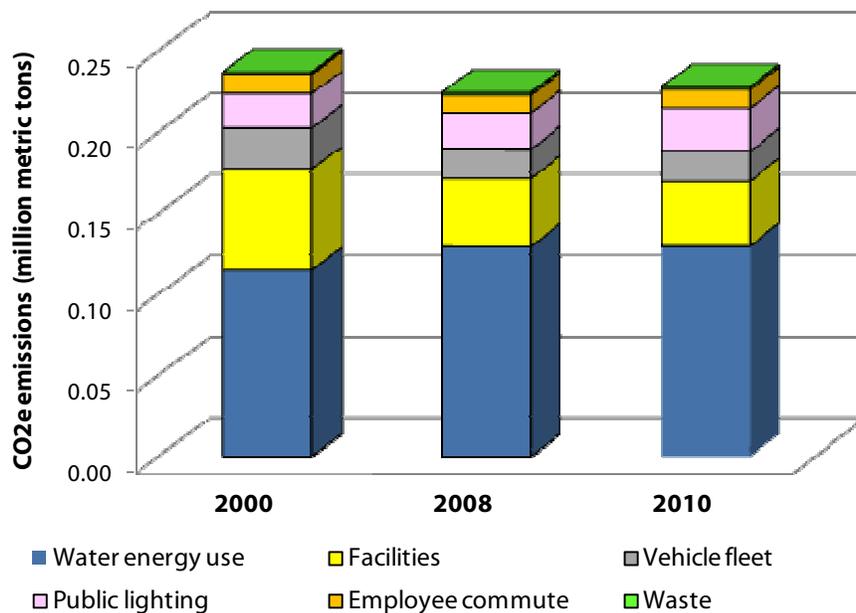
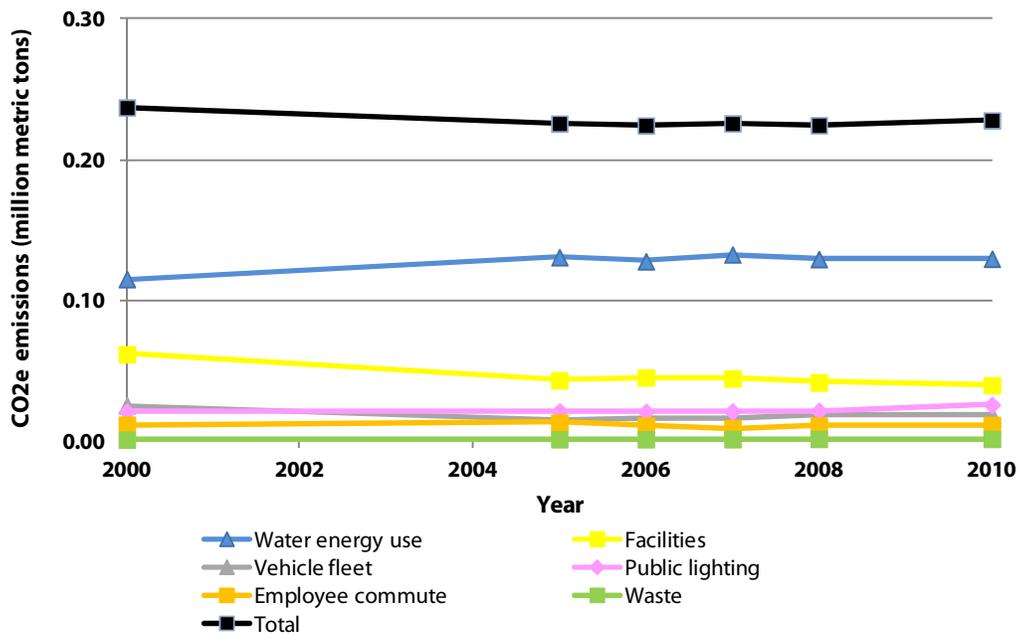


Figure 15. City Government GHG Emissions 2000 to 2010



Water-related Energy Use

Water energy use emissions are the largest source of City Government emissions (Figure 14). From 2000 to 2010, water-related energy use emissions increased by 13 percent, with electricity use responsible for over 80 percent of the energy-related emissions.

From 2008 to 2010 total water-related emissions remained constant. Potable and reclaimed water energy use and associated emissions are discussed separately below in more detail. In 2010, the emissions from all water-related energy use were responsible for 57 percent of the City Government total (Figure 16).

Potable Water System

From 2000 to 2010, potable water energy use emissions increased by 10 percent (Table 6). This trend can be attributed to an 8-fold increase in Trico electricity use and a doubling of natural gas use over this 10-year period. In contrast, potable water’s TEP electricity use declined over this timeframe.

From 2008 to 2010, emissions from potable water energy use remained constant.

Emissions from all energy sources used for the pumping, treatment and delivery of potable water were responsible for 50 percent of the City Government’s emissions in 2010.

Reclaimed Water

According to the most recent information, about 900 sites in Pima County receive reclaimed water, with demand projected to increase through 2050 (Tucson Water, 2012). This increased demand is reflected in the 38 percent rise in energy-related emissions from 2000 to 2010.

From 2008 to 2010, reclaimed water energy use emission increased slightly (2 percent) and represented about 7 percent of the 2010 total City Government emissions.

Public Lighting

A 10-year emission trend for public lighting cannot be determined since the 2007 streetlight and traffic light electricity use data were used for 2000 through 2006. However, from 2007 to 2010, there was a 22 percent increase in emissions.

From 2008 to 2010, public lighting emissions showed a 19 percent increase and in 2010, public lighting emissions were responsible for 11 percent of the City Government's total (Figure 16).

On-road Vehicle Use

Emissions from the City Government fleet and employee commuting are itemized in Table 6 and in Figures 14 through 16, but are combined when viewing data by energy source (gasoline, diesel, biodiesel and CNG) (Figure 17).

Gasoline is the predominant fuel used in the City's fleet and for employee commuting and averages about 10 percent of total City Government emissions over this 10-year period; diesel/biodiesel fleet emissions average about 3 percent of total emissions over this same period.

Below the emissions generated by the City Government fleet and employee commuting are discussed in more detail.

City Government Fleet

Overall, fleet emissions dropped by an estimated 27 percent from 2000 to 2010 (Table 6). Part of this reduction may be due to the method used to calculate 2000 emissions which differed from other survey years. Nevertheless, the City Government officials supported the incremental addition of flex-fueled and alternate fueled vehicles to its fleet starting in 2005 (Appendix I). These vehicle acquisitions in addition to the estimated 11 percent drop in VMT, from 2005 to 2010, contributed to this downward trend in emissions.

A negligible difference in fleet emissions (1 percent) occurred from 2008 to 2010. In 2010, fleet emissions were responsible for about 8 percent of total City Government emissions (Figure 14).

City Employee Commute

Using historic survey data and trends, City Government employee commuting emissions exhibited a 2 percent decline from 2000 to 2011. Despite the 5 percent increase in emissions from 2008 to 2011, City employee commuting emissions remain a small portion of the total 2010 emissions (5 percent).

