Evaluating Ozone Control Programs in the Eastern United States:

Focus on the NO_X Budget Trading Program, 2004

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Executive Summary

Emission Reductions

- EPA has developed more than a dozen programs since 1990 to limit ozone formation by reducing emissions of its key precursors: nitrogen oxides (NO_X) and volatile organic compounds (VOCs). These programs complement state and local efforts to attain the National Ambient Air Quality Standards for ozone.

- Emission trends reflect implementation of these control programs, which began in the mid-1990s. In the eastern United States, NO_X emissions decreased by 25 percent, and VOC emissions dropped by 21 percent, from 1997 to 2004.

- Control programs successfully reduced NO_X emissions during the warm summer months, generally referred to as the ozone season. The most recent of those programs was the NO_X SIP Call, EPA's regulation to reduce the regional transport of NO_X and ground-level ozone in the eastern United States.
  - All affected states chose to comply with the NO_X SIP Call by participating in the EPA-administered NO_X Budget Trading Program (NBP).
  - In response to the NO_X SIP Call, emissions of NO_X from the power industry (one of the largest NO_X sources in the country) dropped significantly after 2002. Other sources did not show this significant drop in emissions.
  - After implementation of the NO_X SIP Call in 2004, ozone season power industry NO_X emissions were about:
    - 30 percent lower than in 2003, when a limited number of states were subject to NO_X SIP Call requirements;
    - 50 percent lower than in 2000, before the NO_X SIP Call was implemented; and
    - 70 percent lower than in 1990, before implementation of the Clean Air Act Amendments.
  - These reductions occurred despite a shorter-than-normal control period for states participating in the NBP for the first time in 2004 and despite the use of compliance supplement pool allowances—additional allowances issued to help states phase in compliance during the first two years of the NBP.

Changes in Ozone

- In most of the eastern United States, reductions in ozone concentrations (adjusted for weather) more than doubled after the NO_X SIP Call was implemented, beginning in 2003.

- Ozone concentrations declined where EPA expected they would. Areas with the greatest decline in ozone concentrations are near, and downwind of, areas with greatest reductions in NO_X emissions.

- Because weather conditions can vary from year to year, ozone levels could be higher in years when weather is conducive to ozone formation-even when current emission control programs are working as expected. To get a truer picture of ozone from year to year, EPA adjusts ozone levels to account for the influence of weather.

Compliance with the NO_X Budget Trading Program (NBP)

- Sources choose from a variety of compliance options to meet the emission reduction targets of the NBP, including reducing generation from certain units, modifying or optimizing the combustion process to reduce NO_X formation, using add-on controls, or purchasing additional emission allowances from sources reducing below their allocations.

- In 2004, there was close to 100 percent compliance. Of the more than 2,500 units covered by the NBP in 2004, nearly all held sufficient allowances to cover their emissions. Just two units at one facility were out of compliance and subject to an automatic penalty deduction (three allowances for each excess ton of emissions).

- Overall trading activity remained robust in 2004, and allowance prices were lower and more stable than in 2003.

- The level of "banked" (i.e., saved) allowances increased significantly in 2004 as a result of additional sources participating in the NBP and the addition of compliance supplement pool allowances to states' budgets.

- Sources in the NBP are required to use consistent rigorous monitoring procedures to measure their emissions. In 2004, both electric generating units and industrial boilers passed more than 98 percent of their required quality assurance tests.

New Regulations, Additional Improvements

- While ozone remains a significant problem in many areas of the United States, EPA anticipates additional improvements, including emission reductions from:

  - Continued implementation of the NO_X SIP Call;

  - Mobile source regulations (new passenger vehicles, heavy-duty diesel engines, and other mobile sources);

  - EPA's Clean Air Interstate Rule (CAIR), which will build on the ozone season emission reductions from the NO_X SIP Call. In 2015, CAIR, the NO_X SIP Call, and other programs in the CAIR region will reduce power industry ozone season NO_X emissions by about 50 percent and annual NO_X emissions by about 60 percent from 2003 levels. CAIR will ensure that Americans continue to breathe cleaner air by dramatically reducing air pollution that moves across state boundaries in 28 eastern states and Washington, D.C.

  - State Implementation Plans to address ozone nonattainment.

Introduction

For more than three decades, the U.S. Environmental Protection Agency (EPA) has worked with state, local, and tribal agencies to reduce emissions that contribute to the formation of ground-level ozone. This pervasive pollutant is responsible for a number of serious health and ecological effects in many areas of the United States.

Early ozone management policies focused on reducing ozone by reducing emissions of one of its key precursors, volatile organic compounds (VOCs). VOCs contribute to ground-level ozone formation by reacting with nitrogen oxides (NO_X) in the presence of sunlight.

While ozone levels have decreased substantially since 1980, the downward trend began to slow in the early 1990s. About that time, emerging science indicated that NO_X controls, in addition to VOC controls, would reduce ozone levels more effectively across large regions of the United States.

EPA responded by developing programs to reduce NO_X emissions, including the NO_X State Implementation Plan (SIP) Call, designed to reduce the regional transport of ozone and ozone-forming pollutants in the eastern half of the United States. All states chose to meet mandatory NO_X SIP Call reductions through participation in the NO_X Budget Trading Program (NBP), a market-based cap and trade program for electric generating and large industrial units.

