

Appendix C-R : Emission Factors for Electricity Use

	1990	2000	2005	2006	2007
	lbs. CO ₂ per MWh				
Tucson Electric Power ¹	1945.1	1899.9	1921.5	1891.2	1908.4
Trico Electric Cooperative ²	1846.8	1846.8	2036.8	2022.6	2024.8
Navajo Generating Station ³	-	2225.6	2310.8	2288.8	2290.9

Bold: Represents revision to previous report (PAG, 2008)

¹ Based on emissions and generation data representative of the fuel type/plant type combinations used by TEP to generate electricity. Data supplied by TEP staff.

² Based on emissions and generation data representative of the fuel type/plant type combinations used by Trico to generate electricity. Data supplied by Arizona Electric Power Cooperative.

³ Based on EPA emissions data and EIA electricity use data. <http://camddataandmaps.epa.gov/gdm/>;
http://www.eia.doe.gov/cneaf/electricity/page/eia906_920.html

APPENDIX D- R : Pima County Data Inputs

	1990	2000	2005	2006	2007
Residential Energy Use					
Natural Gas (therms)	80,471,344	89,825,869	83,839,115	81,977,939	89,225,354
Electricity (GWh)					
TEP	2,070	3,041	3,633	3,778	4,005
Trico	91	194	274	299	340
Tohono O'odham Utility Authority	n.a.	21	31	33	29
Commercial Energy Use					
Natural Gas (therms)	57,056,342	61,913,682	58,896,658	60,203,648	62,368,340
Electricity (GWh)					
TEP	1,357	1,763	2,097	2,220	2,305
Trico	46	74	133	131	151
Tohono O'odham Utility Authority	n.a.	43	62	65	75
Industrial Energy Use					
Natural Gas (therms)	29,375,582	125,509,673	69,931,089	66,182,190	59,582,632
Electricity (GWh)					
TEP	2,650	3,418	3,145	3,203	3,324
Trico	139	76	30	29	26
Transportation (annual County miles)					
Pima County VMT	4,863,931,878	6,932,920,462	8,462,716,569	8,876,221,385	9,289,726,202
Other transportation					
Cat Tran ⁴	0	132,939	222,105	231,957	228,479
Coyote Run ⁴	0	0	140,717	145,069	149,556
Old Pueblo Trolley ⁴	0	6,864	6,864	6,864	6,864
Rural Transit ⁴	0	329,094	416,465	450,831	458,995
Special Needs	417,978	590,664	617,067	660,427	739,248
Sun Tran	6,884,993	7,896,625	7,899,630	7,987,433	8,348,695
Sun Van	1,441,338	2,149,240	3,145,893	3,584,387	3,106,509
TICET ⁴	-	37,841	109,652	105,247	121,593
Waste (short tons)					
Ina	n.a.	14,574	30,279	26,203	27,432
Sahuarita	n.a.	39,156	1,217	583	32,590
Tangerine	n.a.	100,664	151,450	133,550	141,678
Los Reales	516,000	550,200	627,699	674,018	660,840
Other (gallons)					
Propane	n.a.	14,087,926	15,145,652	13,777,713	14,935,613
Jet A fuel ⁵	4,000,000	3,248,398	3,678,189	3,501,655	4,071,865
Aviation Gasoline ⁵	6,600	52,582	48,934	57,956	97,140
Locomotive fuel	n.a.	8,749,627	8,263,844	8,458,508	8,818,992
Industrial Processes					
AZ Portland Cement (metric tons clinker)	n.a.	1,776,769	2,017,325	2,053,881	2,379,074
AZ Portland Cement (gallons diesel)	n.a.	15,700	6,981	9,578	1,082
AZ Portland Cement (gallons biodiesel)	n.a.	0	0	6,753	25,649
Sierrita Mine (gallons diesel)	n.a.	240,027	202,082	191,129	220,170

Bold: Represents revision from previous report (PAG, 2008)

n.a. - Data not available

0 - no use

⁴ Transit was not operational in 1990. Coyote Run not operational until 2002.

⁵ 1990 represents aviation gas and Jet A from Ryan Airfield and TIA; 2000, 2005 and 2006 represents totals from TIA, Ryan Airfield and Marana Airport.

