

## Regional Greenhouse Gas Inventory Addendum - 2009

### 1. Executive Summary

Pima Association of Governments (PAG), on behalf of Pima County and the City of Tucson, has updated the initial *Regional Greenhouse Gas (GHG) Emissions Inventory* released in November 2008 (PAG, 2008). This addendum contains minor revisions to the 1990 to 2006 community data from the previous report and adds 2007 eastern Pima County and Tucson (County and the City, respectively) community GHG emissions and energy use data. As before, the County includes the City and surrounding metropolitan jurisdictions. Additionally, this supplement includes updates to the 2000 to 2007 County and City government emissions and energy use data.

Tables, figures and appendices presented in this addendum serve to replace the corresponding items in the initial report. This inventory continues to be a living document and will be updated as new and more accurate data become available.

County GHG emissions increased by 55 percent from 1990 to 2007, while emissions generated within the City showed a 41 percent increase over the same period. Most of these increases can be attributed to the continued rapid rise in County and City populations with concurrent increases in energy use. Nationally, GHG emissions only increased 17 percent from 1990 to 2007 (USEPA, 2009), reflecting the slower population growth. County and City per capita GHG emissions remained low compared to national averages. In 2007, U.S. per capita emissions were 24 metric tons of carbon dioxide equivalents (CO<sub>2</sub>e), while County and City per capita emissions were 16 and 14 metric tons CO<sub>2</sub>e respectively.

Using the Clean Air and Climate Protection (CACP) model, County emissions for 2007 were estimated to be 15.8 million metric tons CO<sub>2</sub>e. Energy use by the various economic sectors and transportation continued to generate the largest share of GHG emissions at both the County and City levels. In 2007, combined residential, commercial and industrial energy uses were 63 percent of emissions. Transportation emissions contributed 35 percent to the 2007 total County GHG emissions

In 2007, City GHG emissions were slightly less than half of the County's (7.7 million metric tons of CO<sub>2</sub>e) with the major sources and trends mirrored those of the County. Emissions from the City's combined residential, commercial and industrial energy use comprised 63 percent of the total while transportation emissions contributed 34 percent to the City's 2007 total emissions.

Waste-related emissions continued to be a small portion of total emissions; County waste emissions were 2 percent, and City waste emissions were 3 percent of County and City community totals, respectively.

The County and City government operations inventories were revised slightly to incorporate updated electricity emission factors for 2006 (Trico) and 2007 (TEP). As a consequence, County government emissions rose slightly over those originally reported for 2000 to 2007, to 48 percent and the City government remained unchanged with a 6 percent decline. Tucson Water energy-related emissions from Central Arizona Project (CAP) water delivery (2000, and 2005 through 2007) are included in this update. Although not included in the City's community or government totals, energy-related emissions from CAP water transport are increasing rapidly and exceed the City government emission estimates for 2007.

For both government entities, 2007 emissions remain a small portion of community emissions; County government emissions represent about 1 percent and City government emissions are approximately 3 percent of their respective community totals.

## **2. General Methodology**

This addendum provides 2007 data for County and City emissions and energy consumption and revisions and updates to data presented in the *Regional Greenhouse Gas (GHG) Emissions Inventory* (PAG, 2008). The methods used to estimate GHG emissions and energy use were very similar to those used in the initial report and are summarized below. Any deviation from the initial methods or emissions factors is highlighted.

### **I. Community Inventories**

#### **Residential, Commercial and Industrial (RCI) Sector Energy Use**

##### 2007 Data Update

Energy use for the RCI sectors includes natural gas and electricity only. As before, other fuel sources such as heating oil and wood are not included in this update. Electricity and natural gas use was disaggregated into residential, commercial and industrial sectors. Electricity use data for 2007 were submitted by Tucson Electric Power (TEP), Trico and the Tohono O'odham Utility Authority. Electricity generation emission factors for 2007 (Appendix C- R) were calculated using data from TEP and Trico and were applied to electricity consumption data to estimate CO<sub>2</sub>e emissions, as before.

Southwest Gas provided 2007 natural gas consumption by sector and as before, CO<sub>2</sub>e emissions were calculated by applying emission factors from the Department of Energy's Voluntary Greenhouse Gas Emissions Reporting Guidelines.

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.

##### Changes to the PAG (2008) Report:

In the initial report, an error in the Trico 2006 emission factor was corrected and is shown in Appendix C- R. As a result of this change, 2006 County emissions for each sector's electricity, sector energy subtotals and 2006 grand total were updated (Table 1-R). Additionally, a typographical error for 2006 residential electricity use (MMBtu) was corrected (Table 1-R).

#### **On-Road Transportation**

Transportation from on-road vehicles was disaggregated by vehicle and fuel type. Emissions from on-road vehicle fuel use are calculated for gasoline, diesel, B-20 and compressed natural gas (CNG). Data are entered as vehicle miles traveled (VMT) per year by vehicle and fuel type. Currently, emissions and energy use from nonroad vehicles and equipment are not presented in this addendum but are being investigated.

##### 2007 Data Update

##### *Private and Commercial Vehicle Miles Traveled (VMT)*

PAG's Transportation Planning Department provided 2007 VMT data by jurisdiction. A newer, more precise model was used which estimated VMT driven in the County and within the City and is detailed in the following section. This method differs from that used previously where a predetermined percentage was applied to County VMT (49.2 percent) to determine City VMT for all inventory years.

### Changes to the PAG (2008) Report:

The addendum employs a more precise travel demand model for estimating City and County VMT for 2005 and 2006. As a result, County and City estimated VMT for 2005 and 2006 are higher than previously reported, requiring greater energy consumption and generating more GHG emissions (Tables 1-R and 3-R; Appendices D-R and G-R). The changes in County and City VMT estimates can be explained by the improvements in the travel demand model and the difference in the model inputs. The newer model:

- used finalized socioeconomic input data for 2005; the initial model used draft socioeconomic input data for the base year (2005). Employment differences between the draft and final datasets were considerable;
- isolates VMT driven in the City, whereas the initial inventory used a fixed percentage of County VMT to estimate City VMT;
- provides greater accuracy in accounting for roadway congestion and delays and consequently can better track route traffic;
- employs additional procedures for more precise estimation of regional travel patterns including the University of Arizona Student Residence Choice Model.

### *Other Transportation*

#### 2007 Data Update

County and City VMT data from Cat Tran, Coyote Run, Old Pueblo Trolley, Rural Transit, Special Needs, Sun Tran, Sun Van and Ticet were submitted for 2007. These are referred to as "Other Transportation" in Table 1-R and are listed individually in Appendices D-R and G-R. Emission calculations were performed in the same manner as in the previous report for all vehicle types.

### Changes to the PAG (2008) Report:

A correction was made in the calculation method for allocating 2006 Cat Tran diesel VMT. This recalculation accounts for the slight reduction in CO<sub>2</sub>e emissions and energy use reported previously (Tables 1-R and 3-R; Appendices D-R and G-R).

### **Waste**

#### 2007 Data Update

Waste disposal data were provided for the Ina, Sahuarita, Tangerine and Los Reales landfills for 2007 (Appendices D-R and G-R). Waste totals were factored by disposal method and composition and characterized using methods as stated in the previous PAG report (Cascadia, 2003; Cascadia, 2004; Cascadia, 2006).

### Changes to the PAG (2008) Report:

The 2000 Ina landfill waste total reported in Appendix D was a typographical error. The corrected 2000 Ina waste total appears in Appendix D-R.

## *Diverted Waste*

### 2007 Data Update

Recycled waste information was obtained from the Ina, Sahuarita, Tangerine, Catalina and Los Reales facilities and County and City curbside pick-up and private hauler programs for 2007 (Appendices D-R and G-R). EPA released a new version (9.0) of the WARM model in 2008, and it was revised in March 2009 (9.01) (USEPA, 2009b). The newest WARM version contains updated waste emission and waste/energy conversion factors (Appendix F-R). Version 9.01 was used to determine 2007 GHG emission and energy savings resulting from waste diversion. As before, landfill benefits for Los Reales gas capture were included in the calculations for 2007, using the national average methane capture efficiency (75 percent). Emissions and energy savings from waste diversion are not included in the County or City inventory totals.

### Changes to the PAG (2008) Report:

The CO<sub>2</sub>e emissions and energy reductions realized through waste diversion were recalculated for 1990, 2000, 2005 and 2006 using the WARM 9.01 model. Additionally, 2005 and 2006 recycling totals, emission and energy savings were revised to reflect updated information from Los Reales and private haulers.

## **Other**

### 2007 Data Update

#### *Locomotive Emissions*

All locomotive emissions were allotted to the County inventory due to the difficulty isolating tract sections and fuel usage within the city limits. Locomotive yard and line haul fuel use data for 2007 were submitted by Union Pacific Railroad (UPRR). As before, EIA's (2007) 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 inventory due to the difficulty in apportioning County vs. City airshed emissions. Aviation gas and Jet A fuel use data were collected from TIA, Ryan Airfield and Marana Airport for 2007. Davis-Monthan fuel use information was not available for public release. Emissions were calculated in the same manner as in the previous inventory using EIA's emission factors (EIA, 2007) for aviation gas and Jet A.