For this report, EPA analyzed the effectiveness of NO_X and VOC control programs designed to reduce precursor emissions and improve ozone air quality. This report focuses specifically on progress made in reducing emissions in the eastern United States under the NO_X SIP Call. Analyses of emissions in this report do not include emissions from natural sources.

This report:

- Briefly describes ozone formation and its health and environmental effects, and provides an overview of the major programs designed to reduce ozone since 1990.
- Evaluates the effectiveness of the major control programs by reviewing emission reductions and comparing changes in emissions to changes in ozone concentrations.
- Compares actual changes in NO_X emissions and ozone concentrations to those predicted to occur under the NO_X SIP Call.
- Examines progress and compliance under the NO_X Budget Trading Program, including market activity, allowance banking in 2004, and progressive flow control in 2005.
- Looks at future NO_X emission reductions under programs such as mobile source controls and the Clean Air Interstate Rule (CAIR).

Chapter 1: Ozone and Major Control Programs

Ozone Formation and Effects

Ground-level ozone pollution is common in many parts of the United States. While ozone levels in urban areas can be high because of concentrated local sources of ozone-forming pollutants, ozone levels in both urban and rural areas are affected by regional transport—the movement of ozone and/or its precursors by the wind. Because of transport, ozone levels can also be elevated in rural areas with few local emission sources.

EPA revised its national air quality standards for ozone in 1997, establishing an 8-hour standard to better protect public health. The 8-hour standard is 0.08 parts per million (ppm). An area meets the standard if the 3-year average of the annual fourth highest daily maximum 8-hour average concentration is less than or equal to 0.08 ppm.

In April 2004, EPA designated 126 areas in the United States as nonattainment for the 8-hour ozone standard,

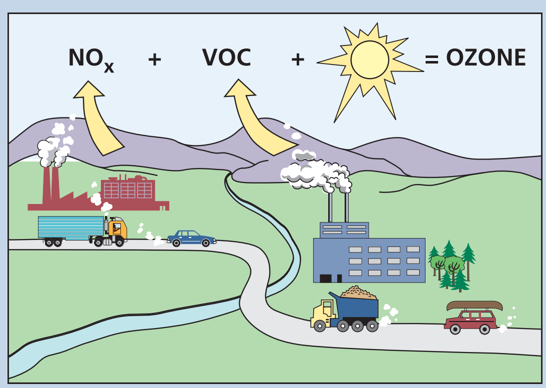
About Ground-Level Ozone

Location & Formation: Beneficial ozone occurs naturally in Earth's upper atmosphere (the stratosphere), where it shields the planet from the sun's harmful ultraviolet rays. At ground level, harmful ozone pollution forms when emissions of NO_X and VOCs react in sunlight. Because ground-level ozone is highest when sunlight is most intense, the warm summer months (May 1 to September 30) are generally referred to as the "ozone season."

Health Effects: Ozone can aggravate respiratory diseases, such as asthma, emphysema, and bronchitis, and can reduce the respiratory system's ability to fight off bacterial infections. Even healthy people can have symptoms related to ozone exposure. Over time, ozone reduces lung function. And recent research suggests that acute exposure to ozone likely contributes to premature death.

Transport: Wind can affect both the location and concentration of ozone pollution. NO_X and VOC emissions can travel hundreds of miles on air currents, forming ozone far from the original emission sources. Ozone also can travel long distances, affecting areas far downwind. High winds tend to disperse pollutants and can dilute ozone concentrations. Light winds, on the other hand, allow pollution levels to build up and become more concentrated.

Ecological Impacts: Ground-level ozone damages vegetation and ecosystems, leading to reduced agricultural crop and commercial forest yields, and increased plant susceptibility to diseases, pests, and other stresses, such as harsh weather. Ozone also damages the foliage of trees and other plants, adversely affecting the landscape of cities and national parks, forests, and recreation areas.



To learn more about ozone and its health impacts, please visit the AIRNow Web site at <www.airnow.gov>. For information on the health and ecological effects of ozone, go to <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=114523>. For more about the relationship between emissions and ozone formation, visit <www.epa.gov/airtrends>.

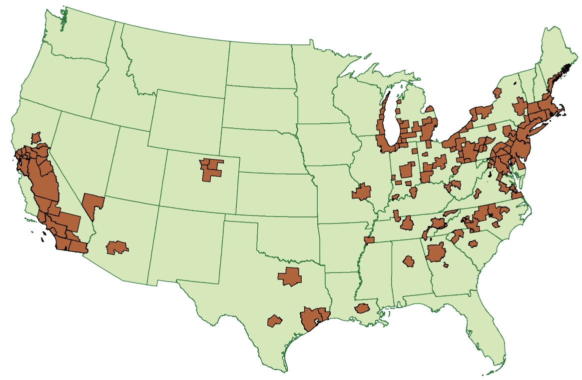
based on ozone levels from 2001-2003 (see Figure 1). The vast majority of these are in the East (404 counties or partial counties) and are home to more than one-third of all Americans.

