A Study to Evaluate the Health Effects of Air Pollution in Bexar County with a Focus on Local Coal and Gas Fired Power Plants

Executive Summary

Submitted by

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As part of its commitment to the citizens of San Antonio, CPS Energy agreed to undertake a study to estimate the impacts of air pollution from its planned operations on the health of those living in Bexar County. The study involved estimating the total emissions from all CPS Energy power plants in Bexar County for three time periods (1997, 2002, 2013) and using these to estimate ground level concentrations of key regulated pollutants, that could be influenced by CPS Energy emissions.

CPS Energy currently has three coal and sixteen gas-fired power plants in Bexar County; a new coal-fired power plant is expected to become operational in 2010, and five new gas-fired power plants are planned. Table 1 below shows the amount of electricity produced (in megawatt-hours) and the emissions of key pollutants from these plants for the three time periods studied. The 2013 numbers are based upon projections by CPS Energy.

Table 1: Characteristics (fuel burned in millions of BTU and megawatt-hours produced) of and emissions from CPS Energy coal and gas fired plants with projections for 2013 (provided by CPS Energy).

			Emissions (Tons per Year)						
Year	Fuel Burned (MMBtu)	Net MWh Output	CO	NOx	VOC	SO_2	PM_{10}	$PM_{2.5}$	Hg
1997	139,450,908	13,439,997	1772	23905	167	28552	1290	505	0.17
2002	126,500,638	12,799,868	2189	11861	196	26306	1563	606	0.33
2013	217,443,415	21,677,583	8265	9189	305	10047	1302	786	0.08

It should be noted that even though the electricity produced increases substantially from 2002 to 2013, there are decreases in the emissions of many of the pollutants of concern. This occurs because of significant improvements in the pollution control equipment on the existing power plants and because the new power plants utilize the best control technologies available. There are increases in some pollutants, but these are pollutants for which power plants are not major sources. For example, CO and VOCs increase; however, power plants are a minor source of these, compared to traffic or even biomass combustion. Direct emissions of particulate matter from power plants is a minor concern; of greater concern are some of the particles that are formed as gaseous emissions of SO_2 and NO_x age and oxidize in the atmosphere. There are also health concerns about ozone, but sources, such as power plants, do not emit ozone directly. Ozone is formed through chemical reactions in the atmosphere between NO_2 and organic compounds, or VOCs, in the presence of sunlight. Since power plants emit NO, they can contribute indirectly to ambient ozone levels; although, in areas near the plants the NO acts as a scavenger of oxygen molecules, which can result in decreased ozone levels.

It should be noted that the air quality in Bexar County is good; San Antonio ranks as the 7th largest US city, yet it has the cleanest air of any large US city, and the only pollutant for which San Antonio has violated the EPA air quality standards is ozone.

The estimated emissions from CPS Energy power plants and from other sources were used as inputs into complex air quality models to estimate the concentrations of these pollutants at various points in Bexar County. The model that was used for this study (Comprehensive Air Quality Model with Extensions, CAMx) is a state-of-the-art model used by EPA. It uses inputs that are based on meteorology since wind, temperature, and many other factors determine where pollutants go and what secondary pollutants form in the atmosphere and at what speed. The most complete meteorological data are available only for 2002. Thus, air pollution concentration estimates for all three years 1997, 2002, and 2013 had to be based on the actual North American meteorology for the year 2002. Clearly weather varies from year to year, but the study used the meteorological data set that EPA uses for its modeling. EPA selects baseline years for modeling purposes from years that are conducive to high pollution levels, usually warmer years with low wind speeds. These models were run with and without estimates of the emissions from CPS Energy sources; the difference in concentrations between these runs allowed the estimation of the incremental impact of CPS Energy emissions on air quality. Emission source data must also be compiled for all pollution sources in North America; these are available for 2002 and have been projected for 2009 for the analyses. Detailed CPS Energy emissions estimates are available for the three years of interest. The air quality models were used to estimate concentrations (later used as exposure dose estimates in the dose-response models) for each 4 km grid in Bexar County and for a 12 km grid in the State of Texas; hence there were a total of 182 grid points in Bexar County, at which concentrations of the various pollutants were estimated.