Table 6. City of Tucson Government Greenhouse Gas Emissions (metric tons CO₂e) and Energy Consumption (million Btu) 2000 to 2010

	2000		2005		2006		2007		2008		2010		Percent Change CO ₂ e 2000-10
	CO ₂ e (metric tons)	MMBtu											
Facilities Energy Use													
Electricity (TEP)	58,447	231,476	39,964	156,489	40,176	159,848	41,370	163,109	38,257	152,512	36,914	144,345	
Natural Gas	3,354	59,834	3,417	60,956	5,303	94,589	3,279	58,526	3,627	64,713	3,085	55,029	
Facilities Energy Use Total	61,801	291,310	43,381	217,445	45,479	254,437	44,649	221,635	41,884	217,225	39,999	199,374	-35
Water Energy Use													
Potable Water													
Electricity (TEP)	85,607	339,041	61,198	239,631	65,364	260,060	57,502	226,714	50,879	202,829	44,673	173,666	
Electricity (Trico)	4,665	19,006	31,625	116,828	25,680	95,530	36,881	137,056	39,833	149,590	42,873	161,763	
Natural Gas	13,671	244,094	26,459	472,069	24,176	431,354	23,657	422,086	23,406	417,629	26,552	446,357	
Potable Water Total	103,943	602,141	119,282	828,528	115,220	786,944	118,040	785,349	114,118	770,048	114,098	781,786	10
Water Reclamation											0.45		
Electricity (TEP)	10,527	41,691	10,529	41,230	11,209	44,596	12,994	51,236	13,389	53,376	13,788	53,600	
Electricity (Trico)	822	3,347	1,027	3,792	1,513	5,630	1,716	6,378	1,944	7,302	1,868	7,050	
Reclamation Water Total	11,349	45,038	11,556	45,022	12,722	50,226	14,710	57,614	15,333	60,678	15,656	60,650	38
All Water Energy Use Total	115,292	647,179	130,838	873,550	127,942	837,170	132,750	842,963	129,451	830,726	129,754	842,436	13
Vehicle Fleet													
Gasoline	15,397	198,586	9,416	122,164	10,002	129,819	10,122	131,418	13,381	173,980	13,287	172,791	
Diesel	10,218	129,852	5,387	68,461	3,588	45,595	0	0	301	3,819	2,986	37,948	
CNG	0	0	333	5,794	251	4,363	110	1,911	79	1,376	156	2,718	
Biodiesel (B-20)	0	0	0	0	3,050	48,354	5,850	92,752	4,788	75,897	2,394	37,948	
E85	0	0	0	0	0	0	0	0	12	886	n.a.	n.a.	
Electric	0	0	0	0	0	0	0	0	0	0	1	4	
Vehicle Fleet Total ²⁴	25,615	328,438	15,136	196,419	16,891	228,131	16,082	226,081	18,561	255,958	18,824	251,409	-27
Employee Commute Total ²⁵	11,944	152,875	13,395	172,503	11,359	146,434	9,381	121,018	11,164	144,084	11,679	150,834	-2
Public Lighting													
Traffic lights (TEP)	3,972	15,730	4,017	15,730	3,954	15,730	3,990	15,730	4,276	17,048	4,597	17,870	
Streetlights (TEP)	17,243	68,289	17,439	68,289	17,164	68,289	17,320	68,289	17,528	69,876	21,400	83,192	
Public Lighting Total ²⁶	21,215	84,019	21,456	84,019	21,118	84,019	21,310	84,019	21,804	86,924	25,997	101,062	
Government Solid Waste Total ²⁷	1,300		1,554		1,610		1,668		1,686		1,705		31
Grand Total	237,167	1,503,821	225,760	1,543,936	224,399	1,550,191	225,840	1,495,716	224,550	1,534,917	227,958	1,545,115	-4
Other													
Central Arizona Water Pumping													
Electricity (Navajo)	29,218	98,779	184,060	599,328	179,385	589,714	272,844	896,123	373,468	1,205,035	253,567	880,605	768

Shading indicates estimated data; 0 – no use

²⁴ Data for 2000 vehicle fleet were calculated using a different method than 2005, 2006, 2007, 2008 and 2010 data.

²⁵ 2007 public lighting energy use data were also used for 2000, and 2005 and 2006.

²⁶ ²⁰⁰⁶ data were interpolated using 2005 and 2007 survey data and 2008 data were interpolated using the 2007 and 2011 surveys.

²⁷ ²⁰⁰⁰, 2005 and 2006 waste data were interpolated.

Government-generated Solid Waste

Waste disposal emissions experienced an estimated 31 percent increase from 2000 to 2010. However caution should be taken when reviewing the emission trend since the 2000 through 2006 totals were estimated by interpolating 1993 and 2007 waste totals.

From 2008 to 2010, both waste tonnage and emissions increased slightly (1 percent) and continue to be a small component of total annual emissions (Figure 16).

Figure 16. 2010 City Government GHG Emissions by Sector

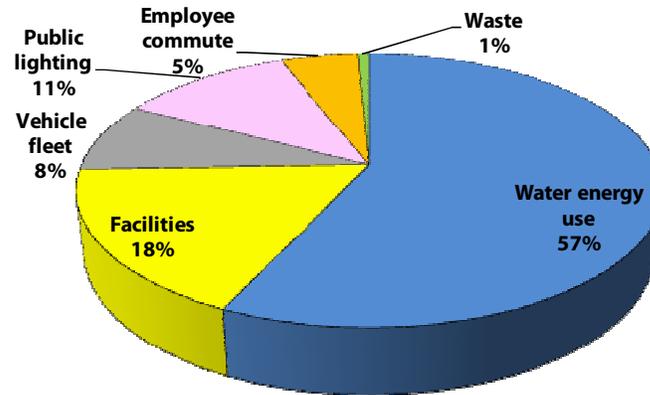
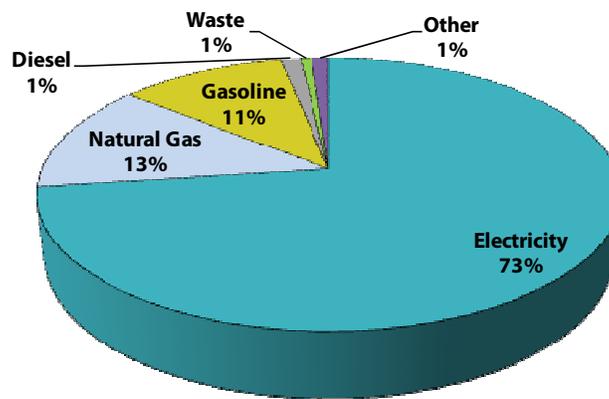


Figure 17. 2010 City Government GHG Emissions by Source



Other-CNG and Biodiesel (B-20)

Other

Central Arizona Project (CAP)

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

Energy-related emissions associated with water conveyance from the CAP have increased more than 8-fold from 2000 to 2010, reflecting more than a 7-fold increase in water volume deliveries (Table 6, Appendix I). From 2008 to 2010, however, CAP energy-related emissions declined by 32 percent reflecting a 26 percent reduction in water delivery volume.

City Government Synopsis

From 2000 to 2010, City Government GHG emissions decreased by approximately 9,200 metric tons (4 percent) and represent 3 percent of the City's Community emissions. Water and facility energy use are the major contributors to City Government emissions.

Over this ten-year period, facility energy use, government fleet and employee commuting emissions decreased by an estimated 35 percent, 27 percent and 2 percent respectively. Water energy use and City employee commuting emissions increased by 13 percent and 3 percent, respectively.

Electricity is the chief energy source and averages about 75 percent of total emissions over this decade; natural gas use emissions averaged 12 percent of City government's total.

TW deliveries of CAP water increased more than 7-fold since 2000, resulting in an 8-fold increase in GHG emissions. CAP energy emission totals continue to be a significant source of GHG emissions for the Tucson area (Table 6).

When comparing 2008 with 2010 emissions, a few trends emerge. Overall City Government's emissions grew by less than 2 percent, with public lighting (19 percent) and employee commuting (5 percent) showing the greatest increases. Facility energy use emissions continued to decline and water energy use emissions, vehicle fleet and waste emissions were virtually unchanged since the 2008 emissions.