#### *Propane*

State propane sales for 2007 were obtained from the Arizona Department of Commerce, Energy Office (2008). As before, County and City sales were allocated using population data and GHG emissions were estimated using CACP model emission factors.

## **Industrial Processes**

### 2007 Data Update

Although efforts were made to acquire data from other County industries, this update only contains data from Arizona Portland Cement and Freeport-McMoRan, (formally Phelps Dodge) two of the larger industries.

### *Arizona Portland Cement (APC)*

The Arizona Department of Environmental Quality (ADEQ) provided APC clinker production data for 2007 (Appendix D-R). Cement production emissions were calculated in the same manner as previously reported (USEPA, 2008, 2009a; IPCC, 2006).

ADEQ staff provided diesel and B-20 use information for 2007 (Appendix D-R). Emissions were calculated as before, applying diesel and biodiesel emission factors imbedded in the CACP model.

### *Freeport- McMoRan Sierrita Mine*

Data for diesel fuel used in blasting operations were provided by ADEQ for 2007 (Appendix D-R). Emissions were estimated using the diesel CACP model emission factors.

### Changes to the PAG (2008) Report:

For conformity with other fuel emission calculations, Freeport-McMoRan's diesel fuel emissions were recalculated using CACP model emissions factors (Table 1-R). The previous report used EIA's diesel emission factors.

## **II. Government Operations Inventories**

### **Other**

#### 2007 Data Update

Electricity use and the associated GHG emissions from the Central Arizona Project (CAP) water delivery to Tucson Water (TW) were included in this update (Appendix I- R, Table 6-R). TW began delivering CAP water in 1992, but due to water-quality issues, CAP water was relegated to recharge and recovery use only (City of Tucson Water Report, 2004). TW uses most of its CAP allotment for its storage and recovery projects in Avra Valley (CAVSARP and SAVSARP). In addition, TW participates in the Pima Mine Road Recharge Project, (north of Sahuarita) and in groundwater savings facilities (GSFs), which provides growers with CAP water in lieu of groundwater (City of Tucson Water Report, 2004). These facilities have different delivery points along the CAP canal and consequently, the energy required for delivery to individual facilities may not be the same.

To estimate electricity use, data from individual pump stations were used to compute the energy needed to deliver an acre-foot<sup>1</sup> (AF) of water to every location used by TW (CAP, personal communication, 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. 2009) (Appendix I-R). CAP water deliveries for 2000, 2005, 2006 and 2007 for each facility were obtained from CAP Water Use Accounting Reports.

The Navajo Generating Station (NGS) provides electricity for CAP water conveyance; electricity emission factors were calculated using EPA emissions data (USEPA, 2009c) and the Department of Energy Information Administration's electricity use data (EIA, 2009) (Appendix C-R).

GHG emissions for the various years were estimated by applying the NGS 2000, 2005, 2006 and 2007 emission factors to the annual electricity usage (Table 6-R). Although estimated, CAP related emissions and energy consumption were not included in the City government totals but are listed as "Other" (Table 6-R). CAP energy use emissions were excluded from the City government total

---

<sup>1</sup> An acre-foot (AF) equals 325,851 gallons, approximately the amount of water used by a family of four for one year

emissions to preserve the relationship between City community emissions and City government emissions. CAP energy use and emissions are not currently included in the City community totals (1990 to 2007) since CAP water delivery only began in 1992.

CAP expenditures were calculated using a cost per AF<sup>2</sup> and the total volume of water delivered to TW (Central Arizona Water Conservation District- 2005-2007; Philbin, A. [2000 data], personal communication, 2009).

#### Changes to the PAG (2008) Report:

### **Facilities, Wastewater Treatment, Water Pumping and Public Lighting Electricity Emissions**

In the previous report (PAG, 2008), a 2006 TEP emission factor was used to estimate 2007 electricity emissions for the County and City governments. Since that time, a 2007 TEP emission factor became available (Appendix C-R). The new factor was applied to the electricity consumption data to recalculate emissions. Consequently, the 2007 TEP electricity emissions for County facilities, wastewater treatment and public lighting were updated (Table 5-R). Additionally, the 2007 City government TEP electricity emissions for facilities, potable and reclaimed water and public lighting were revised (Table 6-R).

A modified Trico emission factor (Appendix C-R), was used to recalculate the City's Trico electricity use emissions for potable and reclaimed water for 2006 (Table 6-R).

Note that any subtotals and/or totals that include 2007 TEP electricity or 2006 Trico electricity emissions were adjusted to reflect these emission factor updates.

### **Appendices**

#### 2007 Data Update:

Several appendices have been added to the update:

- Appendix J includes energy conversion units for various fuel and energy types included in the report
- Appendix K contains information on the per capita emissions for the U.S., Arizona, County and City residents

#### Changes to the PAG (2008) Report:

Appendices C, D, F, G and I have been updated to reflect data changes and additions. These revised documents are replacements for the corresponding appendices published in the initial report (PAG, 2008).

---

<sup>2</sup> Cost per AF of water: **2000:** \$54.00/AF; incentive water: \$44.00/AF; **2005:** \$79.00/AF; **2006:** \$85.00/AF; **2007:** \$87.00/AF

### 3. Updated Results

#### I. Community Inventories

##### A. Eastern Pima County

##### Residential, Commercial, Industrial (RCI) Energy Use

Energy use by the RCI sectors remained the greatest contributor to GHG emissions over this survey period (Figure 2-R). From 1990 to 2007, County residential energy use emissions increased by 83 percent, commercial emissions rose by 64 percent and industrial emissions increased by 24 percent (Figure 3-R; Table 1-R). Combined 2007 RCI energy use produced 63 percent of the County's total emissions (Figure 4-R). Of the 2007 emissions, approximately 56 percent can be attributed to RCI electricity use; natural gas usage is responsible for 7 percent of total emissions (Figure 5-R).

##### On-Road Transportation

From 1990 to 2007, transportation emissions increased by 59 percent, reflecting a greater rate of change than could be predicted by using the older, less precise transportation planning model. Private and commercial vehicle County VMT increased by 91 percent from 1990 to 2007, and is responsible for over 99 percent of transportation emissions. In 2007, transportation-related emissions were approximately 35 percent of total 2007 County emissions (Figure 4-R).

##### Waste Disposal

Since data from all County landfills were not available for 1990, comparisons can only be made between 2000 and 2007. Emissions from waste disposal over this seven-year period increased by 10 percent, but remain a small component of total emissions. In 2007, waste-related emissions contributed 2 percent to total County emissions (Figure 4-R).

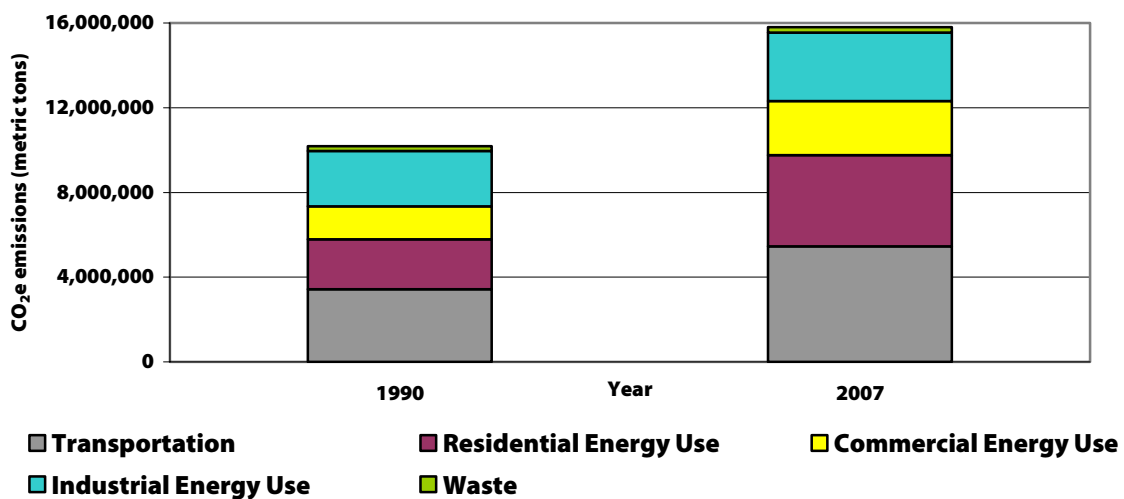


Figure 2-R. Comparison of Eastern Pima County GHG Emissions by Sector 1990 and 2007