The results of this modeling exercise are summarized in tables below. Table 2 shows the average daily concentrations for several pollutants attributable to all sources, after background levels of pollution are subtracted out. It was assumed that background pollution was due to natural sources or to sources outside of North America. Table 3 shows the incremental concentrations due to CPS Energy emissions. CPS Energy emissions contribute very little to the average CO, NO_x, and SO_2 concentrations. Except for some hourly ozone concentrations, including CPS Energy sources results in a decrease in ambient ozone levels across Bexar County. This is because the NO emitted from CPS Energy power plants acts as a scavenger for oxygen resulting in lower ozone levels within Bexar County. The largest relative contributions from CPS Energy sources are for PM, but even here the incremental concentrations due to CPS Energy sources are orders of magnitude less than the EPA standards.

Health effects were estimated by using the resulting estimated concentrations as doses in dose-response functions taken from the health air pollution literature. Dose-response functions are statistical equations that tell us how many people are impacted by a given level of air pollution. For example, a dose-response function would tell what percent of the population is likely to be admitted to a hospital with cardiovascular symptoms given a particular concentration of a given pollutant. There are many dose-response functions from which we could choose. This study tried to choose them from studies that were either undertaken in or included San Antonio or some other location with a demographic structure and weather similar to those of San Antonio. These similar places included Los Angeles, San Jose, and the Coachella Valley, CA as well as Phoenix, AZ. In all cases dose-response functions were taken from studies of US populations.

Table 2: Averaged daily modeled air pollution concentration values (minus EPA background, BG) attributable to all sources averaged over year and across Bexar County; 2002 CPS Energy attributable air pollution concentrations shown for comparison (units in last column)							
Pollutant-AT[1]	**1997**	**2002**	**CPS 2002**	**CPS %[2]**	**2013**	**BG**	**EPA NAAQS[3]**
CO-1	0.369	0.369	0	0.02	0.337	0.13	35 ppm
CO-8	0.280	0.280	0.00008	0.03	0.255	0.13	9 ppm
CO-24	0.169	0.169	0	0.06	0.154	0.13	-
O_3-1	22	22	0.02	0.09	21	25	124 ppb
O_3-8	17	17	-0.13	-0.76	17	25	79 ppb
O_3-24	1.4	1.6	-0.16	-10	2.4	25	-
PM_{10}-24	26.6	26.6	0.2	0.8	26.2	7	150 μg/m3
$PM_{2.5}$-24	13.3	13.3	0.16	1.2	12.9	3	15 μg/m^3

[1]AT = "averaging time": 1-hour, 6 hrs;., 24 hrs.
[2]Percent of 2002 concentration from all sources attributable to CPS Energy
[3]EPA National Ambient Air Quality Standards for comparison; all are daily averages, accept NO_2 and $PM_{2.5}$ which are annual averages

Table 3: Averaged daily modeled air pollution concentrations values (units in last column) attributable to *CPS Energy emissions* averaged over year and across Bexar County				
Pollutant-AT[1]	**1997**	**2002**	**2013**	**EPA NAAQS[2]**
CO-1	0	0	0.00032	35 ppm
CO-8	0.00010	0	0.0004	9 ppm
CO-24	0.00011	0.0001	0.0004	-
O_3-1	-0.22	0.02	0.09	124 ppb
O_3-8	-0.45	-0.13	-0.08	79 ppb
O_3-24	-0.42	-0.16	-0.17	-
NOx-24	0.000604	0.0003	0.000283	0.053 ppm
SO_2-24	0	0.0003	0.00023	0.14 ppm
PM_{10}-24	0.19	0.2	0.24	150 μg/m3
$PM_{2.5}$-24	0.15	0.16	0.19	15 μg/m3
PM_{Coarse}24	0.04	0.05	0.05	-

[1] The year-long average is based on daily data with these averaging times
[2]EPA National Ambient Air Quality Standards for comparison; all are daily averages, accept NO_2 and $PM_{2.5}$ which are annual averages

Several health effects were included. A survey of the health effects-air pollution literature suggested that the health effects in Table 4 below are related to the regulated pollutants listed in the Table.