Appendix F-R

WARM Model per metric tons estimates of GHG Emissions for Alternate Management Scenarios (EPA, 2009b)

Material	GHG Emissions per Ton of Material Source Reduced (MTCO ₂ e)	GHG Emissions per Ton of Material Recycled (MTCO ₂ e)	GHG Emissions per Ton of Material Landfilled (MTCO ₂ e)	GHG Emissions per Ton of Material Combusted (MTCO ₂ e)	GHG Emissions per Ton of Material Composted (MTCO ₂ e)
Aluminum Cans	-8.29	-13.67	0.04	0.06	NA
Steel Cans	-3.19	-1.80	0.04	-1.54	NA
Copper Wire	-7.41	-4.97	0.04	0.06	NA
Glass	-0.58	-0.28	0.04	0.05	NA
HDPE	-1.80	-1.40	0.04	0.91	NA
LDPE	-2.29	-1.71	0.04	0.91	NA
PET	-2.11	-1.55	0.04	1.07	NA
Corrugated Cardboard	-5.59	-3.11	0.33	-0.66	NA
Magazines/third-class mail	-8.66	-3.07	-0.33	-0.48	NA
Newspaper	-4.89	-2.80	-0.89	-0.75	NA
Office Paper	-8.01	-2.85	1.76	-0.63	NA
Phonebooks	-6.34	-2.66	-0.89	-0.75	NA
Textbooks	-9.18	-3.11	1.76	-0.63	NA
Dimensional Lumber	-2.02	-2.46	-0.52	-0.79	NA
Medium Density Fiberboard	-2.22	-2.47	-0.52	-0.79	NA
Food Scraps	NA	NA	0.68	-0.18	-0.20
Yard Trimmings	NA	NA	-0.34	-0.22	-0.20
Grass	NA	NA	0.15	-0.22	-0.20
Leaves	NA	NA	-0.58	-0.22	-0.20
Branches	NA	NA	-0.52	-0.22	-0.20
Mixed Paper, Broad	NA	-3.54	0.27	-0.66	NA
Mixed Paper, Residential	NA	-3.54	0.19	-0.66	NA
Mixed Paper, Office	NA	-3.42	0.38	-0.60	NA
Mixed Metals	NA	-5.26	0.04	-1.07	NA
Mixed Plastics	NA	-1.52	0.04	0.97	NA
Mixed Recyclables	NA	-2.88	0.08	-0.60	NA
Mixed Organics	NA	NA	0.15	-0.20	-0.20
Mixed MSW	NA	NA	0.37	-0.13	NA
Carpet	-4.03	-7.23	0.04	0.37	NA
Personal Computers	-55.97	-2.27	0.04	-0.20	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	-4.01	-1.84	0.04	0.09	NA

APPENDIX G-R: City of Tucson Data Inputs					
	1990	2000	2005	2006	2007
Residential Energy Use					
Natural Gas (therms)	38,956,747	43,485,339	40,587,109	39,686,100	43,194,625
TEP Electricity (GWh)	1,314	1,788	1,831	1,832	1,945
Commercial Energy Use					
Natural Gas (therms)	30,879,205	33,508,024	31,875,194	32,582,544	33,754,087
TEP Electricity (GWh)	957	1,244	1,460	1,508	1,567
Industrial Energy Use					
Natural Gas (therms)	25,640,426	109,550,901	61,039,230	57,767,010	52,006,597
Electricity (GWh)	1,137	1,466	1,247	1,228	1,241
Transportation (annual City miles)					
City VMT	2,393,054,494	3,410,996,867	4,200,216,089	4,339,226,274	4,478,316,459
Other transportation					
Cat Tran ⁶	0	132,939	222,105	231,957	228,479
Old Pueblo Trolley ⁶	0	6,864	6,864	6,864	6,864
Rural Transit ⁶	0	16,455	20,823	22,541	22,950
Special Needs	167,191	236,266	246,827	264,171	295,699
Sun Tran	6,884,993	7,253,929	7,086,526	7,177,224	7,546,146
Sun Van	1,441,338	2,149,240	3,145,893	3,516,284	3,643,498
TICET ⁶	0	37,841	109,652	105,247	121,593
Waste (short tons)					
Los Reales	516,000	550,200	627,699	674,018	660,840
Other (gallons)					
Propane	n.a.	8,418,476	8,679,866	7,777,139	8,345,671