In 2010, water related and facility energy use emissions remained the dominant sources, contributing 57 percent and 18 percent, respectively, to the annual total. Other City Government sources, public lighting (11 percent), fleet (8 percent), employee commuting (5 percent) and waste (1 percent) contributed less to the City Government's 2010 total.

Overview of the Regional/Community and Government Inventories

Regional/Community Inventories

The results of the County Regional and City Community inventories show similar emission sources and trends, with energy use and transportation being the largest contributors to community GHG emissions. Rapid population growth in both jurisdictions resulted in increased emissions expressed most prominently by these sectors. From 1990 to 2010, total County Regional emissions rose by 41 percent and the population grew by 47 percent; City Community emissions increased by 30 percent and experienced a 27 percent increase in population.

Energy use by the RCI sectors is responsible for approximately two-thirds of both communities' emissions. The residential and commercial sectors' energy use emissions showed the greatest rate of increase which is closely linked to regional population growth and the increased demand for services. In contrast, regional industrial energy use emissions exhibited a more modest growth but only at the County level over this 20-year period.

From 1990 to 2010, regional electricity use averaged about 57 percent of energy emissions since local generation is predominantly from coal-fired power plants. Natural gas emissions averaged about 8 percent of the communities' emissions.

Travel by County private and commercial vehicles increased by 60 percent from 1990 to 2010 and public transit VMT increased by 40 percent from 2000 to 2010. Combined, these two forms of transportation average about 30 percent of regional GHG emissions. Almost all of these emissions can be attributed to private and commercial vehicle use.

Community waste emissions have dropped from 2000 to 2010, and remain a small component of regional GHG emissions. Establishment of region wide recycling programs has diverted waste from the landfills and has helped to modify the rate of waste disposal despite the rapid population growth.

Government Inventories

The results of the County and City Government inventories show similarities and differences. In general, emissions from County and City Governments constitute a small portion of overall emissions, generating 1 percent and 3 percent of their respective community totals. Also, facility and water-handling energy use were responsible for over 75 percent of the governments' total emissions. City government is charged with the pumping, treatment and delivery of potable and reclaimed water to most of eastern Pima County; the County government is responsible for most of the region's wastewater reclamation. All of these processes are very energy intensive, relying primarily on electricity use. Approximately 70 percent of the governments' operations' emissions can be attributed to electricity.

Despite these similarities, emission trends are notably different between the County and City Governments. From 2000 to 2010, County Government emissions increased by 55 percent while City Government emissions dropped by 4 percent. These differences can be attributed to several factors. In all sectors of County government, emissions increased from 2000 to 2010, especially WRFs energy use which more than doubled over the decade. In recent years, the County expanded its wastewater treatment capacity to accommodate the growing regional population. In contrast, City Government

facility energy use and vehicle fleet emissions demonstrated an appreciable decline from 2000 to 2010; other City government sectors showed relatively modest increases.

References Cited

Arizona Department of Commerce, Energy Office. First Sales of Petroleum Products into Arizona for Consumption. 2012. <http://azenergy.gov/doclib/petrosales.pdf>

Arizona Department of Administration, Office of Population and Statistics. Accessed July 2012. <http://www.workforce.az.gov/population-estimates.aspx>

Bureau of Transportation Statistics. Accessed May 2012. (Energy emissions factors for aviation gas and jet A) http://www.bts.gov/publications/national_transportation_statistics/html/table_04_06.html

Cascadia Consulting Group Inc. Characterization of Waste from Single-family Residences. Report for the City of Phoenix Public Works Department. 2003.

Cascadia Consulting Group Inc. Statewide Waste Characterization Study. Contractor's Report to the California Integrated Waste Management Board. 2004.

Cascadia Consulting Group Inc. Waste Disposal and Diversion Findings for Selected Industry Groups. Contractor's Report to the California Integrated Waste Management Board. 2006.

Cascadia Consulting Group Inc. Detailed Characterization of Construction and Demolition Waste. Contractor's Report to the California Integrated Waste Management Board. 2006a.

Energy Information Administration (EIA) Department of Energy. Fuel Emission Factors. 2011. http://www.eia.gov/oiaf/1605/emission_factors.html

Envair. Emissions Inventories for the Tucson Air Planning Area. Volume I. 2001.

Hughes, W., Tani, M., Aller, S. and Rathje, W.L. 1993. A Characterization of the Solid Wastes of City of Tucson Governmental Agencies.

Hughes, W. (retired) City of Tucson Environmental Services. 2009. Personal communication.

Nelson, E. Pima County Regional Wastewater Reclamation Department. 2012. Personal communication.

PBL Netherlands Environmental Assessment Agency. 2012. Trends in Global CO₂ Emissions- 2012 Report. PBL Netherlands Environmental Assessment Agency. <http://edgar.jrc.ec.europa.eu/CO2REPORT2012.pdf>

Philbin, A. 2009. Personal communication with Central Arizona Project (CAP) staff.

Philbin, A. Tucson Water. 2012. Personal communication.

Pima Association of Governments (PAG). 2004. 2000 On-Road Mobile Source Emissions Inventory. <http://www.pagnet.org/documents/Air/2000onroadei.pdf>

Pima Association of Governments. (PAG). 2008. Regional Greenhouse Gas Inventory: 1990-2006. <http://www.pagnet.org/documents/Air/GreenHouseGas-2008-11-Inventory.pdf>

Pima Association of Governments. (PAG). 2011. Regional Greenhouse Gas Inventory: 1990-2008. <http://www.pagnet.org/documents/Air/GreenHouseGas-2011-04-Inventory.pdf>

Pima County Regional Wastewater Reclamation Department (PCRWRD). 2012. 2011 Effluent Generation and Utilization Report. http://www.pima.gov/wwm/pubs/pdf/Effluent_gen_2011.pdf

Portland Cement Association. 2011. http://www.cement.org/econ/ind_stats_state.asp?state=3

Portland Cement Association. 2009. (Accessed May 2012). Cement Industry Overview. <http://www.cement.org/econ/industry.asp>

Tucson Water. 2012. Reclaimed. <http://cms3.tucsonaz.gov/water/reclaimed>

U.S. Energy Information Administration (EIA) 2011. Arizona Annual: Petroleum and Other Liquids: Prime Supplier and Sales Volume. http://205.254.135.7/dnav/pet/PET_CONS_PRIM_DCUSAZ_A.htm

U. S. Environmental Protection. (USEPA) August 2010 .WARM model, Version 11. http://epa.gov/climatechange/wycd/waste/calculators/Warm_home.html

U. S. Environmental Protection Agency (USEPA) 2012a. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010. EPA 430-R-12-001. <http://www.epa.gov/climatechange/emissions/downloads12/US-GHG-Inventory-2012-Main-Text.pdf>

U.S. Environmental Protection Agency (USEPA). 2012b. Greenhouse Gas Reporting Program Data for Calendar Year 2010. <http://www.epa.gov/climatechange/emissions/ghgdata/index.html>

United States Census Bureau. (Accessed 2012). Fact Finder-Population Estimates - United States: States and Puerto Rico total population. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=PEP_2009_GCTT01.US01PR&prodType=table

United States Census Bureau. 2011. 2010 Population Distribution and Change: 2000 to 2010. <http://www.census.gov/prod/cen2010/briefs/c2010br-01.pdf>

Appendices

- A. Data Sources
- B. Population Estimates, 1990 to 2010
- C. Emission Factors for Electricity Use, 1990 to 2010
- D. Eastern Pima County Regional Inventory Data Summary
- E. Waste Characterizations
- F. EPA's WARM Model Emission Factors
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- J. City of Tucson Government Facilities Addendum
- K. Energy Conversion Factors
- L. Per Capita Greenhouse Gas Emissions