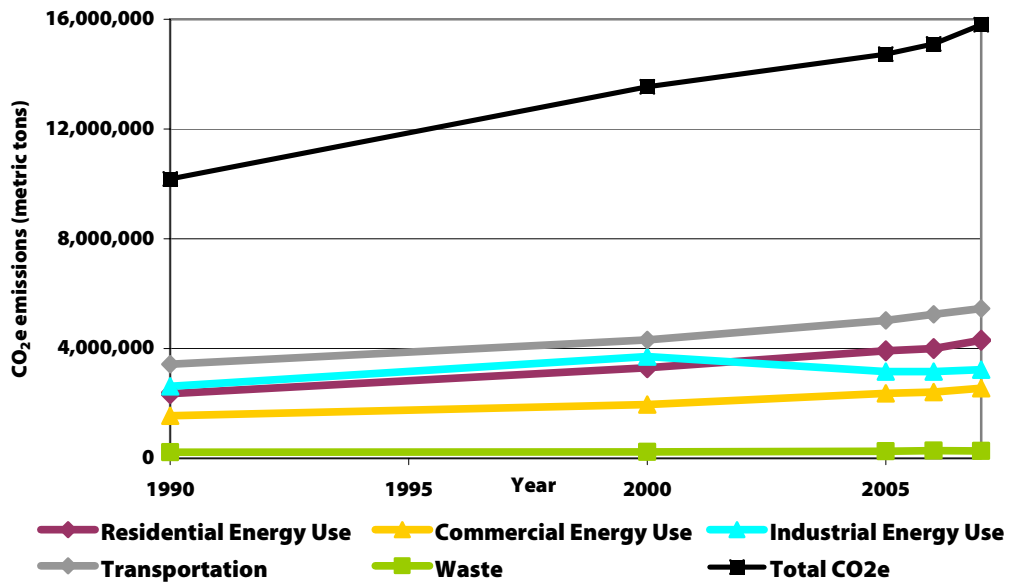


Figure 3-R. Eastern Pima County GHG Emissions 1990 to 2007

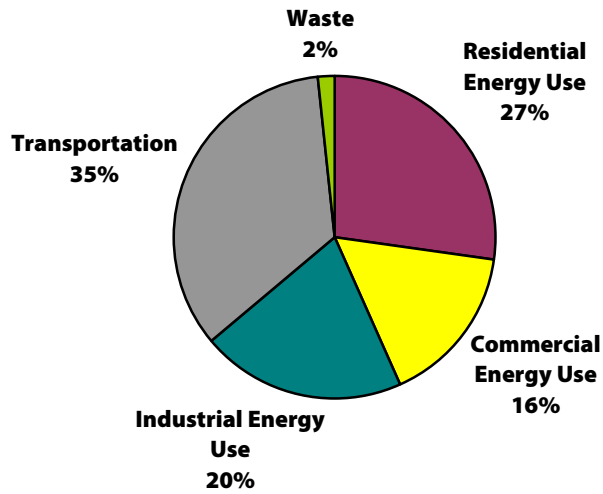
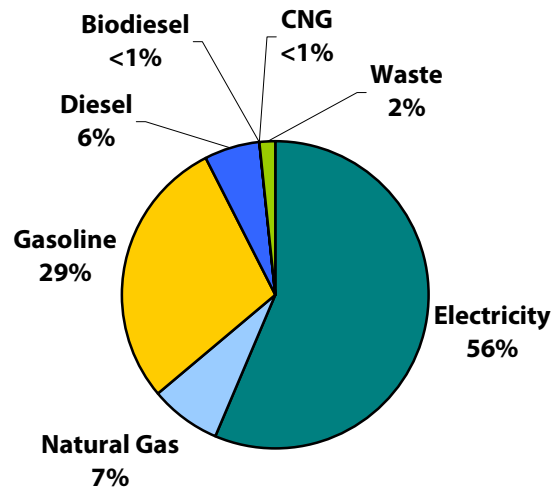


Figure 4-R. 2007 Eastern Pima County GHG Emissions by Sector



**Figure 5-R.** 2007 Eastern Pima County GHG Emissions by Source

**Table 1-R. Eastern Pima County Greenhouse Gas Emissions (metric tons CO<sub>2</sub>e) and Energy (million Btu) 1990 to 2007**

	1990		2000		2005		2006		2007		Percent CO <sub>2</sub> e change 1990-2007
	CO <sub>2</sub> e (metric tons)	MMBtu	CO <sub>2</sub> e (metric tons)	MMBtu	CO <sub>2</sub> e (metric tons)	MMBtu	CO <sub>2</sub> e (metric tons)	MMBtu	CO <sub>2</sub> e (metric tons)	MMBtu	
<b>Residential Energy Use</b>											
Natural Gas	451,025	8,047,134	503,455	8,982,587	469,901	8,383,912	459,469	8,197,794	<b>500,089</b>	<b>8,922,535</b>	
Electricity	1,901,924	7,373,084	2,801,674	11,114,183	3,446,426	13,439,430	<b>3,542,602</b>	<b>14,024,024</b>	<b>3,804,655</b>	<b>14,929,776</b>	
<b>Residential Total</b>	<b>2,352,949</b>	<b>15,420,218</b>	<b>3,305,129</b>	<b>20,096,770</b>	<b>3,916,327</b>	<b>21,823,342</b>	<b>4,002,071</b>	<b>22,221,818</b>	<b>4,304,744</b>	<b>23,852,311</b>	83
<b>Commercial Energy Use</b>											
Natural Gas	319,789	5,705,634	347,013	6,191,368	330,103	5,889,666	337,429	6,020,365	<b>349,561</b>	<b>6,236,834</b>	
Electricity	1,235,612	4,787,865	1,617,714	6,413,811	2,036,099	7,822,904	<b>2,080,283</b>	8,245,709	<b>2,202,813</b>	<b>8,638,002</b>	
<b>Commercial Total</b>	<b>1,555,401</b>	<b>10,493,499</b>	<b>1,964,727</b>	<b>12,605,179</b>	<b>2,366,202</b>	<b>13,712,570</b>	<b>2,417,712</b>	<b>14,266,074</b>	<b>2,552,374</b>	<b>14,874,836</b>	64
<b>Industrial Energy Use</b>											
Natural Gas	164,644	2,937,558	703,455	12,550,967	391,949	6,993,109	370,937	6,618,219	<b>333,948</b>	<b>5,958,263</b>	
Electricity	2,454,013	9,517,092	3,009,036	11,924,148	2,768,660	10,835,382	<b>2,792,468</b>	11,127,712	<b>2,901,334</b>	<b>11,433,643</b>	
<b>Industrial Total</b>	<b>2,618,657</b>	<b>12,454,650</b>	<b>3,712,491</b>	<b>24,475,115</b>	<b>3,160,609</b>	<b>17,828,491</b>	<b>3,163,405</b>	<b>17,745,931</b>	<b>3,235,282</b>	<b>17,391,906</b>	24
<b>Transportation</b>											
Private & commercial vehicle use <sup>3</sup>	3,415,256	43,660,650	4,298,737	55,000,983	<b>5,017,473</b>	<b>64,473,476</b>	<b>5,228,236</b>	<b>67,219,629</b>	<b>5,438,409</b>	<b>69,951,783</b>	
Other Transportation	14,540	185,018	14,673	195,283	13,534	195,307	<b>15,475</b>	<b>229,200</b>	<b>13,620</b>	<b>212,169</b>	
<b>Transportation Total</b>	<b>3,429,796</b>	<b>43,845,668</b>	<b>4,313,410</b>	<b>55,196,266</b>	<b>5,031,007</b>	<b>64,668,783</b>	<b>5,243,711</b>	<b>67,448,829</b>	<b>5,452,029</b>	<b>70,163,952</b>	59
<b>Waste Disposal Total<sup>4</sup></b>	<b>224,689</b>		<b>238,610</b>		<b>258,024</b>		<b>274,245</b>		<b>262,752</b>		-
<b>Total</b>	<b>10,181,492</b>	<b>82,214,035</b>	<b>13,534,367</b>	<b>112,373,330</b>	<b>14,732,169</b>	<b>118,033,186</b>	<b>15,101,144</b>	<b>121,682,652</b>	<b>15,807,181</b>	<b>126,283,005</b>	55
<b>Other</b>											
Locomotives <sup>5</sup>	n.a.	n.a.	89,632	1,216,198	84,657	1,148,674	86,620	1,175,733	<b>90,343</b>	<b>1,225,840</b>	
Aviation Gas <sup>6</sup>	56	793	456	6,320	515	5,882	495	6,966	<b>839</b>	<b>11,676</b>	
Jet A <sup>6</sup>	38,682	540,000	31,413	438,534	35,566	496,555	33,859	472,723	<b>39,376</b>	<b>549,702</b>	
Propane	n.a.	n.a.	86,242	1,282,001	92,717	1,378,254	84,343	1,253,772	<b>91,431</b>	<b>1,359,141</b>	
<b>Industrial Processes</b>	n.a.	n.a.									
AZ Portland Cement (process)			924,275	0	1,049,413	0	1,068,429	0	<b>1,237,594</b>	<b>0</b>	
AZ Portland Cement (fuel)			157	2,182	70	970	150	<b>2,388</b>	<b>216</b>	<b>4,162</b>	
Phelps Dodge (fuel)			<b>2,400</b>	33,364	<b>2,021</b>	28,089	<b>1,911</b>	<b>26,567</b>	<b>2,202</b>	<b>30,604</b>	

n.a.- data not available

**BOLD** : Represents changes from previous report (PAG, 2008)

<sup>3</sup>Transportation VMT data from 1990 and 2000 were estimated using a different PAG transportation model than the model used for 2005 through 2007

<sup>4</sup>1990 waste disposal from Los Reales only; 2000, 2005 through 2007 data are from all County landfills

<sup>5</sup>2000 locomotive fuel use are taken from Emission Inventories for the Tucson Air Planning Area. (Envair, 2001); 2005 through 2007 data were supplied by UPRR

<sup>6</sup>Aviation gas and Jet A totals for 1990 reflect only Ryan Airfield and TIA use; 2000, 2005 through 2007 totals represent all County airports

## Diverted Waste

County emission and energy savings from waste diversion lack a clear pattern over the 1990-2007 period due to the inconsistency in data availability (Table 2-R). Recycling data submissions for 1990 and 2000 were incomplete and consequently, this emission and energy savings data cannot be compared with the 2005 through 2007 results that has complete information for County and City recycling programs.

