

# 1990-2010 Area Source Emission Trends in the State of Texas

Andrew D. Bollman, Holly Chelf, and Randy Strait  
E.H. Pechan & Associates, Inc., 3622 Lyckan Parkway, Suite 2002, Durham, NC 27707  
[abollman@pechan.com](mailto:abollman@pechan.com)

## ABSTRACT

Under subcontract to ENVIRON International, E.H. Pechan & Associates, Inc. (Pechan) assisted the Texas Natural Resource Conservation Commission (TNRCC) in developing annual and ozone season day area source emission trends estimates for 1990-2010 for each county in the State for volatile organic compounds (VOC), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), particulate matter of 10 microns or less (PM<sub>10</sub>), particulate matter of 2.5 microns or less (PM<sub>2.5</sub>), and sulfur dioxides (SO<sub>2</sub>). Pechan also computed area source CO season day emission trends estimates for El Paso county. This paper documents the methods, models, and data sources that were used to develop the emission trends data and presents a summary of major State emission trends including a discussion of the major factors producing these trends. Limitations of the analysis and potential future improvements to the estimates are also described.

## INTRODUCTION

As part of their mission, TNRCC is responsible for communicating information concerning area source emission trends. TNRCC has previously estimated emissions of VOC, NO<sub>x</sub>, and CO for area sources in nonattainment areas for selected years. Because this information was insufficient for identifying annual emission trends for each of the 254 counties in the State, an effort was initiated to develop a consistent set of 1990-2010 emission trends data for each county. To ensure consistency in the emission trends data, Pechan generally applied the methodologies that were utilized in developing emission estimates for a 1999 base year Texas inventory. As part of a related project, Pechan also assisted TNRCC by improving upon the Texas 1999 year National Emissions Inventory (NEI) Version 1.5 emission estimates for select area source categories. These improvements utilized local emissions activity data and the emission calculation procedures identified in the emission inventory guidance documents prepared by the Emission Inventory Improvement Program (EIIP).

The balance of this paper is organized into three major sections. The next section describes the methodologies that were used in developing the 1990-2010 area source emission trends data. This section is followed by a brief summary of the results of the analysis, including a discussion of the major factors producing these results. Analytical limitations and potential areas for future improvements are described in the conclusions section.

## METHODOLOGY

Emission trends were calculated by compiling or estimating emissions activity and control data for the 1990-2010 period for each county in Texas in a manner consistent with the estimates developed for the 1999 base year inventory. Because of the time constraints associated with the project, it was necessary to use surrogate data to represent emissions activity trends for certain area source categories.

Changes in emissions activity levels are generally computed using one of two approaches. These two approaches are identified in this paper as the *detailed* approach and the *general* approach. The *detailed* approach relies on emissions activity data that are directly related to the level of uncontrolled emissions for a particular process. For example, Stage II emissions from vehicle refueling at gasoline

service stations are related to the amount of gasoline pumped from these stations. The EIIP preferred approach for estimating Stage II emissions is to multiply an emission factor (grams per gallon of dispensed gasoline) by the amount of highway vehicle gasoline sold.<sup>1</sup> The *general* approach uses a surrogate indicator, such as employment or output by economic sector, to estimate trends in emissions activity. For this effort, Version 4.0 of the Economic Growth Analysis System (EGAS 4.0), an EPA-approved source of emissions growth factors, was the source of surrogate emission growth indicators for the general emission trends approach.<sup>2</sup>

The following provides an overview of the calculations that were performed to develop the area source emission trends estimates, along with a more detailed discussion of the two types of emission estimation approaches used in this effort. Because of the level of effort necessary to implement the detailed approach, this procedure was reserved for the subset of area source categories identified in Table 1. This subset includes source categories for which 1999 year emission estimates were improved under a concurrent TNRCC effort, and any additional source categories emitting at least 5 percent of total area source VOC or NO<sub>x</sub> emissions as reported in Version 1.5 of the 1999 NEI. The general approach was followed for all other area source categories.