Appendix A: Data Sources

Community Inventories		
Inventory Source	Name/Affiliation	Type of Data
RESIDENTIAL, COMMERCIAL, INDUSTRIAL ENERGY USE		
Tucson Electric Power	Jeff Yockey, TEP	County electricity use by sector City of Tucson use by sector Emissions factors by fuel and plant type
Trico Electricity Cooperative	Romi Wittman, Trico	County electricity usage by sector
Arizona Electric Power Cooperative	Michelle Freeark, Arizona Electricity Power Corp	Emission coefficients by fuel and plant type for Trico
Tohono O'odham Utility Authority	Loren Nixon, Tohono O'odham Utility Authority	Tribal electricity use by sector
Southwest Gas	Dave Naugle, Walter Richter, Kevin Thompson, Rebecca Hudson, Southwest Gas	City and County natural gas use by sector
TRANSPORTATION		
VMT	Aichong Sun, PAG	County and City VMT estimates
Cat Tran	Tom Amparano, University of Arizona	City VMT estimates by fuel type
Coyote Run	Aimee Ramsey, Town of Oro Valley	VMT by fuel type
Old Pueblo Trolley	Eugene Caywood	City VMT estimates
Rural Transit	Patrick McGowan, Pima County; Jeremy Papuga, PAG	County and City VMT by fuel type
Special Needs	Susan Vos, Pima County; Jeremy Papuga, PAG	County and City VMT by fuel type
Sun Tran	George Caria, Rhonda Lugo, Heather Romo, City of Tucson	County and City VMT by bus fuel type
Downtown Loop (Formally TICET)	George Caria, Chris Leighton, John Zukas, City of Tucson	VMT by fuel type
SunVan/VanTran	George Caria, Rhonda Lugo, Heather Romo, City of Tucson	City and County VMT by fuel type
WASTE AND RECYCLED MATERIALS		
Catalina, Ina, Sahuarita, Tangerine Landfills	Judy Tovar, Pima County	Wastes, recycled (drop-off) materials tonnage, type
Eastern Pima County Recycling	Milena Sousa, Jennifer Lynch, Pima County	County curbside recycling tonnage, type
Los Reales Landfill	Wilson Hughes, Fran La Sala, City of Tucson	Wastes and recycled (drop-off) tonnage, type
City of Tucson Recycling	Donald Gibson, Fran La Sala, City of Tucson	Recycled materials tonnage, type
OTHER		
Inventory Source	Name/Affiliation	Type of Data
Propane	Mark Hope, AZ Dept. of Commerce, Energy Office	Gallons of propane sold in Arizona
Aviation Fuels	Fred Brinker, TIA	Gallons of aviation fuels used at TIA and Ryan Airfield
	Ron Herbert, Peter Barbier, Marana Airport	Gallons of aviation fuels used at Marana Airport
	Howard Richmond, Larry Newman, La Cholla Airpark	Gallons of aviation gasoline used at La Cholla Airport
Locomotives	Jon Germer, Union Pacific Railroad	Diesel fuel consumption (2005, 2006, 2007, 2008 and 2010)
	Envair Consulting	Diesel fuel consumption (2000)
INDUSTRIAL PROCESSES		
Arizona Portland Cement	Rick Jacobs, CalPortland	GHG emissions
Freeport MacMoRan Sierrita Mine	Latha Toopal, ADEQ; Chad Fretz, Lana Fretz, Freeport MacMoRan	Diesel fuel consumption

Government Inventories		
Inventory Source	Name/Affiliation	Type of Data
FACILITY ENERGY USE		
County Government Facilities	Paul Guerrero, Marilyn Hutzler, Pima County	County government electricity, natural gas use and costs
City Government Facilities	Asia Philbin, Corrie Nesbitt, Jeremy Mohr, Maricela Rivera, Lorenzo Escobar, City of Tucson	City government electricity, natural gas use and costs
WASTEWATER TREATMENT AND WATER SYSTEM ENERGY USE		
Wastewater Treatment	Wendy Gort, Eric Nelson, Pima County	County government electricity, natural gas use and costs
Potable and Reclaimed Water	Asia Philbin, City of Tucson	Tucson Water electricity, natural gas use and costs
Central Arizona Project Water	Asia Philbin, City of Tucson	CAP electricity use, water volumes and costs
VEHICLE FLEET		
County Government Fleet	Venesa Hartley, Robert Padilla, Pima County	County government fleet descriptions, VMT and costs
City Government Fleet	Tony Leon, Marc Crum, City of Tucson	City government fleet description, VMT and costs
EMPLOYEE COMMUTING		
PAG TRP survey data	Rita Hildebrand, Don Freeman, Ruth Reiman, Jeff Hildebrand, PAG	County and City government employee commuter data
PUBLIC LIGHTING		
Street and Traffic Lights	Don Pittenger, Marilyn Hutzler, Pima County	County public lighting electricity use and costs
	Ernie Encinas, Ray Quihuis, City of Tucson	City public lighting electricity use and costs
GOVERNMENT-GENERATED SOLID WASTE		
Waste tonnage	Eric Ponce, Pima County	County government waste totals and costs
	Wilson Hughes, Chris Leverenz, City of Tucson	City government waste totals and costs

Appendix B: Population Estimate: 1990 to 2010

	United States²⁸	Arizona²⁹	Eastern Pima County³⁰	Tucson²⁹
1990	248,709,873	3,680,800	641,760	408,740
2000	281,421,906	5,130,247	809,996	486,699
2005	295,753,151	5,924,476	902,403	519,182
2006	298,593,212	6,305,210	921,095	521,728
2007	301,579,895	6,116,409	938,168	525,837
2008	304,059,724	6,368,649	944,670	526,373
2010	308,745,538	6,401,569	941,921	520,795

Data represents population estimates as of July, 2012.

Appendix C: Emissions Factors for Electricity Use

	1990	2000	2005	2006	2007	2008	2010
	Lbs. CO₂ per MWH						
Tucson Electric Power	1,945.1	1,899.9	1,921.5	1,891.2	1,908.4	1,887.5	1,935.5
Trico Electric Cooperative	1,846.8	1,846.8	2,036.8	2,022.6	2,024.8	2,003.6	1,994.2
Navajo Generating Station	n.a.	2,225.6	2,310.8	2,288.8	2,290.9	2,331.9	2,166.2

²⁸ U. S. Census Bureau American Factfinder; <http://www.census.gov/population/censusdata/urpop0090.txt> (1990); (2000-2010): http://factfinder.census.gov/servlet/DTable?_bm=y&-geo_id=01000US&-ds_name=PEP_2009_EST&-mt_name=PEP_2009_EST_G2009_T001

²⁹ Source: Arizona Department of Commerce <http://www.workforce.az.gov/population-estimates.aspx>

³⁰ Eastern Pima County totals calculated using Pima County population from the Arizona Department of Commerce and applying an allocation factor (0.96) (PAG, personal communication, 2009). Pima County data: <http://www.workforce.az.gov/population-estimates.aspx>