Reducing Ozone Pollution: Major Control Programs for NO_X and VOCs

The majority of NO_X and VOC emissions in the eastern United States come from three types of sources: mobile sources, industrial processes, and the electric power industry. Mobile sources and the electric power industry were responsible for 78 percent of annual NO_X emissions in 2004 (see Figure 2). That same year, 99 percent of VOC emissions came from industrial processes (including solvents) and mobile sources. Emissions from natural sources, such as trees, may comprise a significant portion of total VOC emissions, especially during the ozone season. Figure 2 does not include these emissions.

EPA has developed more than a dozen control programs since 1990 to reduce ozone by decreasing emissions of NO_X and VOCs (see Table 1). These programs complement state and local efforts to improve ozone air quality and meet national standards.

Figure 1:
8-hour Ozone Nonattainment Areas

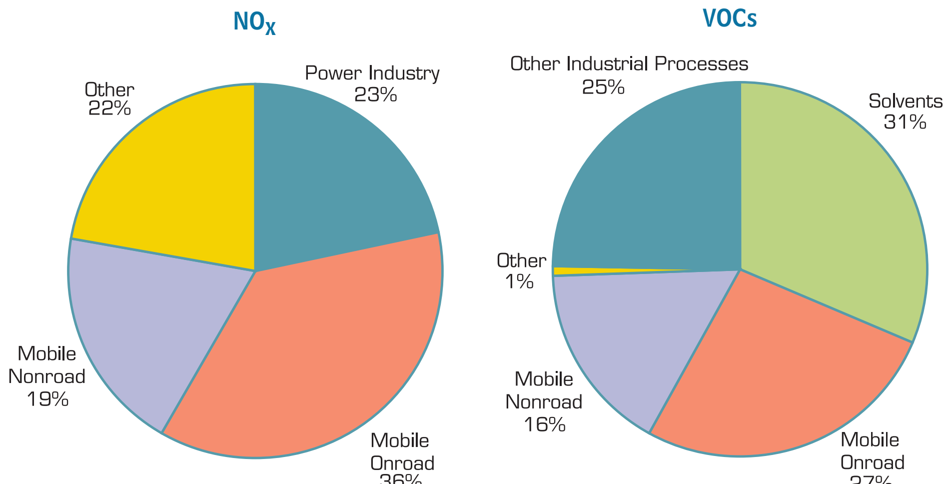


Source: EPA

Notes:

- Map includes partial counties.
- Nonattainment areas as of of April 2004

Figure 2:
Sources of NO_X and VOC Annual Emissions in the Eastern United States, 2004



Source: EPA

Notes:

- Emissions are from the following states: Minnesota, Iowa, Missouri, Arkansas, Louisiana, Wisconsin, Illinois, Tennessee, Mississippi, Michigan, Indiana, Kentucky, Alabama, Florida, Georgia, South Carolina, North Carolina, Virginia, West Virginia, Ohio, Pennsylvania, Delaware, Maryland, District of Columbia, New Jersey, Connecticut, Rhode Island, Massachusetts, New Hampshire, New York, Vermont, and Maine.
- The Other category for NO_X emissions includes some industrial boilers and smaller sources such as residential fuel combustion.
- Emissions are projected from EPA's preliminary 2002 National Emissions Inventory (NEI).

Table 1: Major EPA NOx and VOC Emission Control Programs since 1990

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Mobile Sources																			
Tier I Emission Standards (Onroad)					Both	Both	Both	Both											
Reformulated Gasoline						VOC					Both								
National Low Emission Vehicle Program (Onroad)										Both	Both	Both							
Inspection/Maintenance Programs (Onroad)						Both													
Gasonline Vapor Pressure Controls			VOC																
Evaporative Controls (Onroad)	VOC	VOC					VOC	VOC	VOC	VOC									
Heavy Duty Trucks (Onroad)	NOx	NOx							NOx						Both	Both		Both	
Tier II Vehicle and Gasoline Sulfur Program (Onroad)															Both	Both	Both	Both	Both
Clean Air Nonroad Diesel Rule (Nonroad)																			VOC
Other Engine Standards (Nonroad)							Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
Industrial Processes																			
Synthetic Organic Chemical MACT (HON)					VOC	VOC		VOC		VOC									
Reasonable Available Control Technology (RACT)						NOx													
Solvent and Coating Controls				VOC	VOC	VOC	VOC		VOC										
Power Industry																			
Acid Rain NO_x Reduction Program							NOx				NOx								
Ozone Transport Commission (OTC) NO_x Budget Program										NOx									
NO_x State Implementation Plan (SIP) Call														NOx	NOx			NOx	

Legend:
- NOx = Controls that result in NO_x Reductions
- VOC = Controls that result in VOC Reductions
- Both = Controls that result in both NO_x reductions and VOC reductions

Source: EPA

Notes:
- **Years highlighted indicate implementation or compliance dates.**
- **Early reductions occur prior to compliance date.**
- **In many cases, engine standards are phased in over multiple model years. In some cases the time periods overlap.**
- **For fuel standards, year indicates when the fuel was made available.**

Mobile Sources

Emission control programs established for mobile sources in the 1990s include regulations for new vehicles and for fuels. Benefits from vehicle engine standards increase modestly each year as older, more-polluting vehicles are replaced with newer, cleaner models. In time, these programs yield substantial emission reductions. Benefits from fuel programs generally begin as soon as a new fuel is available.