Bold: Represents revisions from previous report (PAG, 2008)

n.a. - Data not available

0 - no use

⁶ Transit was not operational in 1990

APPENDIX I-R : City of Tucson Government Data

	City Government Operations Data					Expenditures (dollars)				
	1990	2000	2005	2006	2007	1990	2000	2005	2006	2007
Facility Energy Use										
Administration Buildings										
Electricity (KWh)	5,475,525	3,780,863	4,032,921	4,766,890	5,240,735	394,806	337,835	359,632	428,383	466,933
Natural Gas (therms)	60,440	38,172	55,630	61,697	60,526	31,645	28,917	72,187	96,626	61,241
Fire Department										
Electricity (KWh)	2,163,694	2,448,094	2,862,067	3,044,828	3,651,745	161,579	217,703	259,041	273,871	335,017
Natural Gas (therms)	24,988	42,066	42,608	51,274	72,511	14,993	34,915	46,642	71,412	100,826
Libraries ⁷										
Electricity (KWh)	3,920,347	4,150,933	3,732,657	2,888,381	0	292,748	368,580	333,913	259,843	0
Operations										
Electricity (KWh)	1,834,590	2,912,740	3,569,320	3,205,888	3,850,638	138,447	254,067	311,294	280,163	337,220
Natural Gas (therms)	24,418	5,361	5,922	4,563	5,124	16,424	4,601	6,985	6,906	8,252
Parks										
Electricity (KWh)	1,097,038	1,105,080	1,800,763	1,666,503	1,729,951	81,541	97,606	161,163	149,367	155,749
Natural Gas (therms)	65,100	60,576	43,863	59,703	50,413	33,477	43,340	45,234	73,362	70,624
Parks & Recreation										
Electricity (KWh)	7,098,142	12,173,673	12,311,181	12,266,814	12,724,207	5,299,943	1,080,952	1,102,408	1,101,169	1,146,576
Natural Gas (therms)	125,478	251,571	297,786	580,564	276,248	67,879	190,368	313,478	424,685	309,689
Police										
Electricity (KWh)	4,126,030	6,270,420	3,918,750	3,607,353	3,902,462	290,415	509,156	323,638	295,264	333,228
Natural Gas (therms)	5,066	74,465	70,020	63,239	94,238	3,310	59,441	80,921	92,940	114,874
Solid Waste										
Electricity (KWh)	53,760	248,399	310,795	324,570	317,602	4,015	6,898	28,105	29,382	28,748
Natural Gas (therms)	385	409	839	651	666	389	553	1,125	1,148	1,451
Transportation										
Electricity (KWh)	628,592	1,305,901	1,387,711	2,216,741	2,484,724	46,945	115,566	124,129	196,886	219,925
Natural Gas (therms)	15,689	17,825	14,269	13,489	2,925	9,670	13,403	15,013	17,200	4,535
Tucson Convention Center										
Electricity (KWh)	5,921,560	4,212,000	4,581,600	4,316,900	4,702,800	442,234	371,986	405,736	384,439	419,414
Natural Gas (therms)	0	6,722	7,565	8,864	6,869	0	5,266	10,750	15,351	5,536
Zoo										
Electricity (KWh)	348,860	1,061,780	912,150	952,210	970,920	26,078	93,054	80,606	84,447	86,199
Natural Gas (therms)	2,134	3,486	3,533	3,670	3,889	1,451	3,334	4,459	5,770	6,751
Other ⁸										
Electricity (KWh)	5,052,948	4,350,840	4,442,971	5,733,500	6,744,204	382,900	386,640	396,052	508,504	596,485
Natural Gas (therms)	79,939	96,772	67,063	97,619	11,419	41,344	67,566	65,018	112,286	19,383

Bold - Revised from previous report (PAG, 2008) n.a. - Data not available; 0 - No use

⁷ On July 1, 2006, City Libraries became County facilities, subsequent electricity use and costs are included in 2007 County use and costs