Appendix D: Eastern Pima County Regional Inventory Data Summary

	1990	2000	2005	2007	2008	2010
Residential Energy Use						
Natural Gas (therms)	80,471,344	89,825,869	83,839,115	88,398,545	88,263,667	87,483,101
Electricity (GWh)						
TEP	2,070	3,041	3,633	4,005	3,853	3,870
Trico	91	194	274	340	353	285
Tohono O'odham Utility Authority	n.a.	21	31	29	28	30
Commercial Energy Use						
Natural Gas (therms)	57,056,342	61,913,682	58,896,658	139,513,042	139,474,998	74,588,705
Electricity (GWh)						
TEP	1,357	1,763	2,097	2,305	2,290	2,204
Trico	46	74	133	151	155	125
Tohono O'odham Utility Authority	n.a.	43	62	75	83	78
Industrial Energy Use						
Natural Gas (therms)	19,500,818	17,667,033	26,195,852	38,702,983	36,509,522	11,218,549
Electricity (GWh)						
TEP	2,650	3,418	3,145	3,324	3,360	3,218
Trico	139	76	30	26	26	21
Transportation (annual County miles)						
Pima County VMT	4,863,931,878	6,932,920,462	6,864,722,562	7,320,467,317	7,537,355,162	7,774,963,803
Other transportation						
Cat Tran	0	132,939	222,105	228,479	220,958	213,937
Coyote Run ³¹	0	0	140,717	175,841	163,964	140,975
Old Pueblo Trolley ³¹	0	6,864	6,864	6,864	6,864	5,720
Sun Shuttle (Rural Transit) ³¹	0	329,094	416,465	458,995	485,763	978,145
Special Needs	417,978	590,664	617,067	739,248	854,431	1,073,259
Sun Tran	6,884,993	7,896,625	7,899,630	8,348,695	8,706,103	9,151,758
Sun Van (Van Tran)	1,441,338	2,149,240	3,145,893	3,706,509	3,740,787	3,965,337
Downtown Loop (formally TICET) ^{31,32}	0	37,841	109,652	121,593	242,414	27,720
Waste (short tons)						
Ina	n.a.	14,574	30,279	27,432	23,362	3,212
Sahuarita	n.a.	39,156	1,217	32,590	41,955	30,287
Tangerine	n.a.	100,664	151,450	141,678	103,325	31,953
Los Reales	516,000	550,200	627,699	660,840	559,159	483,579
Other (gallons)						
Propane	n.a.	14,011,627	15,167,658	14,988,303	14,557,981	10,942,296
Jet A ³³	4,000,000	3,248,398	3,678,189	4,071,865	4,056,002	3,189,780
Aviation Gasoline ³³	9,900	55,882	52,234	100,440	54,989	37,764
Railroad fuel	n.a.	8,749,627	8,263,844	8,818,992	8,690,890	7,387,709
Industrial Processes						
Freeport McMoRan Sierrita Mine (gallons diesel)	n.a.	240,027	202,082	220,170	280,602	236,506

0- no use; n.a. - data not available; 2006 data removed due to space constraints.

³¹ Transit not operational in 1990; Coyote Run not operational until 2002.

³² TICET ceased operation in Nov. 2008 and its replacement, the Downtown Loop, resumed operation in late fall 2008.

³³1990 data represents aviation gas from Ryan Airfield and La Cholla airport; 1990 Jet A data represents TIA use; 2000 and 2005 through 2010 represents TIA, Ryan Airfield and Marana.

Appendix E: Waste Characterizations

Waste Category	Material	Percent Composition
Commercial ³⁴	Paper products	28
	Food	26
	Plant debris	2
	Wood/textiles	11
	Wastes - other	33
Construction and Demolition ³⁵	Paper products	3
	Food	0
	Plant debris	1
	Wood/textiles	20
	Wastes - other	76
Government-generated ³⁶	Paper products	15
	Food	4
	Plant debris	37
	Wood/textiles	6
	Wastes - other	38
Private self-hauler ³⁷	Paper products	7
	Food	1
	Plant debris	5
	Wood/textiles	22
	Wastes - other	65
Residential ³⁸	Paper products	18
	Food	17
	Plant debris	28
	Wood/textiles	6
	Wastes - other	31

³⁴ Based on *Waste Disposal and Diversion Findings for Selected Industry Group*. Cascadia Consulting Group. June 2006.

³⁵ Based on *Detailed Characterization of Construction and Demolition Waste*. Cascadia Consulting Group. June 2006.

³⁶ Based on a *Characterization of the Solid Wastes of the City of Tucson Governmental Agencies*. Hughes, W. et al, 1993.

³⁷ Based on a *Statewide Waste Characterization Study- Contractors' Report to the California Board*. Cascadia Consulting Group. Dec. 2004.

³⁸ Based on *Characterization of Waste from Single-family Residences for the City of Phoenix Public Works Dept.* Cascadia Consulting Group. Nov. 2003.

Appendix F: EPA's WARM Model Emission Factors

Per Ton Estimates of GHG Emissions for Alternative Management Scenarios

Material	GHG Emissions per Ton of Material Source Reduced (MTCO₂E)	GHG Emissions per Ton of Material Recycled (MTCO₂E)	GHG Emissions per Ton of Material Landfilled (MTCO₂E)	GHG Emissions per Ton of Material Combusted (MTCO₂E)	GHG Emissions per Ton of Material Composted (MTCO₂E)
Aluminum Cans	(8.26)	(13.61)	0.04	0.05	NA
Steel Cans	(3.19)	(1.80)	0.04	(1.54)	NA
Copper Wire	(7.38)	(4.97)	0.04	0.05	NA
Glass	(0.53)	(0.28)	0.04	0.05	NA
HDPE	(1.77)	(1.38)	0.04	1.31	NA
LDPE	(2.25)	(1.67)	0.04	1.31	NA
PET	(2.07)	(1.52)	0.04	1.28	NA
Corrugated Containers	(5.60)	(3.10)	0.08	(0.51)	NA
Magazines/third-class mail	(8.65)	(3.07)	(0.42)	(0.36)	NA
Newspaper	(4.89)	(2.80)	(0.97)	(0.58)	NA
Office Paper	(8.00)	(2.85)	1.38	(0.49)	NA
Phonebooks	(6.29)	(2.65)	(0.97)	(0.58)	NA
Textbooks	(9.13)	(3.11)	1.38	(0.49)	NA
Dimensional Lumber	(2.02)	(2.46)	(0.66)	(0.61)	NA
Medium-density Fiberboard	(2.23)	(2.47)	(0.66)	(0.61)	NA
Food Scraps	0.00	NA	0.75	(0.13)	(0.20)
Yard Trimmings	0.00	NA	(0.11)	(0.16)	(0.20)
Grass	0.00	NA	0.28	(0.16)	(0.20)
Leaves	0.00	NA	(0.54)	(0.16)	(0.20)
Branches	0.00	NA	(0.66)	(0.16)	(0.20)
Mixed Paper (general)	NA	(3.51)	0.05	(0.51)	NA
Mixed Paper (primarily residential)	NA	(3.51)	(0.03)	(0.51)	NA
Mixed Paper (primarily from offices)	NA	(3.60)	0.17	(0.46)	NA
Mixed Metals	NA	(5.40)	0.04	(1.05)	NA
Mixed Plastics	NA	(1.50)	0.04	1.29	NA
Mixed Recyclables	NA	(2.87)	(0.05)	(0.44)	NA
Mixed Organics	NA	NA	0.31	(0.15)	(0.20)
Mixed MSW	NA	NA	1.15	(0.06)	NA
Carpet	(4.02)	(7.22)	0.04	0.66	NA
Personal Computers	(55.78)	(2.26)	0.04	(0.17)	NA
Clay Bricks	(0.29)	NA	0.04	NA	NA
Concrete	NA	(0.01)	0.04	NA	NA
Fly Ash	NA	(0.87)	0.04	NA	NA
Tires	(4.34)	(0.39)	0.04	0.51	NA
Asphalt Concrete	(0.11)	(0.08)	0.04	NA	NA
Asphalt Shingles	(0.20)	(0.09)	0.04	(0.34)	NA
Drywall	(0.22)	0.03	0.13	NA	NA
Fiberglass Insulation	(0.39)	NA	0.04	NA	NA
Vinyl Flooring	(0.63)	NA	0.04	(0.33)	NA
Wood Flooring	(4.08)	NA	0.07	(0.80)	NA