Table 4: Causes of mortality and morbidity chosen for study

Cause of MM	**Age(s)**	**Related Pollutants**
Mortality		
All cause (non-accidental)	All, 30+, 25 +	CO, PM_{10}, $PM_{2.5}$ (ST, LT),O_3
COPD[1]	All	CO, $PM_{2.5}$
CV	All, 65+	CO, PMcoarse, PM_{10}, $PM_{2.5}$ (LT, ST)
Lung Cancer	30+, 25+	$PM_{2.5}$ (LT)
Pneumonia	All	$PM_{2.5}$
Respiratory	<1, All	PM_{10} (LT), $PM_{2.5}$
Morbidity (Hospital admissions)		
Asthma	<65	CO, PM_{10}, $PM_{2.5}$, O_3
Chronic heart disease	65+	$PM_{2.5}$
COPD	All, 65+	CO, O_3, PM_{10}, $PM_{2.5}$
CV	65+	CO, PM_{10}, $PM_{2.5}$
Pneumonia	All	O_3, PM_{10}

[1] Chronic obstructive pulmonary disease

The health effects include several short-term (ST) or acute effects, in which responses to air pollution are relatively quick and assumed to be a result of relatively short exposures, in the order of 24-hours or less. Some effects are the results of longer term (LT) exposures in the order of a year or more. Both of these were considered in this study. In Table 4 all effects studied were short-term unless noted otherwise.

For a given mortality or morbidity endpoint, several dose-response functions are often available, even from the same study. This study chose to be conservative in the sense of being more likely to overestimate an effect than to underestimate it by choosing dose-response functions with positive statistically significant effects (i.e., those studies which did not find positive statistically significant results were not used in this study.), and by considering functions that considered one pollutant at a time. (Since pollutants often co-occur in the environment, when more than one pollutant is included in a model, estimated effects for both pollutants often diminish; although the results of these models can be helpful in discriminating effects among pollutants, they are not considered here.) This selection process likely minimized any possibility that the health effects of air pollution in this study were underestimated.

The pollutant of greatest concern is particulate matter or PM. PM is a collection of particles of different sizes and chemical composition; it is currently regulated as total PM by mass for two size classifications, less that 2.5 microns in diameter ($PM_{2.5}$) and less than 10 microns in diameter (PM_{10}). Primary emissions from coal-fired power plants are small in total mass compared to the secondary particles that are formed from power plant gaseous emissions (SO_2

and NO); hence estimates of the secondary particles created as a result of gaseous emissions were calculated as part of the air quality modeling work described above and included in the analyses to estimate the overall health effects of CPS Energy sources.

The CAMx model was used to estimate the sources that contribute to $PM_{2.5}$ and the components of $PM_{2.5}$ at each of four receptors for the 2013 emissions scenario (Alpine, 2008). The four receptors are the continuous air monitoring stations in Bexar County that currently monitor $PM_{2.5}$. The apportionment results for the four receptors were very similar and thus were averaged. The averaged results are shown in Table 5.

Table 5. Estimated 2013 concentrations (µg/m^3) of PM (bolded values exceed 0.02) apportioned by Source[a] and Fraction and averaged across four Bexar County receptors

	Texas sources						Non Texas				
Fraction	**Bio-genic**	**EGU**	**Non-EGU**	**Area**	**MV**	**Non-road**	**Other**	**BC**	**Total**	**All[e]**	**CPS[f]**
Other coarse $PM_{10-2.5}$[b]	0.00	0.00	**0.14**	**15.04**	**0.06**	0.00	0.00	**0.08**	15.32	17.3	0.05
$PM_{2.5}$ fractions											
Primary elemental carbon	0.00	0.00	0.00	**0.12**	**0.08**	**0.15**	0.01	**0.07**	0.43		
Primary organic aerosol[c]	0.00	**0.08**	**0.10**	**1.20**	**0.05**	**0.11**	**0.05**	**0.37**	1.96		
Nitrate	0.27	0.24	0.50	0.35	0.66	0.40	0.11	0.10	2.62		
Ammonium	0.00	0.01	0.02	**0.97**	**0.20**	0.00	0.01	0.02	1.22		
Sulfate	0.00	**0.97**	**0.65**	**0.33**	0.01	0.02	**0.25**	**0.45**	2.67		
Other fine particulate[d]	0.00	**0.12**	**0.28**	**6.29**	**0.04**	0.01	**0.05**	0.00	6.78		
Total $PM_{2.5}$	0.27	1.41	1.54	9.26	1.03	0.68	0.48	1.02	15.67	15.9	0.19