### Emission Trends Calculations

With some minor exceptions, both emission trends approaches use a similar equation to develop post-1999 year emission trends estimates:

$$E_{ix} = [(E_{i1999} \times GF_x)] \times [1 - (CE_x \times RP_x \times RE_x)] \quad (1)$$

where:

- $E_{ix}$  = emissions for county i for post-1999 trends year x, tons/year or tons/day;
- $E_{i1999}$  = emissions for county i for year 1999, tons/year or tons/day;
- $GF_x$  = emissions activity growth factor for trends year x relative to 1999 (1999 = 1.0);
- $CE_x$  = control effectiveness (fraction) of applicable rules for trends year x, unitless;
- $RP_x$  = rule penetration (fraction) of applicable rules for trends year x, unitless; and
- $RE_x$  = rule effectiveness (fraction) of applicable rules for trends year x, unitless.

The Equation 1 term that reflects the level of emission reduction from an applicable control program ( $[1 - (CE_x \times RP_x \times RE_x)]$ ), can be ignored when there are no controls affecting a source category's future year emissions. In most cases, the major distinguishing characteristic of the general approach is that it utilizes emissions activity growth factors ( $GF_x$ ) from EGAS 4.0, while the detailed approach uses emissions activity growth factors that are based on the activity data used in estimating 1999 emissions (e.g., residential natural gas consumption data for the residential natural gas combustion category).

Equation 2 was used to compute pre- and post-1999 emissions for source categories whose 1999 year emissions incorporate the effect of an emission control program and whose pre- or post-1999 control levels were different than the levels in 1999 (e.g., due to increased rule penetration).

$$E_{ix} = [(E_{i1999} \times GF_x)] \times [ [1 - (CE_x \times RP_x \times RE_x)] / [1 - (CE_{1999} \times RP_{1999} \times RE_{1999})] ] \quad (2)$$

where:

- $E_{ix}$  = emissions for county i for post-1999 trends year x, tons/year or tons/day;
- $CE_{1999}$  = control effectiveness (fraction) of applicable rules for year 1999, unitless;
- $RP_{1999}$  = rule penetration (fraction) of applicable rules for year 1999, unitless; and
- $RE_{1999}$  = rule effectiveness (fraction) of applicable rules for year 1999, unitless.

The 1999 base year emission estimates were generally developed before the emission trends estimates. Because the emission trends estimates were developed concurrently with the 1999 emission estimates for a few detailed approach source categories, these source categories did not utilize the above equations. These area source categories included:

- Architectural and industrial maintenance coatings;
- Traffic markings;
- Asphalt (emulsified and cutback); and
- Gasoline distribution–vehicle refueling (Stage I) and spillage.

The emission trends calculations for these source categories were typically performed using the same procedures that were used to compute the 1999 year estimates. Further details on the calculations for these categories are provided in a report prepared for TNRCC.<sup>3</sup>

Because some source categories' 1999 year emission factors incorporate the effect of control programs that were not in place for some pre-1999 years, it was necessary to estimate pre-1999 emissions by applying an adjustment to the 1999 emission estimates. As indicated in Equation 3, this adjustment, which was used in estimating emissions for all years before the specific control program was implemented, effectively removes the emission reduction term that is incorporated into the 1999 emission estimates. This adjustment was not necessary for counties and source categories that were not affected by control programs in 1999.

$$E_{ix} = [(E_{i1999} \times GF_x)] / [1 - (CE_{1999} \times RP_{1999} \times RE_{1999})] \quad (3)$$

The following subsections further clarify the general and detailed emission trend estimation approaches.