Appendix G: City of Tucson Community Inventory Data Summary

	1990	2000	2005	2007	2008	2010
Residential Energy Use						
Natural Gas (therms)	65,506,985	73,121,953	68,248,489	71,960,153	71,309,619	67,657,052
TEP Electricity (GWh)	1,314	1,788	1,831	1,945	1,878	1,974
Commercial Energy Use						
Natural Gas (therms)	20,462,503	22,204,524	21,122,508	50,034,509	54,576,034	41,527,639
TEP Electricity (GWh)	957	1,244	1,460	1,567	1,556	1,555
Industrial Energy Use						
Natural Gas (therms)	7,853,274	7,114,782	10,549,466	15,587,754	11,847,867	1,386,229
Electricity (GWh)	1,137	1,466	1,247	1,241	1,225	1,178
Transportation (annual City miles)						
City VMT	2,393,054,494	3,410,996,867	3,450,470,029	3,610,311,294	3,687,517,725	3,683,200,127
Other transportation						
Cat Tran ³⁹	0	132,939	222,105	228,479	220,958	213,937
Old Pueblo Trolley ³⁹	0	6,864	6,864	6,864	6,864	5,720
Sun Shuttle (formally Rural Transit) ³⁹	0	16,455	20,823	22,950	24,288	42,956
Special Needs	167,191	236,266	246,827	295,699	341,772	53,663
Sun Tran	6,884,993	7,253,929	7,086,526	7,546,146	7,914,560	8,309,796
Sun Van	1,441,338	2,149,240	3,145,893	3,643,498	3,660,346	3,886,030
Downtown Loop (formally TICET) ^{39,40}	0	37,841	109,652	121,593	242,414	27,720
Waste (short tons)						
Los Reales	516,000	550,200	627,699	660,840	559,159	483,579
Other (gallons)						
Propane	n.a.	8,419,108	8,904,410	8,645,203	8,382,761	6,042,185

0- no use; n.a. - data not available; 2006 data removed due to space constraints.

³⁹ Transit was not operational in 1990.

⁴⁰ TICET ceased operations in Nov. 2008; its replacement, the Downtown Loop, resumed operation in late Nov. 2008.

Appendix H: Pima County Government Inventory Data Summary

	County Government Operations Data					Expenditures				
	2000	2005	2007	2008	2010	2000	2005	2007	2008	2010
Facility Energy Use	Electricity- KWh; Natural gas- therms					Dollars				
Electricity	57,843,399	68,453,706	72,992,291	70,264,870	71,099,032	5,165,261	6,013,512	5,813,167	7,518,327	7,607,597
Natural Gas	559,530	1,014,500	1,085,803	770,200	2,183,495	335,718	1,014,497	1,248,674	885,727	1,751,165
Wastewater Treatment										
Electricity	6,696,337	17,612,538	34,583,254	32,687,079	29,402,033	535,550	1,584,664	3,699,324	3,497,521	3,144,929
Natural Gas	1,461,343	2,070,970	2,450,820	2,549,100	2,329,740	876,806	2,070,970	2,818,443	2,931,460	1,868,451
Vehicle Fleet ⁴¹	Miles per fiscal year									
Gasoline vehicles	14,387,937	15,398,472	16,245,101	16,641,864	16,020,335	1,330,631	2,612,584	2,965,782	2,636,025	2,970,681
Diesel vehicles	839,369	1,164,743	1,122,953	1,070,112	955,879	206,190	472,543	516,138	482,244	587,881
Employee Commute ⁴²	Miles per year									
Gasoline vehicles	28,743,765	29,753,238	30,189,499	34,567,433	41,920,000	0	0	0	0	0
Public Lighting ⁴³	KWh									
Electricity	1,602,440	1,602,440	1,602,440	1,682,562	2,301,544	116,978	116,978	116,978	122,827	246,265
Solar	241	241	241	241	241	0	0	0	0	0
Government Solid Waste ⁴⁴	Short tons/year									
	1,800	1,800	1,800	3,222	2,776	42,300	42,300	42,300	75,706	86,746

0 - no use; 2006 data removed due to space constraints.
 Shaded areas represent estimated values

⁴¹ 2006 VMT and costs were interpolated using FY05/06 and FY06/07 data

⁴² 2008 employee VMT were estimated using 2007 and 2010 data

⁴³ 2007 public lighting electricity and cost data were used for 2000, and 2005 through 2007

⁴⁴ 2007 waste totals and costs were used for 2000, and 2005 and 2006; these costs were based on a \$23.50 tipping fee/short ton

APPENDIX I: City of Tucson Government Data

	City Government Operations Data					Expenditures				
	2000	2005	2007	2008	2010	2000	2005	2007	2008	2010
Facility Energy Use	Electricity - KWh; natural gas - therms					Dollars				
Administration Buildings										
Electricity	3,780,863	4,032,921	5,240,735	4,758,640	4,133,663	337,835	359,632	466,933	443,776	423,949
Natural Gas	38,172	55,630	60,526	61,686	37,429	28,917	72,187	61,241	51,186	46,670
Fire Department										
Electricity	2,448,094	2,862,067	3,651,745	2,746,475	2,319,452	217,703	259,041	335,017	253,728	246,119
Natural Gas	42,066	42,608	72,511	46,244	34,783	34,915	46,642	100,826	74,430	50,357
Libraries ⁴⁵										
Electricity	4,150,933	3,732,657	0	0	0	368,580	333,913	0	0	0
Operations										
Electricity	2,912,740	3,569,320	3,850,638	1,947,505	1,577,640	254,067	311,294	337,220	175,309	172,401
Natural Gas	5,361	5,922	5,124	12,518	2,351	4,601	6,985	8,252	26,096	3,698
Parks										
Electricity	1,105,080	1,800,763	1,729,951	1,784,723	1,592,532	97,606	161,163	155,749	162,820	173,437
Natural Gas	60,576	43,863	50,413	11,883	11,370	43,340	45,234	70,624	23,725	18,382
Parks & Recreation										
Electricity	12,173,673	12,311,181	12,724,207	11,087,791	9,930,524	1,080,952	1,102,408	1,146,576	1,021,608	1,029,788
Natural Gas	251,571	297,786	276,248	256,393	222,666	190,368	313,478	309,689	383,265	244,636
Police										
Electricity	6,270,420	3,918,750	3,902,462	5,421,680	7,385,017	509,156	323,638	333,228	478,802	459,268
Natural Gas	74,465	70,020	94,238	76,175	81,515	59,441	80,921	114,874	105,023	105,023
Solid Waste										
Electricity	248,399	310,795	317,602	300,904	158,120	6,898	28,105	28,748	35,203	44,350
Natural Gas	409	839	666	705	126	553	1,125	1,451	1,452	548
Transportation										
Electricity	1,305,901	1,387,711	2,484,724	1,873,987	2,712,496	115,566	124,129	219,925	166,694	276,522
Natural Gas	17,825	14,269	2,925	8,581	16,893	13,403	15,013	4,535	12,666	20,838
Tucson Convention Center										
Electricity	4,212,000	4,581,600	4,702,800	4,737,500	3,843,500	371,986	405,736	419,414	423,431	378,960
Natural Gas	6,722	7,565	6,869	12,620	12,658	5,266	10,750	5,536	16,382	16,122
Tucson Water										
Electricity	1,273,940	1,386,060	1,471,140	1,556,320	1,069,260	113,018	123,596	131,704	139,497	107,381
Natural Gas	900	452	418	845	1,975	1,144	740	958	2,733	3,388
Zoo										
Electricity	1,061,780	912,150	970,920	866,240	791,530	93,054	80,606	86,199	77,257	77,397
Natural Gas	3,486	3,533	3,889	442	240	3,334	4,459	6,751	1,049	701
Other ⁴⁶										
Electricity	4,350,840	4,442,971	6,744,204	7,891,676	6,779,108	386,640	396,052	596,485	698,144	642,151