**Table 2-R.** Summary of County Recycled Waste Activity and Emission and Energy Savings 1990 to 2007

All Pima County Facilities and Collections <sup>7</sup>	Recycled Waste (metric tons)	CO <sub>2</sub> e Saved (metric tons)	MMBtus Saved
<i>1990</i>	<i>51,710</i>	<b>255,792</b>	<b>1,004,291</b>
<i>2000</i>	<i>30,744</i>	<b>50,984</b>	<b>505,703</b>
2005	<b>86,157</b>	<b>196,686</b>	<b>1,545,956</b>
2006	<b>97,183</b>	<b>259,791</b>	<b>2,174,543</b>
2007	<b>95,902</b>	<b>255,578</b>	<b>2,202,797</b>

**Bold:** Represents changes from previous report (PAG, 2008)

**Italics:** Incomplete data

## Other

Emissions and energy consumption by locomotives, aircraft and propane fuel use are presented but not included in County totals due to incomplete data for 1990 (Table 1-R; Appendix D-R).

### Locomotive Emissions

From 2000 to 2007, locomotive fuel emissions remained relatively constant, increasing by less than 1 percent.

### Aviation Fuels: Aviation Gas and Jet A

The totals shown in Table 1-R represent the total sum of emissions by fuel type for TIA, Marana and Ryan airports combined. From 2000 to 2007, GHG emissions from aviation gas increased by 84 percent while jet A emissions increased by 25 percent. Overall, the combined aviation fuel emissions increased by 26 percent over this 7-year period.

### Propane

Emissions from County propane use increased by 6 percent from 2000 to 2007.

## Industrial Processes

### Arizona Portland Cement (APC)

Emissions from cement manufacturing have increased by 34 percent from 2000 to 2007. APC fuel emissions increased by 38 percent from 2000 to 2007.

---

<sup>7</sup> 1990 data represent only Los Reales voluntary recycling. The 2000 totals represent green bin City curbside pick-up and County landfills' collections only. Totals for 2005 through 2007 represent volunteer drop-offs, curbside and commercial City and County recycling activities and private hauler collections

## *Freeport-McMoRan Sierrita Mine*

Diesel fuel use emissions declined 8 percent from 2000 to 2007.

### **Pima County Synopsis**

From 1990 to 2007, County GHG emissions grew by 5.6 million metric tons, an estimated 55 percent increase. Emissions due to sector energy use and transportation continued to rise and remained the major sources of GHG emissions over this period. County per capita emissions rose slightly over this time period, averaging about 16 metric tons of CO<sub>2</sub>e per County resident (Appendix K).

The rate of emissions increase from all economic sectors rose appreciably from 1990 to 2007. Residential energy use emissions experienced an 83 percent increase, commercial emissions exhibited a 64 percent increase and industrial GHG emissions showed a 24 percent rise. Electricity is the major energy source and was responsible for 56 percent of energy-related emissions in 2007. Most of these increases can be attributed to the continued, rapid expansion in County and economic growth and the associated increase in energy use.

Transportation emissions continue to be a significant source of emissions, rising by 59 percent from 1990 to 2007. Most of this increase can be attributed to County private and commercial VMT which rose by 91 percent from 1990 to 2007. Transportation emissions contributed 35 percent to total 2007 County emissions; 99 percent of which was generated by private and commercial vehicle travel. A reliable per vehicle emission estimate for County vehicles could not be determined, however, EPA estimates that the average U.S. passenger vehicle generates 5.5 million metric tons per year (EPA, 2005). EPA estimates are based on a vehicle averaging 20.3 miles per gallon of gasoline and driving 12,000 miles per year.

Emissions associated with County solid waste disposal have increased 10 percent from 2000 to 2007, but their relative contribution to County totals remains low (less than 2 percent).

## **B. Tucson**

### **Residential, Commercial, Industrial (RCI) Energy Use**

Trends in Tucson's energy-related emissions continue to track those of the County (Figure 6-R). However, the City's rate of emissions increase is much lower than that of the County, largely due to the City's slower population growth (Figure 7-R). From 1990 to 2007, residential and commercial energy emissions rose by 40 percent and 52 percent, respectively.

Industrial emissions increased by only 19 percent from 1990 to 2007 (Table 3-R). Combined RCI energy use produced 63 percent of the City's GHG emissions in 2007 (Figure 8-R); approximately 54 percent of these emissions can be attributed to electricity use. Natural gas use contributes much less, representing 9 percent of the total City GHG emissions in 2007 (Figure 9-R).

### **On-Road Transportation**

From 1990 to 2007, transportation emissions increased by 55 percent (Table 3-R), most of which can be attributed to private and commercial vehicle travel. From 1990 to 2007, private and commercial vehicle travel within the City increased by 87 percent (Appendix G-R), and is responsible for over 99 percent of transportation emissions. Transportation-related emissions were approximately 34 percent of total 2007 City emissions.

## Waste Disposal

From 1990 to 2007, emissions from wastes disposed at Los Reales increased by 8 percent (Table 3-R), and remain a small component of total emissions, contributing 3 percent to total City emissions (Figure 8-R).