### **General Approach**

Time and resource constraints dictated that EGAS 4.0 and related data be used to estimate trends in emissions activity levels for some area source categories. For most EGAS 4.0 source categories, emission growth indicators are based on 3-digit Standard Industrial Classification (SIC) code economic output data. These output data are produced by econometric models developed by Regional Economic Models, Inc. (REMI).<sup>4</sup> It is important to note that EGAS 4.0 is constructed from data sources that are not specified at the county-level. For Texas, the EGAS 4.0 REMI models were defined into 4 regions:

- Houston-Galveston-Brazoria Nonattainment Area;
- Beaumont-Port Arthur Nonattainment Area;
- El Paso Nonattainment Area; and
- Rest-of-Texas.

The counties that comprise each of these regions are identified in Table A-1 of the EGAS 4.0 User's Guide.<sup>5</sup> EGAS 4.0 also employs surrogate indicator data from other information sources. One key data source for fuel combustion sources is the U.S. Department of Energy (DOE), Energy Information Administration (EIA)'s *Annual Energy Outlook 1999*.<sup>6</sup> This data source develops fuel production and consumption projections on a multi-state regional basis (e.g., the West South Central region includes Texas as well as Arkansas, Louisiana, and Oklahoma). The EGAS 4.0-based data, therefore, do not reflect county-specific trends that may deviate from the regional data incorporated into the model.

With the exception of the specific area source categories identified in Table 1, Pechan utilized EGAS 4.0 growth factors to reflect 1996-2010 emissions activity level changes. These growth factors

are generally based on forecasts for economic variables, not emissions activity variables. In EGAS 4.0, for example, the Stage II gasoline service station source classification code (SCC) is assigned the gasoline and oil expenditures variable as the surrogate emissions activity indicator. In developing EGAS 4.0, researchers identified that this indicator has historically correlated with total gasoline demand at the national level. Because of the level of effort required to identify the existence of such correlations and the lack of readily available long-term data for conducting these analyses, EGAS 4.0 developers conducted correlation analyses for less than 30 emissions activities. For all of the other more than 9,000 SCCs included in EGAS 4.0, a surrogate indicator was assigned based on judgment. Without conducting detailed analyses, however, it is not possible to be certain that these indicators are correlated with their assigned emissions activities.

For 1990-1995 emissions activity level changes, Pechan utilized the same data sources that underlie EGAS 4.0 whenever these sources were available. The economic output data are available for 1990-1995 from the REMI models that underlie EGAS 4.0.<sup>4</sup> However, DOE/EIA's *Annual Energy Outlook* publications do not report historical energy consumption/production data. To reflect historical emissions activity levels for these source categories, Pechan compiled energy data from the DOE/EIA's *State Energy Data Report 1999*.<sup>7</sup> This DOE/EIA publication provides data that characterize state-level changes in fuel combustion-related emissions activities.

## **Detailed Approach**

The detailed emissions estimation approach is to compile the same emissions activity data that were used in developing the 1999 baseline emission estimates for all other years over the analysis period. This approach was used for the source categories identified in Table 1. Because the detailed emission trends methods are specific to each source category, a discussion of the emission trends methodology for the residential natural gas combustion source category is provided below as an example of how these methods were implemented. The detailed emissions trends methods used for other source categories are presented in the emission trends report prepared for TNRCC.<sup>3</sup>

### **Residential Natural Gas Combustion Example**

Base year (1999) emissions from the residential natural gas combustion sector were estimated by multiplying county-level residential natural gas consumption estimates by an emission factor. The 1999 inventory relied on 1999 Railroad Commission of Texas (RCOT) residential natural gas consumption data.<sup>8</sup> These data were not available in electronic format and were only available at the municipal level. Pechan entered the 1999 year municipal residential natural gas consumption data into a data base and then aggregated the data to the county-level. The RCOT data were not used to reflect residential natural gas combustion emission trends because these data were not available for each analysis year, and because the required compilation effort could not be completed within the time constraints of the project.