As Table 1 shows, many of the mobile source controls required since the mid-1990s apply to onroad vehicles, such as cars and trucks. EPA also has established programs to reduce emissions from nonroad mobile sources, including the Clean Air Nonroad Diesel Rule of 2004. This rule includes new engine standards that will reduce NO_x emissions and particle pollution by 90 percent from nonroad diesel engines used to power equipment such as backhoes, tractors, material heavy forklifts, and airport service vehicles. The rule's particle pollution controls will also yield VOC reductions.

Industrial Processes

Large VOC reductions from industrial processes during the 1990s primarily resulted from solvent controls. These emission reductions typically occur where and when the solvent is used, such as during commercial and residential painting. In some cases, states are required to adopt Reasonably Available Control Technology (RACT) for major industrial sources of NO_x and VOCs. Implemented in the late 1990s, RACT is expected to achieve an average of 30 to 50 percent

NO_X reduction per major NO_X emission source. EPA's New Source Review Program (not shown in Table 1) requires new industrial facilities or existing facilities making major modifications to install Best Available Control Technology to limit emissions.

In addition, EPA's rule that controls hazardous air pollutants (commonly referred to as the "HON") is expected to reduce emissions of VOCs generated by the synthetic organic chemical manufacturing industry and several other processes by 1 million tons per year from 1999 levels.

The Power Industry

The power industry is one of the largest emitters of NO_X in the United States. Power industry emission sources include large electric generating units and some large industrial boilers and turbines. There are three major control programs that affect the power industry: EPA's Acid Rain Program, the Ozone Transport Commission's NO_X Budget Program, and EPA's NO_X SIP Call.

The Acid Rain NO_X Reduction Program

Congress established the Acid Rain Program as part of the Clean Air Act Amendments of 1990. This national program reduces sulfur dioxide (SO_2) and NO_X emissions from coal-fired electric generating units greater than 25 megawatts (MW). The Acid Rain Program's NO_X Reduction Program is not a cap and trade program. Instead, affected sources must meet certain NO_X emission rates established for different coal-fired boiler types (emission rates are the amount of NO_X emitted per unit of heat input). Companies can develop emissions averaging plans that provide compliance flexibility. The program began in 1996 for the largest NO_X emitters among coal-fired electric generating units; a second phase to reduce NO_X emissions from the remaining coal-fired generating units began in 2000.

The OTC NO_X Reduction Programs

The Ozone Transport Commission (OTC) was established under the Clean Air Act to help reduce summertime ground-level ozone in the Northeast and mid-Atlantic regions. In 1995, the OTC required existing stationary sources to reduce NO_X emissions to meet RACT limits. From 1999 to 2002, most of the states in the OTC region implemented the OTC NO_X Budget Program. This program achieved reductions in NO_X from fossil fuel-fired electric generating units and large industrial boilers and turbines through an ozone season (May 1 through September 30) cap and trade program. The second phase of the OTC NO_X Budget Program was slated to begin on May 1, 2003, but was superseded by EPA's NO_X SIP Call. The OTC states include: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and Washington, D.C.[1]

The NO_X SIP Call

In 1995, EPA and the Environmental Council of the States formed the Ozone Transport Assessment Group to begin addressing the problem of ozone transport in the eastern United States. In 1998, based on the group's

What Is Cap and Trade?

Cap and trade is a policy tool for reducing emissions from a group of sources over a broad geographic region.

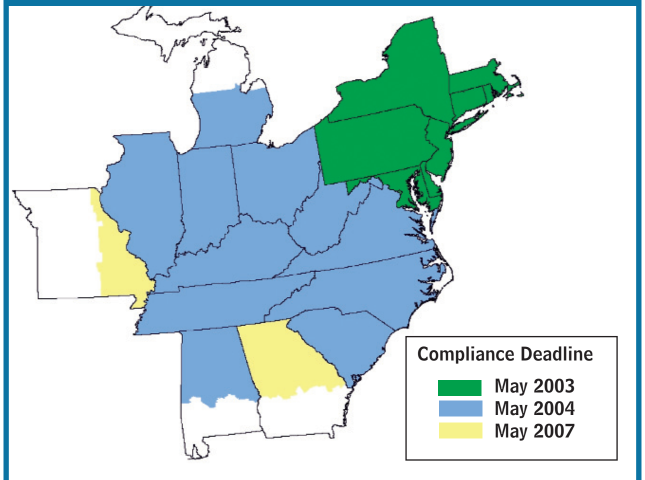
This approach first sets an overall cap, or maximum amount of emissions per compliance period, for all sources under the program. Authorizations to emit, known as emission allowances, are then allocated to affected sources. The total number of allowances allocated cannot exceed the cap.