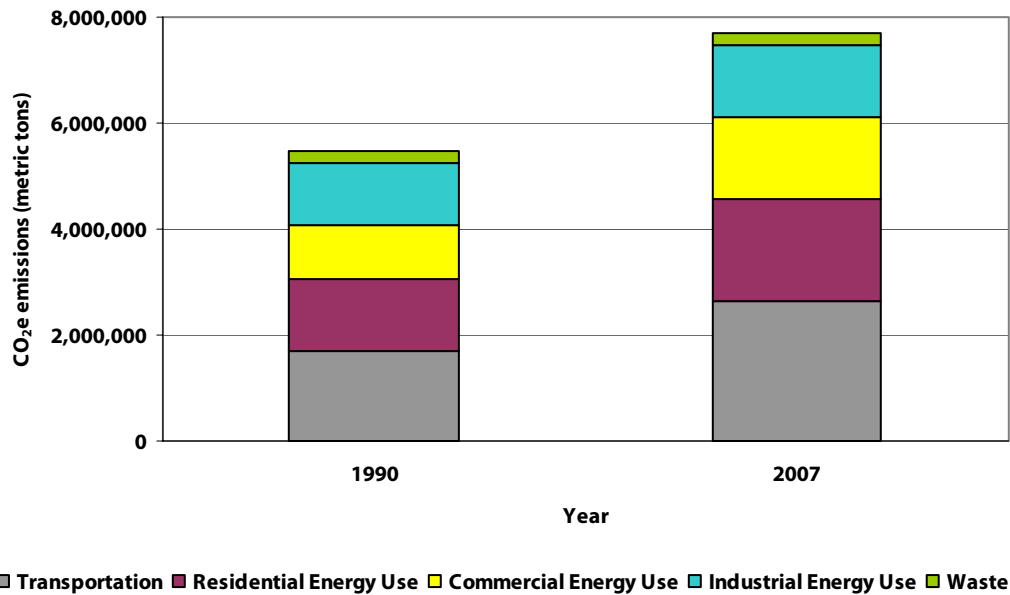


Figure 6-R. Comparison of Tucson GHG Emissions by Sector 1990 and 2007

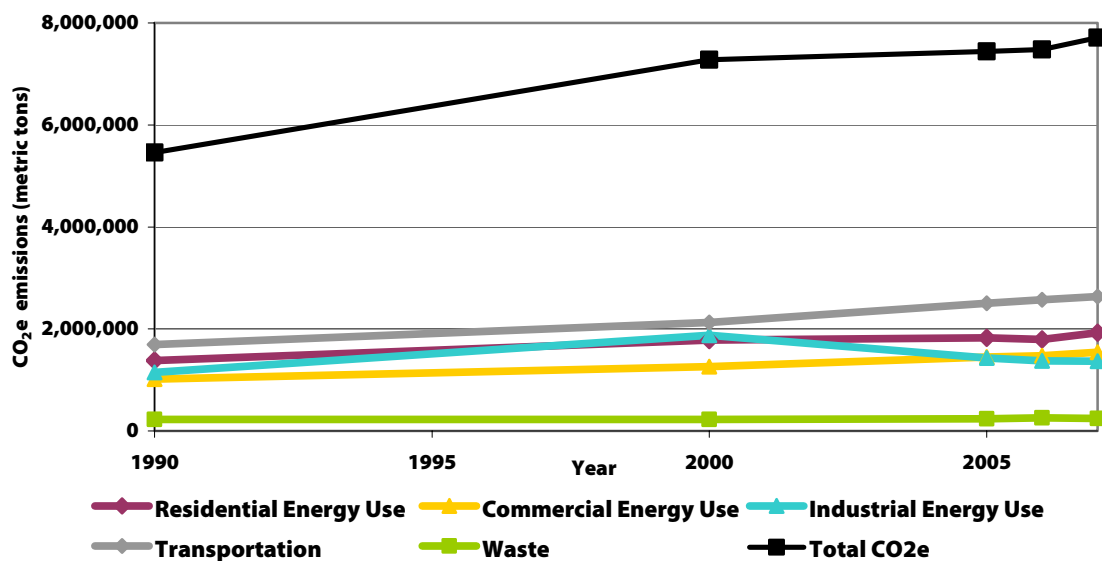
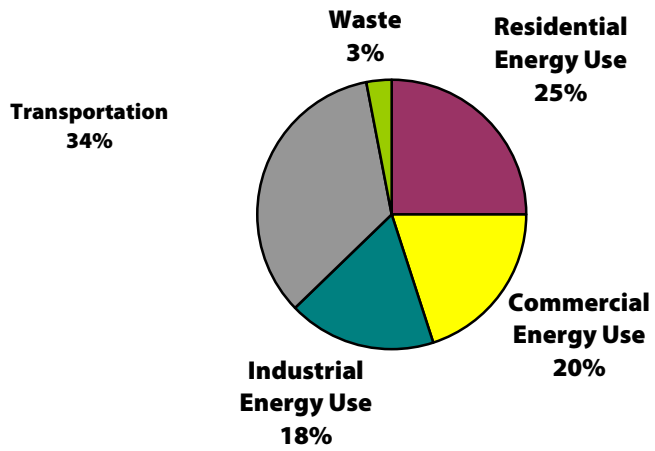
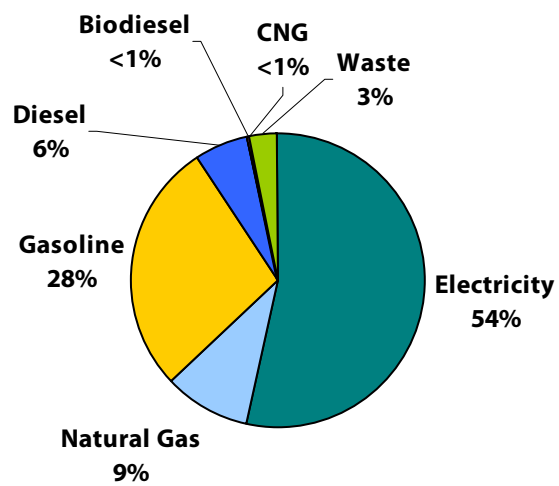


Figure 7-R. Tucson GHG Emissions 1990 to 2007



**Figure 8-R.** 2007 Tucson GHG Emissions by Sector



**Figure 9-R.** 2007 Tucson GHG Emissions by Source

**Table 3-R. Tucson Greenhouse Gas Emissions (metric tons CO<sub>2</sub>e) and Energy (million Btu) 1990-2007**

	1990		2000		2005		2006		2007		Percent CO <sub>2</sub> e change 1990-2007
	CO <sub>2</sub> e (metric tons)	MMBtu	CO <sub>2</sub> e (metric tons)	MMBtu	CO <sub>2</sub> e (metric tons)	MMBtu	CO <sub>2</sub> e (metric tons)	MMBtu	CO <sub>2</sub> e (metric tons)	MMBtu	
<b>Residential Energy Use</b>											
Natural Gas <sup>8</sup>	218,344	3,895,675	243,726	4,348,534	227,482	4,058,711	222,432	3,968,610	<b>242,097</b>	<b>4,319,463</b>	11
Electricity <sup>9</sup>	1,159,530	4,485,563	1,541,177	6,103,652	1,596,105	6,250,003	1,571,870	6,253,955	<b>1,683,662</b>	<b>6,638,158</b>	45
<b>Residential Total</b>	<b>1,377,874</b>	<b>8,381,238</b>	<b>1,784,903</b>	<b>10,452,186</b>	<b>1,823,587</b>	<b>10,308,714</b>	<b>1,794,302</b>	<b>10,222,565</b>	<b>1,925,759</b>	<b>10,957,621</b>	40
<b>Commercial Energy Use</b>											
Natural Gas <sup>8</sup>	173,071	3,087,921	187,805	3,350,802	178,654	3,187,519	182,618	3,258,254	<b>189,185</b>	<b>3,375,409</b>	9
Electricity <sup>9</sup>	844,324	3,266,212	1,071,749	4,244,539	1,272,901	4,984,404	1,293,813	5,147,660	<b>1,356,546</b>	<b>5,348,442</b>	61
<b>Commercial Total</b>	<b>1,017,395</b>	<b>6,354,133</b>	<b>1,259,554</b>	<b>7,595,341</b>	<b>1,451,555</b>	<b>8,171,923</b>	<b>1,476,431</b>	<b>8,405,914</b>	<b>1,545,731</b>	<b>8,723,851</b>	52
<b>Industrial Energy Use</b>											
Natural Gas <sup>8</sup>	143,699	2,563,865	613,967	10,954,330	342,088	6,103,499	323,749	5,776,300	<b>291,486</b>	<b>5,200,660</b>	103
Electricity <sup>10</sup>	1,002,743	3,879,044	1,263,460	5,003,788	1,086,654	4,255,102	1,053,015	4,189,603	<b>1,074,612</b>	<b>4,236,863</b>	7
<b>Industrial Total</b>	<b>1,146,442</b>	<b>6,442,909</b>	<b>1,877,427</b>	<b>15,958,118</b>	<b>1,428,742</b>	<b>10,358,601</b>	<b>1,376,764</b>	<b>9,965,903</b>	<b>1,366,098</b>	<b>9,437,523</b>	19
<b>Transportation</b>											
Private/commercial vehicle use <sup>11</sup>	1,680,306	21,481,039	2,114,978	27,060,478	<b>2,490,273</b>	<b>31,999,480</b>	<b>2,555,897</b>	<b>32,861,266</b>	<b>2,621,704</b>	<b>33,721,793</b>	56
Other Transportation	14,314	182,115	13,183	175,554	11,822	171,037	<b>13,658</b>	<b>203,107</b>	<b>11,849</b>	<b>186,184</b>	-17
<b>Transportation Total</b>	<b>1,694,620</b>	<b>21,663,154</b>	<b>2,128,161</b>	<b>27,236,032</b>	<b>2,502,095</b>	<b>32,170,517</b>	<b>2,569,555</b>	<b>33,064,373</b>	<b>2,633,553</b>	<b>33,907,977</b>	55
<b>Waste Disposal Total</b>	<b>224,689</b>		<b>227,483</b>		<b>237,108</b>		<b>259,163</b>		<b>242,932</b>		8
<b>Total</b>	<b>5,461,020</b>	<b>42,841,434</b>	<b>7,277,528</b>	<b>61,241,677</b>	<b>7,443,087</b>	<b>61,009,755</b>	<b>7,476,215</b>	<b>61,658,755</b>	<b>7,714,073</b>	<b>63,026,972</b>	41
<b>Other</b>											
Propane	n.a.	n.a.	51,535	766,081	53,135	789,868	47,609	707,720	<b>51,090</b>	<b>759,456</b>	

n.a. - data not available

**BOLD:** Represents revisions to previous report (PAG, 2008)

<sup>8</sup> The ratio of Tucson: Eastern Pima County natural gas use for 1990 is assumed to be constant from 1990 through 2006 and is based on 2007 use data supplied by Southwest Gas

<sup>9</sup> Tucson residential energy use for 1990 and 2000 is based on communication with PAG's Technical Services Division using historical data on the number of estimated TEP hookups

<sup>10</sup> The ratio of Tucson: Eastern Pima County commercial and industrial electricity use for 1990 and 2000 is assumed to be the same as that of 2002 city use from data supplied by TEP

<sup>11</sup> Transportation VMT data from 1990 and 2000 were estimated using a different PAG transportation model than the model used for 2005 through 2007

## Diverted Waste

City emission and energy savings from waste diversion lack a clear pattern from 1990 to 2007 due to the inconsistency in the data for the earlier years (Table 4-R). Recycling data for 1990 and 2000 represent rough estimates of voluntary landfill drop offs and from rudimentary recycling programs. As a result, 1990 and 2000 emissions and energy savings data can not be compared with the 2005 through 2007 results, which include complete information from City recycling programs.

**Table 4-R.** Summary of City Recycled Waste Activity and Emission and Energy Savings 1990-2007

<b>City Collections<sup>12</sup></b>	<b>Recycled Waste (metric tons)</b>	<b>CO<sub>2</sub>e Saved (metric tons)</b>	<b>MMBtus Saved</b>
<i>1990</i>	<i>51,710</i>	<i>255,792</i>	<i>1,004,291</i>
<i>2000</i>	<i>18,189</i>	<i>47,449</i>	<i>504,920</i>
<b>2005</b>	<b>45,430</b>	<b>73,649</b>	<b>828,583</b>
<b>2006</b>	<b>67,074</b>	<b>127,570</b>	<b>1,331,365</b>
<b>2007</b>	<b>66,728</b>	<b>127,027</b>	<b>1,283,565</b>

**Bold:** Represents changes from previous report (PAG, 2008)

**Italics:** Incomplete data

## Other

While GHG emissions and energy consumption for the “Other” source were estimated (Table 3-R) they were not included in the City totals.