Changes in 1990-1999 state-level emissions activity for this category were estimated based on state-level residential natural gas consumption estimates reported by the Department of Energy's Energy Information Administration (DOE/EIA).<sup>7</sup> County-level emissions activity was based on these state-level data and the estimated number of 1990-2000 housing units using utility gas. The use of these housing units data is consistent with the Emission Inventory Improvement Program (EIIP)'s Area Source Method Abstract that identifies the number of housing units using utility gas as one of the appropriate sets of data for allocating state consumption to local areas.<sup>9</sup>

For 1990-1999, each county's proportion of total state housing units using utility gas was calculated. These county proportions were first developed for 1990 and 2000 based on the percentage of

housing units in each county using utility gas in 1990 and the total number of housing units in each county, which are reported for 1990 and 2000 by the Bureau of the Census.<sup>10,11</sup> The 1991-1999 proportions of total state housing units using utility gas in each county were estimated through interpolation. Next, ratios were developed for each trends year. These ratios represented the change in the county's proportion of state number of housing units using utility gas relative to the county's proportion in 1999. These ratios were then applied to growth factors developed from the state-level EIA data to derive county trends in residential natural gas consumption.

Post-1999 emissions activity trends were based on DOE/EIA projected West South Central region residential natural gas consumption growth rates and the change in each county's proportion of state number of housing units using gas.<sup>12</sup> The projected county number of housing units using gas was estimated through 2010 using the Texas Comptroller of Public Account (TCPA)'s estimated number of state housing starts for 2000-2010, F.W. Dodge county-level 2000-2005 housing unit projections data supplied by TNRCC, and the 1990 percentage of housing units in each county using utility gas.<sup>13,14,10</sup> The lack of F.W. Dodge data beyond 2005 results in the projected state trend being used to estimate each county's 2006-2010 trend.

A TNRCC regulation that sets NO<sub>x</sub> emission limits for natural gas-fired water heaters, boilers, and process heaters will affect this category statewide beginning in 2002.<sup>15</sup> Staff from TNRCC provided control efficiency estimates for the water heater component of this regulation—for 2002-2004, control efficiency (CE) is estimated at 53 percent, after 2004, CE is estimated at 88 percent.<sup>16</sup> TNRCC also provided an estimate of the annual water heater turnover rate (10 percent), which is based on the average lifetime of a water heater (10 years) as reported by the Gas Appliance Manufacturers Association. This annual turnover rate, along with information on the effective date of the regulation, and the projected percentage of total residential natural gas consumption from water heaters, was used in developing rule penetration (RP) estimates for each year. The projected percentage of national residential natural gas consumption from water heaters was compiled for 2002-2010 from the Department of Energy's *Annual Energy Outlook 2001*.<sup>12</sup> In 2002, approximately 31 percent of total residential gas consumption is estimated from water heaters; this percentage is estimated at approximately 28 percent in 2010. Based on this percentage and the projected annual turnover rate, RP is estimated at approximately 24 percent for the year 2010. Rule effectiveness was assumed at 100 percent.

## **EMISSION TRENDS RESULTS**

Figure 1 displays statewide Texas 1990-2010 area source emission trends relative to the 1999 base year. The figure indicates that VOC and NO<sub>x</sub> emissions are the only two pollutants expected to decline in the post-1999 period. This result may be misleading in that the emission trends analysis focused the use of the more accurate, detailed emissions estimation approach on VOC and NO<sub>x</sub> emission source categories. Further discussion of this issue is provided in the Conclusions section that follows.

Statewide annual VOC and NO<sub>x</sub> emissions are estimated to decline throughout the analysis period. The main contributor to these declines is the Oil and Gas Production source category. VOC emissions from this category are projected to decline from more than 580,000 tons per year (tpy) in 1990 to less than 250,000 tpy in 2010. Because no emission controls affect this area source category, the reduction is attributable to the historical and projected decline in oil and gas production activity in Texas. Control programs that provide significant VOC or NO<sub>x</sub> reductions include Stage II controls on service stations and NO<sub>x</sub> emission reductions from the state's water heater NO<sub>x</sub> regulations. The service stations source category is associated with the second largest VOC emission reductions over the analysis period.