Under an emissions cap and trade program, sources have flexibility to choose how to meet the emission reduction requirements. A source may either limit emissions to meet the number of allowances it receives each compliance period, or it may purchase additional allowances. Sources with emissions below their limits may sell excess allowances or save ("bank") them for future use.

Sources must accurately measure and routinely report all emissions to guarantee that the overall emissions cap is achieved. Rigorous emissions monitoring ensures credibility of trading programs. For more on emissions cap and trade programs, visit <www.epa.gov/airmarkets>.

[1] Maine, Vermont, and Virginia did not join the OTC trading program. New Hampshire is not subject to requirements of the NO_X SIP Call.

Figure 3:
NO_X SIP Call Region, Program Implementation



Source: EPA

findings and other technical analyses, EPA issued a regulation to reduce the regional transport of ground-level ozone. This rule, commonly called the NO_X SIP Call, requires states to reduce ozone season NO_X emissions that contribute to ozone nonattainment in other states.

Compliance with the NO_X SIP Call was scheduled to begin in 2003. The OTC states adopted the original compliance date of May 1, 2003, in transitioning to the NO_X SIP Call. In states outside the OTC region, however, litigation delayed the initial deadline until May 31, 2004. For those states, the first compliance period (2004) was for a shorter-than-normal ozone season (see Figure 3). In addition, litigation delayed the start date for portions of Georgia and Missouri until 2007. EPA has proposed to stay the NO_X SIP Call requirements for Georgia while it responds to a petition to reconsider Georgia's inclusion in the NO_X SIP Call.

The NO_X SIP Call did not mandate which sources must reduce emissions; rather, it required states to meet an overall emissions budget and gave them flexibility to develop control strategies to meet that budget. All affected states chose to meet their NO_X SIP Call requirements by participating in the NO_X Budget Trading Program (NBP).

The NO_X Budget Trading Program

More than 2,500 units were affected under the NBP in 2004. These include electric generating units, which are large boilers, turbines, and combined cycle units used to generate electricity for sale. As shown in Figure 4, electric generating units constitute more than 85 percent of all regulated units. The program also applies to large industrial units that produce electricity and/or steam, primarily for internal use. Examples of these units are boilers and turbines at heavy manufacturing facilities, such as paper mills, petroleum refineries, and iron and steel production facilities. These units also can include steam plants at institutional settings, such as large uni-

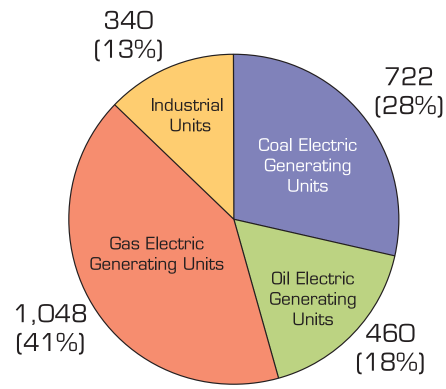
Key Components of the NO_X Budget Trading Program

- The NBP is a cap and trade program for electric generating units and large industrial boilers and turbines.
- The emissions budget sets a cap on emissions at a level chosen to help states meet their air quality goals.
- The NO_X emissions market allows sources to trade (buy and sell) allowances throughout the year.
- At the end of every ozone season, each source must surrender sufficient allowances (each allowance represents one ton of emissions) to cover its ozone season NO_X emissions. This process is called annual reconciliation.
- If a source does not have enough allowances to cover its emissions, EPA will automatically deduct allowances from the following year's allocation at a 3:1 ratio.
- If a source has excess allowances because it reduced emissions beyond required levels, it can sell the unused allowances or "bank" (i.e., save) them for use in a future ozone season.
- To accurately monitor emissions, sources use continuous emissions monitoring systems (CEMS) or other approved monitoring methods under EPA's stringent monitoring requirements (40 CFR Part 75).

versities. Some states have included other types of units, such as petroleum refinery process heaters and cement kilns.

Two criteria are part of determining whether a unit is affected under the NBP: the unit must be fossil fuel-fired and must meet specific size thresholds. For electric generating units, the program generally applies to any unit connected to a generator with a nameplate capacity (the power output in MW that the machine is designed to produce) greater than 25 MW. Some OTC states, however, include units connected to generators with at least 15 MW capacity. For industrial units, the NBP applies to units with a maximum design heat input capacity greater than 250 million British thermal units per hour (mmBtu per hr).

Figure 4: Number of Units in the NO_X Budget Trading Program by Type, 2004



Source: EPA

Note: Total affected units in 2004 = 2,570

State Trading Budgets, Allowance Allocations, and Compliance Supplement Pool (CSP) Allowances

EPA provided broad discretion to states as to how they could allocate allowances from their trading budget to affected sources. One option was to allocate allowances based on each source's share of statewide ozone season heat input (i.e., fuel use). Another option was based on each source's share of ozone season output (e.g., generation) to reward sources that generate more energy with less fuel input. States could also set-aside allowances for new sources or as incentives for energy efficiency and renewable energy programs.