## *Propane*

City propane use emissions were minor but remained relatively constant from 2000 to 2007, dropping by less than 1 percent (Table 3-R).

## Industrial Processes

At the time of this report, data were not available for City industrial process emissions.

## City of Tucson Synopsis

City GHG sources and emission trends mirrored those of the County. City GHG emissions have increased by 2.3 million metric tons from 1990 to 2007, representing a 41 percent increase. Over the past 17 years, City GHG emissions averaged about one-half of County emissions but the ration of City to County emissions is declining. In 1990, City emissions were 54 percent of County emissions but in 2007, City emissions represented 49 percent of County emissions. City per capita emissions rose slightly over this time period, averaging about 14 metric tons of CO<sub>2</sub>e per Tucson resident (Appendix K).

Over the past 17 years, residential and commercial energy use emissions continued to rise at a rapid rate, 40 percent and 52 percent, respectively. Industrial energy use showed a 19 percent increase from 1990 to 2007. RCI energy-related emissions comprise 63 percent of 2007 City emissions, with electricity being the major energy source and contributor to City emissions.

---

<sup>12</sup> Data for 1990 represents only voluntary drop-offs at Los Reales; 2000 data represent limited City Curbside pick-ups and drop-offs; 2005 through 2007 totals include comprehensive curbside pick-ups, commercial collections and voluntary drop-offs.

On-road vehicle travel continues to be another major source of City GHG emissions. From 1990 to 2007, transportation emissions increased by 55 percent. Private and commercial vehicle VMT increased by 87 percent from 1990 to 2007, and is responsible for over 99 percent of the transportation emissions. In 2007, transportation emissions comprised 34 percent of the City's total emissions

Emissions associated with City solid waste disposal have increased 8 percent over the past 17 years, and continue to be a small portion of City emissions, approximately 3 percent of the 2007 total.

## **Overview of the County and City Community Inventories**

From 1990 to 2007, the County and City exhibited similar trends in GHG emissions, energy use, transportation and waste disposal. County GHG emissions have increased by 55 percent, while City emissions have increased by 41 percent. Energy use and on-road vehicle travel remain the major sources of regional GHG emissions and have shown the greatest increases. Both are associated with the rapid population growth in the Tucson metropolitan area. Residential and commercial energy consumption and subsequent emissions continue to show the greatest rate of increase at both the County and City levels, with electricity being the predominant source of regional GHG emissions.

Private and commercial vehicle travel have increased sharply over this 17-year period, with County VMT increasing by 91 percent and City daily VMT increasing by 87 percent. As a consequence, emissions from personal and commercial vehicle use are responsible for over 99 percent of all on-road transportation emissions in the region. In 2007, GHG emissions from regional transportation produce more than one-third of total emissions in both communities.

Waste-related emissions have increased at both the County and City levels, but remain a small component of total GHG emissions. Continuation of the region-wide recycling programs diverts waste from the landfills and curtails emissions.

## **II. Government Operations Inventories**

### **C. Pima County Government Operations**

Minor modifications were made to the County government emissions calculations resulting in small changes to the inventory totals (Table 5-R, Figure 10-R, Figure 11-R). As mentioned, the 2007 TEP emission factor was applied to all County electricity use data for that year, thus affecting electricity emissions for County facilities, wastewater treatment and public lighting. This resulted in rate increases for the 2000 to 2007 emission trends for facilities, wastewater treatment and total County government emissions, over those previously reported (PAG, 2008) (Table 5-R).

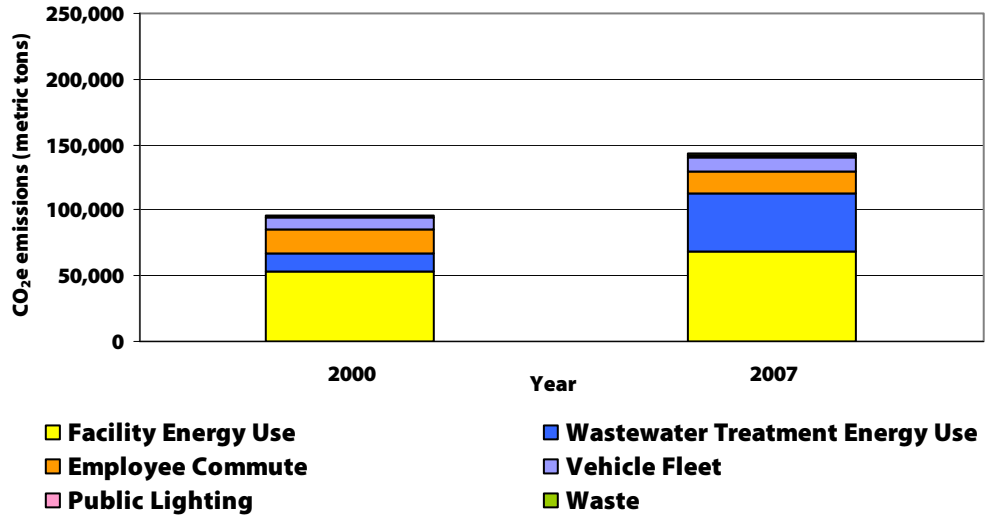


Figure 10-R. Comparison of County Government GHG Emissions by Sector 2000 and 2007

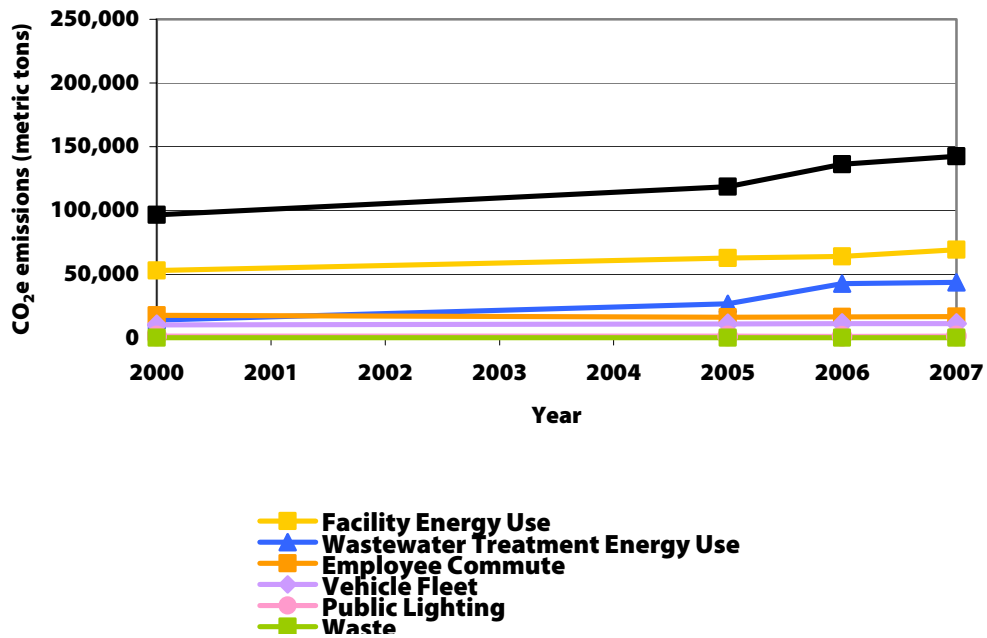


Figure 11-R. County Government GHG Emissions 2000 to 2007

**Table 5-R. Pima County Government Greenhouse Gas Emissions (metric tons CO<sub>2</sub>e), Energy (million Btu) and Expenditures (dollars) 2000 to 2007**