a Biogenic from biological sources including grass fires; EGU, electric generating utilities, gas and coal fired; non-EGU, other industrial point sources; area, other sources not included in point sources and vehicles, e.g. agriculture, fireplaces, dirt roads, fires, construction, quarries, bbq grills, restaurants, airports, marine terminals; MV, motor vehicles; nonroad, other gasoline and diesel engines such as farm and construction equipment; other, contributions from outside the United States including Mexico and Canada and offshore oil and gas platforms; BC, boundary conditions are US contributions from outside the state of Texas.
b Other coarse PM is everything except crustal. Crustal is a small fraction in Bexar and was not modeled. So this is essentially all the coarse PM.
c These are organic compounds emitted from the various sources, i.e. primary. The estimates have not accounted for secondary organics formed in the atmosphere, and thus the term *organic carbon* that has been used in some of the epidemiological work would include both and is slightly underestimated here.
d Other fine PM is primary PM.
e These are the total or non speciated values that were derived in the first Alpine report (2007) for the 2013 model year, Table 2). For coarse PM, the difference (17.3-15.3) is probably the crustal fraction that was not speciated. For $PM_{2.5}$ the small difference of 0.23 is crustal, secondary organics, sodium, chloride, and water content, none of which were speciated.
f These are the total values attributable to CPS Energy for 2013 in Alpine (2007) and Table 3.

The estimated incidence for various mortality categories for 2002 are presented in Table 6 for both CO and PM, both of which have been associated with premature mortality for both all sources of pollution in Bexar County and for CPS Energy sources. Table 7 shows how the mortality results could vary if alternative studies were used. This table indicates that studies based on the chronic effects of pollution (again all $PM_{2.5}$) indicate that as many as 0.23%[11] of all non-accidental deaths in Bexar County might be related to CPS Energy emissions. Of even greater interest is that effect estimates from one long term study (Laden) would estimate that about 1900 out of 8675 deaths (about 19.6%) among people older than 25 in Bexar County are caused by air pollution. Factors such as workplace exposures, smoking, diet, alcohol, genetic disease, and many others have to be accounted for in the remaining 80% of deaths. If the epidemiological results that these incidence values are based on are accurate, then of approximately 9000 deaths in Bexar County in 2002, *perhaps as many* as 0.23% were caused by CPS Energy emissions and 19.6% were caused by all sources of pollution. These estimates are based on methods with inherent errors that could cause both overestimation in some instances and underestimation in other instances.

Table 6: Incidence of mortalities in Bexar County, attributable to CPS Energy and all sources of pollution, as a percent of total deaths from various causes for 2002

Pollutant-AT	Disease	CPS	All sources	Total deaths	Age
CO-24	COPD	0.01%	0.6%	488	All
$PM_{2.5}$-24	COPD	0.03%	3.1%	488	All
$PM_{2.5}$-24	Pneumonia	0.06%	5.6%	226	All
$PM_{2.5}$-24	Respiratory	0.03%	2.4%	890	All
CO-24	CV	0.01%	0.4%	3087	All
PM_C-24	CV	0.01%	1.6%	2813	65+
PM_{10}-24	CV	0.02%	2.0%	2813	65+
PM_{10}-24	CV	0.04%	5.5%	3087	All
$PM_{2.5}$-24	CV	0.01%	1.2%	3087	All
Long term estimates					
$PM_{2.5}$-yr	CV	0.21%	17.4%	2813	25+
$PM_{2.5}$-yr	Lung Cancer	0.38%	21.7%	610	25+
$PM_{2.5}$-yr	Lung Cancer	0.21%	17.3%	610	30+
PM_{10}-yr	Respiratory	0.38%	14.1%	8	<1

[11] The estimates do not warrant the use of two significant figures; however, they were used throughout the report to be consistent and avoid confusion.

Table 7: Incidence of all cause (non-accidental, ICD-9 <800) mortality in Bexar County, potentially attributable to CPS Energy and all sources of pollution, *as a percent* of the total deaths in the county from all causes for 2002					
Pollutant-AT	**CPS[1]**	**All sources**	**Total deaths**	**Age**	**Study**
Short term estimates					
CO-24	0.01%	0.36%	9025	All	Moolgavkar (HEI 2003)
CO-24	0.00%	0.10%	9025	All	Zeka Schwartz (2004)
CO-8	0.00%	0.56%	9025	All	Ostro et al. (2000)
O3-24	0.00%	0.03%	9025	All	Bell et al. (2004)
O3-24	0.00%	0.07%	9025	All	Dominici reanalysis, 90 City (2003)
O3-24	0.00%	0.14%	9025	All	Moolgavkar (HEI 2003)
PM10	0.00%	0.67%	9025	All	Dominici(2002) Zeka/Schwartz(2004)avg
PM10	0.03%	4.05%	9025	All	Fairley (HEI 2003)
PM10	0.01%	1.88%	9025	All	Klemm and Mason (2003)
PM10	0.01%	1.05%	9025	All	Moolgavkar (HEI 2003)
PM2.5	0.05%	4.22%	9025	All	Fairley (HEI 2003)
PM2.5	0.02%	1.61%	9025	All	Franklin (2007)
PM2.5	0.02%	1.60%	9025	All	Klemm and Mason (2003)
Long term estimates					
PM2.5-yr	0.09%	7.70%	8675	30+	Pope (2002)
PM2.5-yr	0.23%	19.6%	8675	25+	Laden et al. (2006)