⁸ Other facilities include TOPSC Buildings 2, 3 and 5 and Water Stores

	City Government Operations Data					Expenditures (dollars)				
	1990	2000	2005	2006	2007	1990	2000	2005	2006	2007
Potable Water Energy Use (Continued)										
Wells - Central										
Electricity (KWh)	26,955,136	28,867,614	10,817,171	13,369,705	9,251,160	1,622,872	2,025,405	739,161	925,937	641,214
Natural Gas (therms)	192,177	83,594	0	0	0	107,513	46,084	568	6	0
Wells - East										
Electricity (KWh)	7,519,660	8,520,084	6,041,016	5,499,764	5,042,660	435,294	551,429	366,010	339,893	310,592
Wells - Northwest										
Electricity (KWh)	164,730	2,151,680	1,306,040	1,579,320	882,800	12,086	133,778	82,712	97,217	58,612
Wells - Other										
Electricity (KWh)	1,105,650	1,775,570	2,638,025	2,047,662	2,314,470	68,901	156,996	234,885	183,270	204,745
Natural Gas (therms)	23,050	20,771	0	0	0	12,145	11,485	0	0	0
Wells - Park										
Electricity (KWh)	407,776	234,357	401,035	349,687	399,114	30,417	20,902	36,030	31,434	35,237
Wells - Rillito										
Electricity (KWh)	3,514,538	6,123,740	4,961,870	4,836,711	3,807,264	242,942	463,541	384,320	371,693	307,810
Wells - Santa Cruz										
Electricity (KWh)	4,620,220	3,203,084	2,954,049	3,150,322	2,491,395	287,692	219,182	210,210	229,247	182,953
Natural Gas (therms)	243,512	155,079	175,251	193,433	155,642	122,233	77,438	187,687	259,475	209,063
Wells - South										
Electricity (KWh)	3,144,540	11,223,906	9,067,346	9,276,859	8,517,304	233,056	835,751	653,628	667,860	615,484
Natural Gas (therms)	43,483	33,248	30,675	7,095	21,121	22,687	18,427	34,116	9,992	28,793
Wells - Southside & TARP										
Electricity (KWh)	2,496,770	4,050,204	2,162,340	3,763,374	3,043,205	155,792	241,374	122,138	218,675	173,315
Natural Gas (therms)	41,370	37,706	32,626	39,965	24,693	21,754	20,569	36,234	54,870	35,816
Wells - Tanque Verde										
Electricity (KWh)	6,232,470	6,009,343	2,223,409	3,051,109	2,118,461	393,032	418,727	155,121	201,215	145,321
Reclaimed Water Energy Use										
All Reclaimed Systems										
Trico Electricity (KWh)	0	980,710	1,111,063	1,649,667	1,868,696	0	99,167	90,404	182,008	214,169
Alvernon										
Electricity (KWh)	3,760	1,440	1,100	1,400	1,340	280	127	99	118	120
Northeast										
Electricity (KWh)	530,740	970,240	1,064,260	961,680	1,094,183	38,193	53,489	59,141	53,529	61,051
Northwest										
Electricity (KWh)	25,020	170,240	62,340	407,660	387,309	1,106	9,540	3,521	23,166	22,284
Silverbell										
Electricity (KWh)	400,480	1,055,907	1,295,073	2,089,676	3,041,480	29,467	59,348	73,896	147,512	217,158
Southeast										
Electricity (KWh)	6,600	92,878	65,220	79,412	78,579	493	8,151	5,744	7,021	6,967
Southwest										
Electricity (KWh)	340,420	1,114,450	848,140	723,880	730,320	24,617	67,549	52,453	48,305	48,182