	City Government Operations Data					Expenditures				
	2000	2005	2007	2008	2010	2000	2005	2007	2008	2010
Potable Water Energy Use	Electricity - KWh; natural gas - ccf					Dollars				
All Potable Systems										
Trico Electricity	5,568,637	34,230,466	40,157,421	43,829,964	47,396,597	575,861	2,403,124	3,871,996	3,256,261	4,353,587
Cathodic Protection										
Electricity	16,293	29,827	34,960	37,661	32,422	1,526	2,682	3,063	3,460	3,370
CAP Canal Pump Station										
Natural Gas	197,541	52,568	30,496	59,401	30,349	92,729	53,704	40,186	82,721	24,956
Lighting										
Electricity	3,270	700	580	680	1,255	448	122	52	63	204
Hayden Udall Water Treatment Plant										
Electricity	3,911,840	3,143,300	3,280,100	2,630,380	1,843,800	206,185	165,496	173,341	140,196	105,938
Natural Gas	37,242	12,971	8,729	51	1,420	44,645	19,160	8,361	1,171	2,532
Plant 1										
Electricity	440,546	501,284	490,019	457,926	448,846	39,515	45,638	44,796	42,749	48,548
Natural Gas	12,185	13,410	14,361	16,653	9,179	10,779	15,926	23,246	27,801	15,336
Plant 2										
Electricity	49,360	52,164	59,015	69,031	67,590	4,405	4,956	5,583	6,708	7,416
Natural Gas	762	254	273	394	568	923	546	732	998	1,210
Plant 3										
Electricity	47,910	0	0	0	0	4,278	0	0	0	0
Plant 4										
Electricity	0	39,960	41,820	43,280	34,110	0	3,607	3,784	4,046	3,670
System Booster Pumps										
Natural Gas	431,877	1,500,107	1,428,808	1,591,388	1,518,879	261,549	1,343,933	2,242,794	1,733,098	1,219,340
Tucson Airport Remediation Project										
Natural Gas	47,031	16,030	32,958	0*	0*	32,207	18,189	16,883	0	0
Water Distribution										
Electricity	19,608,347	21,130,979	21,403,035	20,762,352	20,923,333	1,540,898	1,628,148	1,612,005	1,657,358	1,858,513
Water Distribution & Treatment										
Electricity	354,920	212,120	340,560	422,920	370,520	19,862	12,060	19,305	24,195	24,627
Wells - Avra Valley North										
Natural Gas	776,822	446,055	252,865	294,598	415,926	500,053	514,058	409,789	469,706	346,476
Wells - Avra Valley South										
Electricity	2,746,640	2,529,520	2,910,000	2,309,280	933,840	150,879	139,525	161,484	128,392	57,874
Natural Gas	559,015	605,826	589,440	536,742	372,297	355,610	660,101	876,514	797,943	304,861
Wells - CAVSARP										
Natural Gas	0	1,741,900	1,578,327	1,461,315	1,795,316	0	1,863,028	2,379,371	1,944,003	1,490,640

0 - no use; n.a. - data not available; 2006 data removed due to space constraints.

	City Government Operations Data					Expenditures				
	2000	2005	2007	2008	2010	2000	2005	2007	2008	2010
Potable Water Energy Use	Electricity - KWh; natural gas - ccf					Dollars				
Wells - Central										
Electricity	28,867,614	10,817,171	9,251,160	8,076,411	6,724,433	2,025,405	739,161	641,214	599,810	591,095
Natural Gas	83,594	0	0	0	0	46,084	568	0	0	0
Wells - East										
Electricity	8,520,084	6,041,016	5,042,660	2,707,624	3,065,785	551,429	366,010	310,592	179,029	257,842
Wells - Northwest										
Electricity	2,151,680	1,306,040	882,800	1,597,840	2,568,951	133,778	82,712	58,612	104,049	221,622
Wells - Other										
Electricity	1,775,570	2,638,025	2,314,470	2,372,667	1,184,194	156,996	234,885	204,745	209,301	111,754
Natural Gas	20,771	0	0	0	0	11,485	0	0	0	0
Wells - Park										
Electricity	234,357	401,035	399,114	422,601	362,457	20,902	36,030	35,237	38,547	38,526
Wells - Rillito										
Electricity	6,123,740	4,961,870	3,807,264	2,548,308	1,237,888	463,541	384,320	307,810	220,764	124,181
Wells - Santa Cruz										
Electricity	3,203,084	2,954,049	2,491,395	1,704,484	2,107,472	219,182	210,210	182,953	127,856	189,357
Natural Gas	155,079	175,251	155,642	97,440	67,649	77,438	187,687	209,063	135,499	58,570
Wells - South										
Electricity	11,223,906	9,067,346	8,517,304	8,667,510	6,025,051	835,751	653,628	615,484	635,998	502,288
Natural Gas	33,248	30,675	21,121	12,667	11,237	18,427	34,116	28,793	17,588	8,938
Wells - Southside & TARP										
Electricity	4,050,204	2,162,340	3,043,205	3,366,484	2,951,871	241,374	122,138	173,315	193,675	194,232
Natural Gas	37,706	32,626	24,693	20,338	19,726	20,569	36,234	35,816	28,482	17,616
Wells - Tanque Verde										
Electricity	6,009,343	2,223,409	2,118,461	1,231,186	2,234,243	418,727	155,121	145,321	83,382	175,906
Reclaimed Water Energy Use	Electricity - KWh									
All Reclaimed Systems										
Trico Electricity	980,710	1,111,063	1,868,696	2,139,572	2,065,644	99,167	90,404	214,169	251,357	287,125
Alvernon										
Electricity	1,440	1,100	1,340	1,300	680	127	99	120	120	69
Northeast										
Electricity	921,200	1,042,720	1,090,920	989,510	852,340	50,746	57,910	60,864	55,540	54,226
Northwest										
Electricity	170,240	62,340	387,309	364,734	15,704,956	9,540	3,521	22,284	21,021	1,234,916
Silverbell										
Electricity	1,055,907	1,295,073	3,041,480	3,382,237	3,818,604	59,348	73,896	217,158	249,734	327,232
Southeast										
Electricity	92,878	65,220	78,579	92,956	91,203	8,151	5,744	6,967	8,488	9,636
Southwest										
Electricity	1,114,450	848,140	730,320	534,366	715,270	67,549	52,453	48,182	40,781	54,719