Annual statewide CO emissions decline significantly between 1996 and 1997, but then hold relatively constant through 2010. There are three source categories that account for the bulk of the reductions between 1996 and 1997. Emission reductions from the Open Burning source category result from implementation of the state's open burning ban in 1997. In addition, the Residential Wood and Oil and Gas Production sectors are significant CO categories that experienced emission declines between 1996 and 1997. The Residential Wood and Oil and Gas Production categories declined due to reductions in each sector's emissions activity.

Annual PM<sub>10</sub> and PM<sub>2.5</sub> emissions, which are dominated by the Miscellaneous source category, experienced a significant reduction between 1996 and 1997, but are projected to undergo a small increase thereafter. The only significant emission control programs affecting PM sources are the state's open burning ban and the New Source Performance Standard (NSPS) affecting wood heaters. The open burning ban resulted in most of the emission reductions that occurred between 1996 and 1997.

Annual SO<sub>2</sub> emissions declined dramatically between 1996 and 1997, continued to decline slightly through 1999, and are projected to increase slowly through 2010. The only area source control program affecting SO<sub>2</sub> sources is the state's open burning ban which produced the majority of the SO<sub>2</sub> emission reductions that occurred between 1996 and 1997. Other source categories with significant emission changes in the historical period include Oil and Gas Production, Commercial/Institutional Fuel Combustion, Oil, and Residential Fuel Combustion, Other. All three of these categories' emission reductions were solely due to declines in emissions activity.

## CONCLUSIONS

The Texas area source emission trends analysis contributes valuable information for air quality planning, and provides a number of lessons concerning future analytical improvements. The most noteworthy results of the analysis are the significant VOC and NO<sub>x</sub> reductions that are projected to occur through 2010. The primary contributor to both the VOC and NO<sub>x</sub> reductions is the forecasted decline in Texas oil and gas production. Given the importance of this sector to total VOC and NO<sub>x</sub> emissions, it will be important for the State to monitor activity in this sector. If the State decides to rely on these reductions to achieve air quality planning goals, it may be necessary for Texas officials to consider additional control programs if oil and gas production does not decline as projected.

An important analytical limitation of the analysis was the use of the general emissions estimation approach for many area source categories. Before making any firm conclusions about future CO, SO<sub>2</sub>, PM<sub>10</sub>, and PM<sub>2.5</sub> emissions, it is recommended that additional analyses be conducted. These analyses should focus on applying the detailed emissions estimation approach for the largest CO, SO<sub>2</sub>, PM<sub>10</sub>, and PM<sub>2.5</sub> source categories.

The EPA can play an important role in improving emission trends analyses through continued support for improvements to its EGAS emissions growth factor model. These improvements should focus on refining the use of surrogate data for estimating changes in emissions activity. For a small number of source categories, EGAS 4.0 projects emissions activity growth using identified relationships between surrogate economic data and emissions activity data. For example, projections of gasoline consumption are based on a relationship between gallons of gasoline consumed and oil and gasoline expenditures. These relationships were determined in EGAS 4.0 based on regression analyses relating historical trends in emissions activity data with trends in surrogate economic data. Expanding this effort to additional source categories should improve the accuracy of the emissions growth factors produced by the model, and the emission projections produced using these growth factors.

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## **Keywords**

emissions  
inventory  
projection  
area source  
growth

**Table 1.** Detailed emissions estimation approach area source categories.

Residential Natural Gas Combustion  
Commercial/Institutional Natural Gas Combustion  
Residential Wood Combustion  
Oil and Gas Production  
Architectural and Industrial Maintenance (AIM) Coatings  
Automobile Refinishing  
Traffic Markings  
Industrial Surface Coatings  
Graphic Arts  
Asphalt (Emulsified and Cutback)  
Agricultural Pesticide Application  
Consumer and Commercial Products  
Gasoline Distribution  
Open Burning  
Agricultural Field Burning  
Wildfires  
Managed Burning: Slash  
Managed Burning: Prescribed

**Figure 1.** Texas annual area emission trends relative to 1999.