	2000			2005			2006			2007			Percent Change CO <sub>2</sub> e 2000-2007
	CO <sub>2</sub> e (metric tons)	MMBtu	Cost (dollars)	CO <sub>2</sub> e (metric tons)	MMBtu	Cost (dollars)	CO <sub>2</sub> e (metric tons)	MMBtu	Cost (dollars)	CO <sub>2</sub> e (metric tons)	MMBtu	Cost (dollars)	
<b>Facilities</b>													
<i>Electricity (TEP)</i>	49,848	197,418	5,165,261	57,049	223,391	6,013,512	55,870	222,289	5,257,981	<b>63,184</b>	249,116	5,813,167	
<i>Natural Gas</i>	3,136	55,953	335,718	5,686	101,450	1,014,497	8,200	146,305	1,536,199	6,086	108,580	1,248,674	
<b>Facilities Total</b>	<b>52,984</b>	<b>253,371</b>	<b>5,500,979</b>	<b>62,735</b>	<b>324,841</b>	<b>7,028,009</b>	<b>64,070</b>	<b>368,594</b>	<b>6,794,180</b>	<b>69,270</b>	<b>357,696</b>	<b>7,061,841</b>	<b>31</b>
<b>Wastewater Treatment Total</b>													
<i>Electricity (TEP)</i>	5,769	22,848	535,550	15,347	60,094	1,584,664	29,471	117,257	3,538,667	<b>29,928</b>	117,998	3,699,324	
<i>Natural Gas</i>	8,191	146,134	876,806	11,607	207,097	2,070,970	13,233	236,095	2,479,000	13,736	245,082	2,818,443	
<b>Wastewater Treatment Total</b>	<b>13,960</b>	<b>168,982</b>	<b>1,412,356</b>	<b>26,954</b>	<b>267,191</b>	<b>3,655,634</b>	<b>42,704</b>	<b>353,352</b>	<b>6,017,667</b>	<b>43,664</b>	<b>363,080</b>	<b>6,517,767</b>	<b>213</b>
<b>Vehicle Fleet Total</b>													
<i>Gasoline</i>	8,951	115,007	1,330,631	9,299	120,081	2,612,584	9,451	122,126	2,780,593	9,704	125,457	2,965,782	
<i>Diesel</i>	1,268	16,109	206,190	1,744	22,144	472,543	1,785	22,674	502,931	1,595	20,251	516,138	
<b>Vehicle Fleet Total<sup>13</sup></b>	<b>10,219</b>	<b>131,116</b>	<b>1,536,821</b>	<b>11,043</b>	<b>142,225</b>	<b>3,085,127</b>	<b>11,236</b>	<b>144,800</b>	<b>3,283,524</b>	<b>11,299</b>	<b>145,708</b>	<b>3,481,920</b>	<b>11</b>
<b>Employee Commute Total<sup>14</sup></b>	<b>17,735</b>	<b>227,000</b>		<b>16,394</b>	<b>211,135</b>		<b>16,592</b>	<b>213,898</b>		<b>16,702</b>	<b>215,448</b>		<b>-6</b>
<b>Public Lighting</b>													
<i>Electricity (TEP)</i>	1,381	5,469	116,678	1,397	5,469	116,678	1,375	5,469	116,678	<b>1,387</b>	5,469	116,678	
<i>Solar</i>		1	0	0	1	0	0	1	0	0	1	0	
<b>Public Lighting Total<sup>15</sup></b>	<b>1,381</b>	<b>5,470</b>	<b>116,678</b>	<b>1,397</b>	<b>5,470</b>	<b>116,678</b>	<b>1,375</b>	<b>5,470</b>	<b>116,678</b>	<b>1,387</b>	<b>5,470</b>	<b>116,678</b>	
<b>Government Solid Waste Total<sup>16</sup></b>	<b>269</b>		<b>42,300</b>	<b>269</b>		<b>42,300</b>	<b>269</b>		<b>42,300</b>	<b>269</b>		<b>42,300</b>	
<b>Grand Total</b>	<b>96,548</b>	<b>785,939</b>	<b>8,609,134</b>	<b>118,792</b>	<b>950,862</b>	<b>13,927,748</b>	<b>136,246</b>	<b>1,086,114</b>	<b>16,254,349</b>	<b>142,591</b>	<b>1,087,402</b>	<b>17,220,506</b>	<b>48</b>

**BOLD:** Revised from previous report (PAG, 2008)

<sup>13</sup> 2006 vehicle fleet data were interpolated using FY05/06 and FY06/07 data supplied by Pima County staff.

<sup>14</sup> 2006 County government employee commuting VMT was interpolated using 2005 and 2007 PAG TRP survey data.

<sup>15</sup> 2007 public lighting energy use and expenditure data were used for all years.

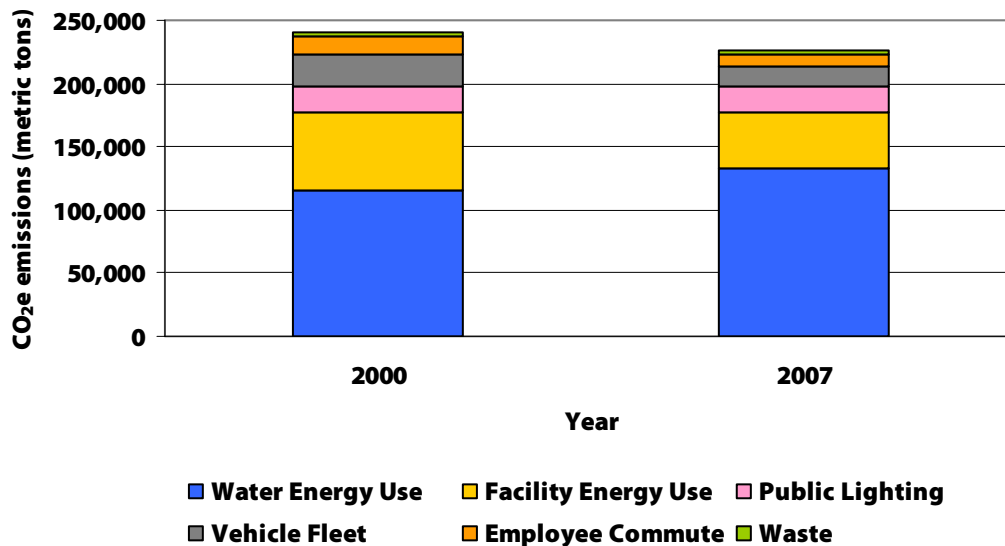
<sup>16</sup> 2007 waste totals and expenditure data were used for all years.

## D. City of Tucson Government Operations

Slight modifications were made to the City government emission calculations resulting in small changes to the inventory totals (Table 6-R, Figure 14-R, Figure 15-R). A 2007 TEP emission factor was applied to 2007 City government facilities, public lighting, potable and electricity use data, thereby, affecting the 2007 emission totals and the 2000 to 2007 emission trends for reclaimed and total water emissions. Overall, the 2000 to 2007 trend in City government emissions remained the same (a 6 percent reduction) (Table 6-R).

### Other

Energy-related emissions associated with water conveyance from the CAP represent a new addition to the City government report but the emissions and Btu are not included in the City inventory totals. CAP water deliveries to TW increased almost six-fold from 2000 to 2007, resulting in an estimated 800 percent rise in emissions (Appendix I-R, Table 6-R). CAP energy emission totals represent a significant and increasing source of GHG emissions for the Tucson area (Table 6-R).



**Figure 14-R.** Comparison of City Government GHG Emissions by Sector 2000 and 2007

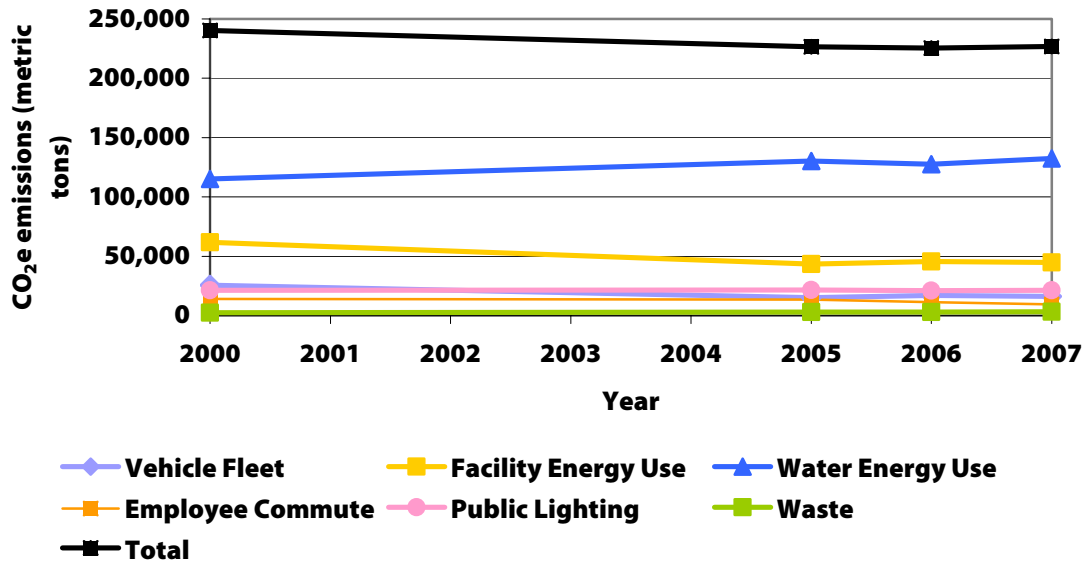


Figure 15-R. City Government Emissions 2000 to 2007

**Table 6-R.** City of Tucson Government Greenhouse Gas Emissions (metric tons CO<sub>2</sub>e), Energy (million Btu) and Expenditures (dollars) 1990 to 2007