[1] 0.00 means less than 0.01%

It should be noted that the results of this study, like all others, are subject to uncertainty. There are several assumptions inherent in this study. First of all it is assumed that the emissions estimates are accurate for various sources. In general, estimates are better for major sources than for small sources, some of which may be missing. If this is so, then the relative contribution of CPS Energy sources to air pollution concentrations and to health effects will be smaller than the estimates of this study. Assumptions about the validity of the air quality modeling and meteorological uncertainties could have influenced the results, but there is no reason to believe that these assumptions bias the results in one way or another. Results can also be influenced by the choice of dose-response functions. Those selected are thought to have biased the results upwards if anything; hence our estimates of health impacts are possibly high.

Table 8 presents similar results for morbidity categories. It should be noted that the CPS Energy contribution is well below 1% for all of these categories. This analysis was extended to consider 1997 and 2013; in an effort to address the results of different health-air pollution studies, results were presented separately for each dose-response study. Except possibly for the longer-term mortality results, there is little difference between the three time periods. Depending upon the specific study utilized, the increase in long-term mortality was at most 0.06% over the 1997-2013 timeframe.

Table 8: Incidence of hospital admissions in Bexar County, attributable to CPS Energy and all sources of pollution, as a percent of hospital admissions for each of the causes for 2002.						
Pollutant	**AT**	**Disease**	**CPS[1]**	**All Sources**	**HA**	**Age**
CO	1	Asthma	0.01%	1.62%	1200	<65
O_3	8	Asthma	0.00%	4.65%	1200	<65
PM_{10}	24	Asthma	0.04%	4.59%	1200	<65
$PM_{2.5}$	24	Asthma	0.05%	5.65%	1200	<65
$PM_{2.5}$	24	CHF	0.02%	1.74%	2557	65+
CO	24	COPD	0.01%	0.60%	3450	all
O_3	8	COPD	0.00%	1.50%	1376	65+
PM_{10}	24	COPD	0.03%	4.50%	1376	65+
PM_{10}	24	COPD	0.02%	3.15%	3450	all
$PM_{2.5}$	24	COPD	0.02%	2.03%	3450	all
CO	1	CV	0.00%	0.60%	8248	65+
CO	24	CV	0.01%	0.77%	8248	65+
$PM_{2.5}$	24	CV	0.02%	1.81%	8248	65+
PM_{10}	24	CV	0.01%	1.54%	8248	65+
PM_{10}	24	CV	0.02%	2.64%	8248	65+
O_3	8	Pneu	0.00%	1.26%	481	65+
PM_{10}	24	Pneu	0.03%	4.54%	481	65+
$PM_{2.5}$	yr	PTB[2]	0.23%	18.6%	2667	new

[1] 0.00 = less than 0.00%; [2] pre-term births (24-36 weeks)

Mercury was also considered in this study as a special case. The largest exposure to mercury is not through inhalation, but from ingestion of food, largely fish, that contain mercury. Atmospheric deposition of mercury contributes to the mercury content of food.
The air quality modeling was used to estimate the deposition patterns of mercury from coal-fired power plants as mercury is a naturally-occurring element in coal, and indeed in most soils. These estimates were applied to some worst-case scenarios assuming that an individual ate enormous quantities of fish (99th percentile in terms of fish consumption by Americans) from two lakes thought to be most impacted by CPS Energy emissions. It was estimated that less than 0.005% of the mercury in these lakes comes from CPS Energy sources. If that individual ate 122 grams (over ¼ pound) of fish per day from these two lakes, that individual would still consume less mercury than is considered unsafe by the US EPA. Hence mercury from the CPS Energy power plants does not present a hazard to residents of Bexar County.

A list of references is available with the full report.