	City Government Operations Data					Expenditures				
	2000	2005	2007	2008	2010	2000	2005	2007	2008	2010
Reclaimed Water Energy Use	Electricity - KWh					Dollars				
Speedway										
Electricity	200,540	207,670	182,040	184,140	173,460	17,868	18,775	16,496	16,857	18,749
Sweetwater										
Electricity	8,658,820	8,557,660	8,739,580	9,042,040	8,660,280	528,999	513,679	526,526	557,696	647,201
Thorneydale										
Electricity	0	0	712,584	985,165	947,194	0	0	62,115	85,727	90,886
12th Avenue										
Electricity	0	0	47,920	63,280	54,160	0	0	4,465	5,955	5,903
Vehicle Fleet ⁴⁷	Gallons/year	Miles/year								
Gasoline vehicles		14,430,006	15,726,626	16,254,928	16,254,928	1,424,508	3,068,344	3,742,401	3,221,418	n.a.
Diesel vehicles		3,070,951	0	178,737	1,777,422	833,309	2,878,285	0	107,887	
CNG vehicles		499,568	161,782	122,883	247,749	0	1,531,950	1,314,739	13,550	
B-20 vehicles		0	4,167,616	3,554,844	1,777,422	0	0	3,911,984	2,437,768	
E-85 vehicles			n.a.	142,351	n.a.	0	n.a.	n.a.	23,672	
Electric					2,547					
Gasoline (gallons)	1,581,063									
Diesel (gallons)	1,064,241									
		18,000,525	20,056,024	20,253,743	20,060,068					
Employee Commute		Miles/year								
Gasoline vehicles	21,178,147	24,309,216	16,957,524	20,189,719	21,135,540	0	0	0	0	0
Public Lighting	Electricity - KWh									
Streetlights	20,008,582	20,008,582	20,008,582	20,473,809	24,375,250	1,400,601	1,400,601	1,400,601	1,842,643	2,193,773
Traffic Lights	4,608,922	4,608,922	4,608,922	4,994,918	5,235,830	322,625	322,625	322,625	449,543	471,225
		Short tons/year								
Government Solid Waste ⁴⁸	8,706	10,404	11,172	12,190	12,322	200,238	239,292	256,958	559,276	631,682
Other										
CAP Totals										
Water Delivery Volume (acre-feet)	12,755	61,596	90,880	127,759	94,201					
Navajo Electricity (KWh)	28,942,279	175,603,186	262,564,182	353,075,292	258,017,399	653,620	4,866,084	7,906,560	11,626,069	11,115,718
Energy (KWh) per acre-foot delivered ⁴⁹	2,269	2,851	2,889	2,764	2,739					

0 – no use; n.a. - data not available; shaded areas represent estimated data

⁴⁵ On July 1, 2006, City libraries became County facilities; 2007, 2008 and 2010 electricity use and expenditures are included with the County government data

⁴⁶ Other facilities include TOPSC Buildings 2, 3 and 5 and Water Stores

⁴⁷ Vehicle data for 2000 represents gallons of fuel and is based on 2001 to 2005 percent change in fuel use and costs

⁴⁸ 2000 to 2007 waste disposal costs are based on \$23.00/short ton tipping fee

⁴⁹ Calculated by Tucson Water (TW) staff (2009) based on amount of water delivered to TW sites

Appendix J. City of Tucson Government Facilities Revised Totals for Select Departments Reflecting City of Tucson Staff Additions, 2012

	City Government Operations Data					Expenditures					Emissions (metric tons) and Energy Use (MMBtu)									
	2005	2006	2007	2008	2010	2005	2006	2007	2008	2010	2005		2006		2007		2008		2010	
Facility Energy Use	Electricity - KWh; natural gas - therms					Dollars					CO ₂ e	MMBtu	CO ₂ e	MMBtu	CO ₂ e	MMBtu	CO ₂ e	MMBtu	CO ₂ e	MMBtu
Parks & Recreation																				
Electricity	13,116,001	13,049,384	13,502,747	11,766,441	10,525,497	1,174,399	1,171,350	1,216,540	1,085,627	1,091,052	11,432	44,765	11,194	44,537	11,689	46,084	10,074	40,159	9,241	35,923
Natural Gas	310,303	592,242	291,116	271,024	235,136	327,576	443,275	330,056	403,887	258,608	1,739	31,030	3,319	59,224	1,632	29,112	1,519	27,102	1,318	23,514
Police																				
Electricity	4,260,070	3,913,913	4,236,222	5,753,400	7,663,657	354,195	322,841	363,261	508,819	493,300	3,713	14,539	3,357	13,358	3,667	14,458	4,926	19,636	6,728	26,156
Natural Gas	72,339	65,466	97,771	80,469	87,219	83,534	96,171	120,297	111,586	113,093	405	7,234	367	6,547	548	9,777	451	8,047	489	8,722
Transportation																				
Electricity	3,120,111	3,825,941	4,305,924	4,260,475	5,657,096	271,660	334,091	374,856	337,214	541,074	2,719	10,649	3,282	13,058	3,727	14,696	2,075	8,273	4,967	19,307
Natural Gas	14,269	13,489	2,925	8,581	16,893	15,013	17,200	4,535	12,666	20,838	80	1,427	76	1,349	16	293	48	858	95	1,689
Other																				
Electricity	8,152,509	9,261,158	10,310,955	11,324,221	9,903,421	713,098	810,112	897,811	991,890	939,822	7,106	27,824	7,944	31,608	8,926	35,191	9,695	38,649	8,694	33,800
Natural Gas	147,379	172,346	95,005	274,866	229,805	152,984	212,435	113,988	118,609	217,717	826	14,738	966	17,235	532	9,501	1,541	27,487	1,288	22,981

Bold: No changes to previous data

Appendix K. Energy Conversion Factors

Unit	Equivalent Btu	Equivalent MMBtu	Equivalent KWh
Electricity			
1 GWh	3,412,141,633	3,412.000	1,000,000
1 MWh	3,412,141	3.412	1,000
1 KWh	3,412	0.003	-
Natural Gas			
1 Therm	100,000	0.100	29.3
Fuel			
1 US gallon (aviation gas)	120,000	0.120	
1 US pound (biodiesel- B-20)	16,928	0.016	
1 gallon (CNG)	20,000	0.020	
1 US gallon (diesel)	139,000	0.139	
1 US gallon (gasoline)	124,000	0.124	
1 US gallon (Jet A)	135,000	0.135	
1 US gallon (locomotive diesel)	139,000	0.139	
1 US gallon (propane)	91,000	0.091	

Appendix L. Per Capita Greenhouse Gas Emissions (metric tonsCO₂e/person)

	United States ⁵⁰	Arizona ⁵¹	Eastern Pima County ^{52,53}	Tucson ^{53,54}
1990	19.7	18.0	15.8	13.5
2000	20.8	17.3	16.6	15.0
2005	18.9	16.9	15.9	14.1
2006	18.4	16.7	15.9	14.0
2007	18.5	16.7	16.3	14.3
2008	18.0	16.8	15.0	13.3
2010	17.8	n.a.	15.2	13.6

Shading indicates estimates

⁵⁰ 1990, 2000 and 2010 data from the *Trends in CO₂ Emissions – 2012 Report*. PBL Netherlands Environmental Assessment Agency. <http://www.pbl.nl/en/publications/2012/trends-in-global-co2-emissions-2012-report>.

2005, 2006, 2007 and 2008 data from The World Databank. The World Bank. Accessed 9/26/12. <http://databank.worldbank.org/ddp/home.do>.

⁵¹ **Arizona populations:** Arizona Department of Commerce <http://www.azcommerce.com/EconInfo/Demographics/>; **Emissions:** 1990, 2000 data from Arizona Climate Action Plan: Shading - estimates for 2005, 2006, 2007 and 2008 are based on linear interpolation from 2000 and reference case projections for 2010 (Center for Climate Strategies, 2006). <http://www.azclimatechange.gov/download/O40F9293.pdf>.

⁵² Per capita values estimated using total emissions divided by total population of the geographic area.

⁵³ **E. Pima County populations:** estimated by applying a 0.96 allocation factor to Pima County population total from the Arizona Department of Commerce <http://www.workforce.az.gov/population-estimates.aspx>. **Emissions:** PAG's Regional GHG Emissions Inventory 1990-2010.

⁵⁴ **Tucson populations:** Arizona Department of Commerce <http://www.workforce.az.gov/population-estimates.aspx>. **Emissions:** PAG's Regional GHG Emissions Inventory 1990-2010.