	City Government Operations Data					Expenditures (dollars)				
	1990	2000	2005	2006	2007	1990	2000	2005	2006	2007
Reclaimed Water Energy Use (Continued)										
Speedway										
Electricity (KWh)	217,790	200,540	207,670	182,050	182,040	16,260	17,868	18,775	16,432	16,496
Sweetwater										
Electricity (KWh)	3,862,380	8,658,820	8,557,660	8,443,360	8,739,580	192,448	528,999	513,679	519,105	526,526
Thornsdale										
Electricity (KWh)	0	0	0	195,196	712,584	0	0	0	20,912	62,115
12th Avenue										
Electricity (KWh)	0	0	0	1,600	47,920	0	0	0	260	4,465
Vehicle Fleet (miles/fiscal year) ⁹										
Gasoline vehicles	n.a.		14,430,006	15,435,097	15,726,626	n.a.	1,424,508	3,068,344	3,428,333	3,742,401
Diesel vehicles			3,070,951	2,045,879	0		833,309	2,878,285	2,859,033	0
CNG vehicles		0	499,568	377,500	161,782		0	1,531,950	1,372,072	1,314,739
B-20 vehicles		0	0	2,169,703	4,167,616		0	0	3,325,132	3,911,984
Gasoline (gallons)		1,581,063								
Diesel (gallons)		1,064,241								
Employee Commute (miles/year)										
Gasoline vehicles	n.a.	24,928,617	24,309,216	20,518,913	16,957,524	0	0	0	0	0
Public Lighting (KWh)¹⁰										
Streetlights	n.a.	20,008,582	20,008,582	20,008,582	20,008,582	n.a.	1,400,601	1,400,601	1,400,601	1,400,601
Traffic Lights		4,608,922	4,608,922	4,608,922	4,608,922		322,625	322,625	322,625	322,625
Government Solid Waste (short tons)¹¹										
	n.a.	16,321	19,504	20,211	20,945	n.a.	375,387	448,582	464,852	481,737
Other										
CAP Totals										
Water Delivery Volume (acre-feet)	0	12,755	61,596	62,320	90,880	0	653,620	4,866,084	5,297,200	7,906,560
Navajo Electricity (KWh)	0	28,942,279	175,603,186	172,786,068	262,564,182					
Energy (KWh) per acre-foot delivered¹²	0	2,269.093	2,851.886	2,772.562	2,889.131					

n.a. - Data not available; 0 - No use

Bold - Revised from previous report (PAG, 2008)

⁹ Vehicle fleet data for 2000 represents gallons of fuel and costs based on the 2001 to 2005 percent change in fuel use and costs

¹⁰ 2007 public lighting energy use and costs were used for all years

¹¹ Waste disposal costs based on \$23.00 tipping fee per short ton

¹² Calculated by Tucson Water Staff (2009) based upon amount of water delivered to Tucson Water sites

Appendix J- Energy Conversion Factors

Unit	Equivalent Btu	Equivalent MMBtu	Equivalent KWh
Electricity			
1 GWh	3,412,141,633	3,412	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 U S 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 K- Per Capita Greenhouse Gas Emissions (metric tonsCO₂e/person)¹³

	United States ¹⁴	Arizona ¹⁵	Eastern Pima County ¹⁶	Tucson ¹⁷
1990	24.5	18.0	15.8	13.5
2000	24.8	17.3	16.6	15.0
2005	24.0	<i>16.9</i>	15.9	14.1
2006	23.6	<i>16.7</i>	15.9	14.0
2007	23.7	<i>16.7</i>	16.3	14.3

¹³ Regional per capita values estimated using total emissions (without sinks) divided by total population of the area

¹⁴ **U.S. population:** U.S. Census Bureau American FactFinder: <http://factfinder.census.gov/home/saff/main.html?lang=en>; **Emissions:** Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2007 (EPA, 2009) <http://epa.gov/climatechange/emissions/downloads/2009GHGFastFacts.pdf>

¹⁵ **Arizona population:** Arizona Department of Commerce <http://www.workforce.az.gov/>; **Emissions:** 1990, 2000 data from Arizona Climate Action Plan; *Italics:* estimates for 2005, 2006 and 2007 are based on linear interpolation from 2000 and reference case projections for 2010 (Center for Climate Strategies, 2006). <http://www.azclimatechange.gov/>

¹⁶ **E. Pima County population:** estimated by applying a 0.96 allocation factor to Pima County population total; Arizona Department of Commerce <http://www.workforce.az.gov/>; **Emissions:** PAG's Regional GHG Inventory Update (2009)

¹⁷ **Tucson population:** Arizona Department of Commerce <http://www.workforce.az.gov/>; **Emissions:** PAG's Regional GHG Inventory Update (2009)