In addition to their NO_X budgets, states received additional allowances to distribute from the Compliance Supplement Pool (CSP). EPA created the CSP allowances to address concerns that initial efforts to comply with the NO_X emissions cap could have too many primary electric generating units out of operation at the same time to install pollution control retrofits, which could have adversely affected electricity supply reliability. The CSP allowances help states to phase-in compliance during the first two years of the trading program and allow sources to limit units out of service at critical times during the year. States were allowed to distribute their CSP allowances based on early reductions in NO_X emissions, on the basis of demonstrated need, or on some combination of the two methods.

The CSP allocation was a one-time, up-front allocation. For the states that began to comply with the NO_X SIP Call in 2003 (states that had been a part of the OTC trading program), all CSP allowances were distributed as vintage year 2003 allowances and replaced existing banked OTC allowances. The non-OTC states distributed CSP allowances as vintage year 2004 allowances. The vintage is the first year an allowance can be used for compliance (i.e., deducted to cover emissions). For example, almost all 2004 vintage allowances may be used for compliance beginning in 2004, or for any year thereafter. The only exception is the 2004 CSP allowances, which may only be used for compliance through the 2005 ozone season.

Chapter 2: Control Program Effectiveness: Changes in Emissions

EPA and state, local, and tribal agencies have implemented several programs that reduce NO_X and VOC emissions. In order to assess the effectiveness of major control programs, EPA examined trends in NO_X and VOC emissions since 1990, looked at when and where the reductions occurred, and then focused on progress made under the NO_X SIP Call in 2004.

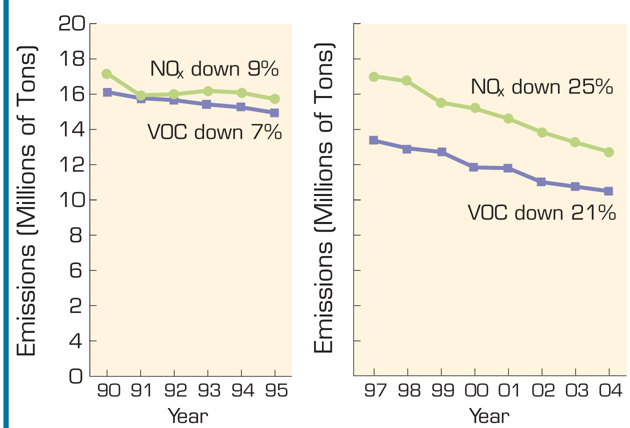
Annual NO_X and VOC Emissions in the Eastern United States

Figure 5 shows trends in annual NO_X and VOC emissions for two time periods: 1990 to 1995 and 1997 to 2004. In the first period, control programs for mobile sources and industrial processes gradually reduced both NO_X and VOC emissions, with NO_X emissions decreasing by 9 percent and VOC emissions decreasing by 7 percent.

The second period reflects implementation of many control programs mandated by the 1990 Clean Air Act Amendments. The results of these programs are evident in emission trends from 1997 to 2004: NO_X emissions decreased by 25 percent and VOC emissions decreased by 21 percent.

It is important to note that a significant portion of total VOC emissions can come from natural sources, such as trees, especially during the ozone season. For example, EPA estimates that nearly 60 percent of total ozone season VOC emissions in 2001 were from natural sources. These emissions are not shown in Figure 5.

Figure 5: Annual Emissions in the Eastern United States, 1990-1995 and 1997-2004



Source: EPA

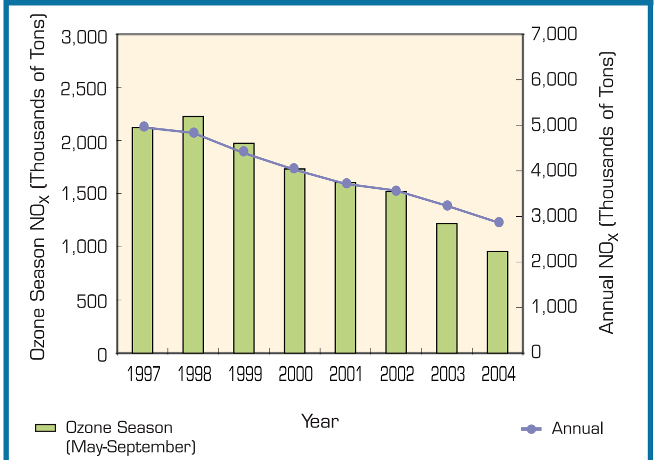
Notes:

- **Emissions are from Minnesota, Iowa, Missouri, Arkansas, Louisiana, and states east.**
- **The emissions data used in this report are measured or estimated values from EPA's National Emissions Inventory (NEI). Starting in 1997, the NEI incorporated power industry data measured by the Continuous Emissions Monitoring System (CEMS). For 2002, the preliminary version of the NEI was used, which includes the 2002 CEMS data, but does not include 2002 data for other sources submitted by state, local, and tribal air agencies. For this analysis, EPA used CEMS data for the power industry for 2003 and 2004. Emissions for other sources for that period were estimated by interpolating between the 2002 preliminary NEI data and a projected 2010 emission inventory developed to support the Clean Air Interstate Rule.**
- **1996 is not represented in the graphs because there was a change in the method used to collect and estimate emissions, particularly for NO_X emissions from stationary sources such as the power industry.**