	1990			2000			2005			2006			2007			Percent Change CO <sub>2</sub> e 2000-2007
	CO <sub>2</sub> e (metric tons)	MMBtu	Cost (dollars)	CO <sub>2</sub> e (metric tons)	MMBtu	Cost (dollars)	CO <sub>2</sub> e (metric tons)	MMBtu	Cost (dollars)	CO <sub>2</sub> e (metric tons)	MMBtu	Cost (dollars)	CO <sub>2</sub> e (metric tons)	MMBtu	Cost (dollars)	
<b>Facilities Energy Use</b>																
Electricity (TEP)	33,289	128,777	2,792,434	58,447	231,476	3,996,256	39,964	156,489	4,063,092	40,176	159,848	4,156,961	<b>41,370</b>	163,109	4,257,198	
Natural Gas	2,265	40,419	221,049	3,354	59,834	452,847	3,417	60,955	662,553	5,303	94,589	918,795	3,279	58,526	704,150	
<b>Facilities Energy Use Total</b>	<b>35,554</b>	<b>169,196</b>	<b>3,013,483</b>	<b>61,801</b>	<b>291,310</b>	<b>4,449,103</b>	<b>43,381</b>	<b>217,444</b>	<b>4,725,645</b>	<b>45,479</b>	<b>254,437</b>	<b>5,075,756</b>	<b>44,649</b>	<b>221,635</b>	<b>4,961,348</b>	-28
<b>Water Energy Use</b>																
<b>Potable Water</b>																
Electricity (TEP)	64,629	250,016	4,487,030	85,607	339,041	7,035,121	61,198	239,631	4,986,449	65,364	260,060	5,381,670	<b>57,502</b>	226,714	4,698,696	
Electricity (Trico)	2,647	10,783	322,471	4,665	19,006	575,861	31,625	116,828	2,403,124	<b>25,680</b>	95,530	2,595,652	36,881	137,056	3,871,996	
Natural Gas	7,524	134,247	793,350	13,411	239,288	1,472,498	25,937	462,742	3,538,310	23,701	422,855	5,522,390	23,190	413,772	6,271,248	
<b>Potable Water Total</b>	<b>74,800</b>	<b>395,046</b>	<b>5,602,851</b>	<b>103,683</b>	<b>597,335</b>	<b>9,083,480</b>	<b>118,760</b>	<b>819,201</b>	<b>11,927,883</b>	<b>114,745</b>	<b>778,445</b>	<b>13,499,712</b>	<b>117,573</b>	<b>777,542</b>	<b>14,841,940</b>	13
<b>Water Reclamation</b>																
Electricity (TEP)	4,752	18,386	302,865	10,569	41,858	745,371	10,548	41,303	727,308	11,225	44,661	836,360	<b>12,997</b>	51,247	965,364	
Electricity (Trico)	0	0	0	822	3,347	99,167	1,027	3,792	90,404	<b>1,513</b>	5,630	182,008	1,716	6,378	214,169	
<b>Reclamation Water Total</b>	<b>4,752</b>	<b>18,386</b>	<b>302,865</b>	<b>11,391</b>	<b>45,205</b>	<b>844,538</b>	<b>11,575</b>	<b>45,095</b>	<b>817,712</b>	<b>12,738</b>	<b>50,291</b>	<b>1,018,368</b>	<b>14,713</b>	<b>57,625</b>	<b>1,179,533</b>	29
<b>Water Energy Use Total</b>	<b>79,552</b>	<b>413,432</b>	<b>5,905,716</b>	<b>115,074</b>	<b>642,540</b>	<b>9,928,018</b>	<b>130,335</b>	<b>864,296</b>	<b>12,745,595</b>	<b>127,483</b>	<b>828,736</b>	<b>14,518,080</b>	<b>132,286</b>	<b>835,167</b>	<b>16,021,473</b>	15
<b>Vehicle Fleet</b>																
Gasoline				15,397	198,586	1,424,509	9,416	122,164	3,068,344	10,002	129,819	3,428,333	10,122	131,418	3,725,711	
Diesel				10,218	129,852	833,308	5,387	68,461	2,878,285	3,588	45,595	2,859,033	0	0	0	
CNG				0	0	0	333	5,794	1,531,951	251	4,363	1,372,074	110	1,911	1,314,740	
Biodiesel (B-20)				0	0	0	0	0	0	3,050	48,354	3,325,132	5,850	92,752	3,928,674	
<b>Vehicle Fleet Total<sup>17</sup></b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>25,615</b>	<b>328,438</b>	<b>2,257,817</b>	<b>15,136</b>	<b>196,419</b>	<b>7,478,580</b>	<b>16,891</b>	<b>228,131</b>	<b>10,984,572</b>	<b>16,082</b>	<b>226,081</b>	<b>8,969,125</b>	-37
<b>Employee Commute Total<sup>18</sup></b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>14,059</b>	<b>179,948</b>		<b>13,395</b>	<b>172,503</b>		<b>11,359</b>	<b>146,434</b>		<b>9,381</b>	<b>121,018</b>		-33
<b>Public Lighting</b>																
Traffic lights (TEP)				3,972	15,730	322,625	4,017	15,730	322,625	3,954	15,730	322,625	<b>3,990</b>	15,730	322,625	
Streetlights (TEP)				17,243	68,289	1,400,601	17,439	68,289	1,400,601	17,164	68,289	1,400,601	<b>17,320</b>	68,289	1,400,601	
<b>Public Lighting Total<sup>19</sup></b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>21,215</b>	<b>84,019</b>	<b>1,723,226</b>	<b>21,456</b>	<b>84,019</b>	<b>1,723,226</b>	<b>21,118</b>	<b>84,019</b>	<b>1,723,226</b>	<b>21,310</b>	<b>84,019</b>	<b>1,723,226</b>	
<b>Government Solid Waste Total</b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>2,437</b>		<b>375,387</b>	<b>2,912</b>		<b>448,582</b>	<b>3,018</b>		<b>464,853</b>	<b>3,128</b>		<b>481,737</b>	28
<b>Grand Total</b>				<b>240,201</b>	<b>1,526,255</b>	<b>18,733,551</b>	<b>226,615</b>	<b>1,534,681</b>	<b>27,121,628</b>	<b>225,348</b>	<b>1,541,757</b>	<b>32,766,487</b>	<b>226,836</b>	<b>1,487,920</b>	<b>32,156,909</b>	-6
<b>Other</b>																
Central Arizona Water Pumping																
Electricity (Navajo)	0	0	0	<b>29,218</b>	<b>98,779</b>	<b>653,620</b>	<b>184,060</b>	<b>599,328</b>	<b>4,866,084</b>	<b>179,385</b>	<b>589,714</b>	<b>5,297,200</b>	<b>272,844</b>	<b>896,123</b>	<b>7,906,560</b>	834

**Bold:** Revised from PAG, 2008 Report

n.a. Data not available

0 - No use

<sup>17</sup> Data for 2000 vehicle fleet were calculated using a different method than 2005, 2006 and 2007 data

<sup>18</sup> 2006 City employee commuting VMT were interpolated using 2005 and 2007 PAG TRP survey data

<sup>19</sup> 2007 public lighting energy use and expenditure data were used for all years

## References Cited

- Arizona Department Commerce, Energy Office. First Sales of Petroleum Products into Arizona for Consumption. 2008.
- 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. 2006.
- Central Arizona Project (CAP). <http://www.cap-az.com/deliveries/> (2009).
- Central Arizona Water Conservation District. Financial Statements and Other Financial Information Reports. <http://www.cap-az.com/operations/water-rates/> (2005 through 2007).
- City of Tucson Water Department. Water Plan: 2000-2050. (2004)  
<http://www.ci.tucson.az.us/water/waterplan.htm>
- Energy Information Administration (EIA), Department of Energy. Fuel Emission Factors. 2007.  
<http://www.eia.doe.gov/oiaf/1605/excel/Fuel%20Emission%20Factors.xls>
- Energy Information Administration (EIA), Department of Energy. 2009.  
[http://www.eia.doe.gov/cneaf/electricity/page/eia906\\_920.html](http://www.eia.doe.gov/cneaf/electricity/page/eia906_920.html)
- Envair. (Authors: Causley, M, Meszler, D. Jones, R. Reynolds, S.) Emissions Inventories for the Tucson Planning Area. Vol.1. 2001.
- Hughes, W., City of Tucson Environmental Services, personal communication. 2008.
- Intergovernmental Panel on Climate Change (IPCC). 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3: Industrial Processes and Product Use. Chapter 2: Mineral Industry Emissions. 2006. <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>
- Philbin, Asia. Tucson Water, personal communication. 2009.
- Pima Association of Governments (PAG). Regional Greenhouse Gas Inventory. 2008.  
<http://www.pagnet.org/documents/Air/GreenHouseGas-2008-11-Inventory.pdf>
- U.S. Environmental Protection Agency (USEPA). Emission Facts: Greenhouse Gas Emissions from a Typical Passenger Vehicle. EPA420-F05-004. 2005. <http://www.epa.gov/OMS/climate/420f05004.htm>
- U.S. Environmental Protection Agency (USEPA). Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2006. USEPA #430-R-08-005. 2008.  
[http://www.epa.gov/climatechange/emissions/downloads/08\\_CR.pdf](http://www.epa.gov/climatechange/emissions/downloads/08_CR.pdf)
- U.S. Environmental Protection Agency (USEPA). 2009a. Inventory of Greenhouse Gas Emissions and Sinks 1990-2007. <http://epa.gov/climatechange/emissions/usinventoryreport.html>

U.S. Environmental Protection Agency (USEPA). Waste Reduction Model (WARM). 2009b. [http://epa.gov/climatechange/wycd/waste/calculators/Warm\\_home.html](http://epa.gov/climatechange/wycd/waste/calculators/Warm_home.html)

U.S. Environmental Protection Agency (USEPA). 2009c. <http://camddataandmaps.epa.gov/gdm/>