Ozone Season NO_X Reductions, 2003 and 2004

Because ozone levels are highest during the summer months, it is important to evaluate NO_X and VOC emission reductions during that time period. EPA compared annual and ozone season emission trends for all NO_X and VOC sources from 1997 through 2004. For all emission categories, except power industry NO_X, the ozone season trend is similar to the annual trend. Figure 6 shows a comparison of annual and ozone season NO_X emissions from the power industry. From 1997 to 2002, the trend in ozone season emissions is similar to the annual trend. However, in 2003 and 2004, ozone season NO_X emissions show a greater reduction. These larger

Figure 6: Power Industry NO_X Emissions in the Eastern United States, Annual and Ozone Season, 1997–2004



Source: EPA

Note: Emissions are from Minnesota, Iowa, Missouri, Arkansas, Louisiana, and states east.

reductions are attributable to NO_X SIP Call controls which were applied in the summers of 2003 and 2004. (For details about the types of controls used, see Chapter 4, Compliance and Market Activity, page 23.)

Focus on the NO_X SIP Call: Emissions under the NO_X Budget Trading Program

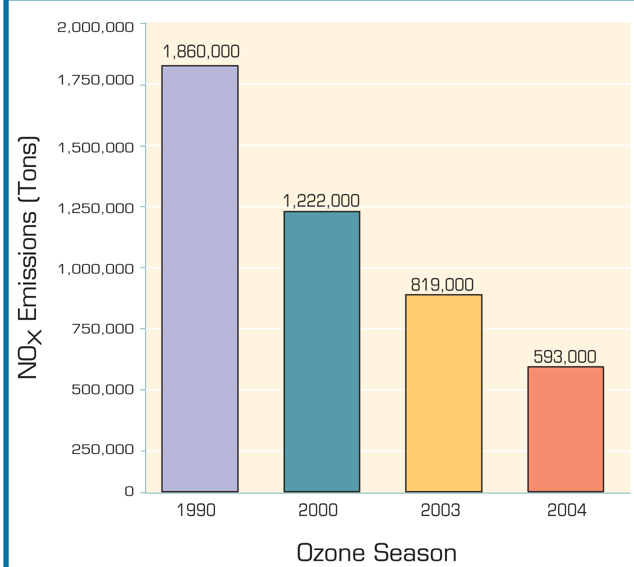
This section assesses progress under the NO_X Budget Trading Program (NBP) by comparing NO_X emission levels in 2004 (the second year of the NBP) to levels in 1990, 2000 (baseline years), and 2003. Therefore, these results include emissions from affected sources in states included in the NO_X SIP Call in 2004 (see figure 3).[2]

In 2003, all affected sources in the NBP region conducted ozone season emissions monitoring, but only the states previously in the OTC NO_X Budget Program were subject to the emission reduction requirements of the program.[3] All sources subject to the NO_X SIP Call in 2004 were required to have enough allowances to cover emissions during the 2004 ozone season. Sources in the OTC states were required to comply for the full ozone season (May 1 to September 30) in 2004. The compliance period did not begin until May 31 in the non-OTC states.

Ozone Season Emission Reductions Across the Region

Figure 7 shows the total ozone season NO_X emissions for the NBP region in 2004 compared to 1990, 2000, and 2003. In 2004, NBP sources emitted about 593,000 tons of NO_X, reducing emissions by nearly 30 percent from 2003, 50 percent from 2000, and nearly 70 percent from 1990. Many of the NO_X reductions since 1990 are a result of programs implemented under the Clean Air Act such as the Acid Rain NO_X Reduction Program, and other state, local, and federal programs. The significant decrease in NO_X emissions after 2000 reflects additional reductions that show the impacts of the NO_X SIP Call.

Figure 7: Ozone Season Emissions under the NO_X Budget Trading Program



Source: EPA

[2] For further information on estimating baseline emissions, refer to the NO_X Budget Trading Program 2003 Progress Report at www.epa.gov/airmarkets/fednox

[3] In 2003, North Carolina sources were not required to monitor, although many sources did so voluntarily. The lack of 2003 data for certain North Carolina sources has a negligible effect on the results in this report.

Emission Reductions in the OTC and Non-OTC States

In light of the different control periods in 2004, it is useful to look at total NBP emissions as well as a breakdown of emissions by the two groups of states (OTC and non-OTC states). States that began compliance for the first time in 2004 (non-OTC states) received compliance supplement pool (CSP) allowances. Figure 8 presents the sum of the 2004 trading budgets (OTC states) and the trading budget with CSP allowances (non-OTC states). The budgets also reflect some allowances provided to opt-in[4] units in New York, Ohio, and West Virginia. For a more thorough description of trading budgets and allowance allocations, see page 6.

As Figure 8 shows, the CSP allowances increase the trading budget significantly in the non-OTC states. The trading budget levels for the OTC states show no difference, because the OTC states received all of their CSP allowances in 2003. Figure 8 also presents the 2004 ozone season results both for the full ozone season (OTC states) and the shortened control period for the non-OTC states.

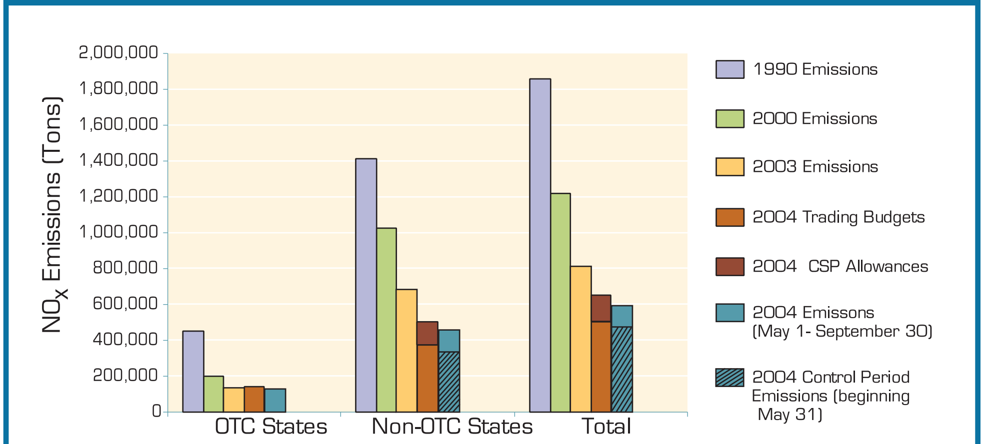
During the OTC NO_X Budget Program, emissions were less than allocated allowances in every year of the program (1999 to 2002). That trend has continued under the NBP in both 2003 and 2004. In 2004, ozone season NO_X emissions in the OTC states were approximately 132,000 tons, about 10 percent less than the sum of the 2004 trading budget for those states, and more than 30 percent less than their 2002 emissions.

Baseline Years for Measuring Progress Under the NO_X Budget Trading Program

One measure of progress under the NBP is whether emissions under the program meet the emission budgets established for the states. Also, it is helpful to understand how emissions under the program compare to emissions prior to the program. EPA has chosen two baseline years for measuring progress under the NBP:

- 1990, which represents emission levels before the implementation of the 1990 Clean Air Act Amendments.
- 2000, because most of the reductions required under the 1990 Clean Air Act Amendments had already occurred by this time, but sources were not yet implementing the NBP.

Figure 8: NO_X Budget Trading Program: 1990, 2000, 2003, and 2004 Ozone Season Emissions, and the 2004 Trading Budgets

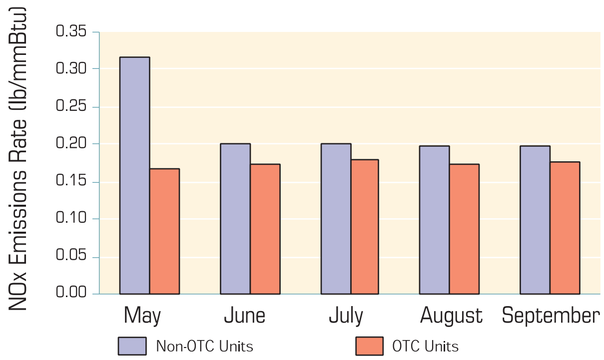


Source: EPA

Note: 2004 allowances include 2004 Trading Budgets and 2004 Compliance Supplement Pool (CSP) allowances.

[4] An opt-in unit is a unit not covered by the applicability provisions of a program that requests to voluntarily enter the program and, because it meets specific program requirements (e.g., continuous emission monitoring capability), is approved to participate.

Figure 9: Comparison of Average Monthly NO_X Emission Rates, OTC and Non-OTC States, 2004



Source: EPA

Note: Average monthly emission rates are based on total reported NOx mass emissions and heat input for each applicable month for all participating units.

EPA anticipated that the states outside the OTC region would achieve only modest reductions in 2004, because of the shorter control period and the CSP allowances distributed that year. However, the sum of emissions in these states for the full ozone season were more than 30 percent below 2003 levels. In addition, emissions for the 2004 control period (May 31 to September 30) were below the sum of their 2004 trading budgets (the budgets without CSP allowances).

Figure 9 shows that, on average, the non-OTC states reduced their NO_X emission rates to nearly the same level as the OTC states. Their average emissions rate in May (prior to the control period) was considerably higher. These results indicate that the non-OTC states made significant progress toward installing adequate controls to meet their trading budget levels in 2005.

Emission Reductions from Industrial Sources

Collectively, affected NBP industrial units reduced emissions approximately 25 percent from 2003 to 2004, despite the shorter 2004 control period. Emissions from these sources in the full 2004 ozone season were about 40,000 tons, compared to 53,000 tons for the same period in 2003.

Although industrial units have achieved reductions, they are much less likely than electric generating units to use add-on control devices, such as selective catalytic reduction (SCR). As a result, these units tended to have higher ozone season NO_X emission rates in 2004 than the full population of affected units (about 0.25 lb per mmBtu compared to 0.21 lb per mmBtu). However, the 2004 average ozone season NO_X emissions rate (0.25 lb per mmBtu) among industrial units decreased from the 2003 rate of approximately 0.38 lb per mmBtu.

Emission Reductions at the State Level

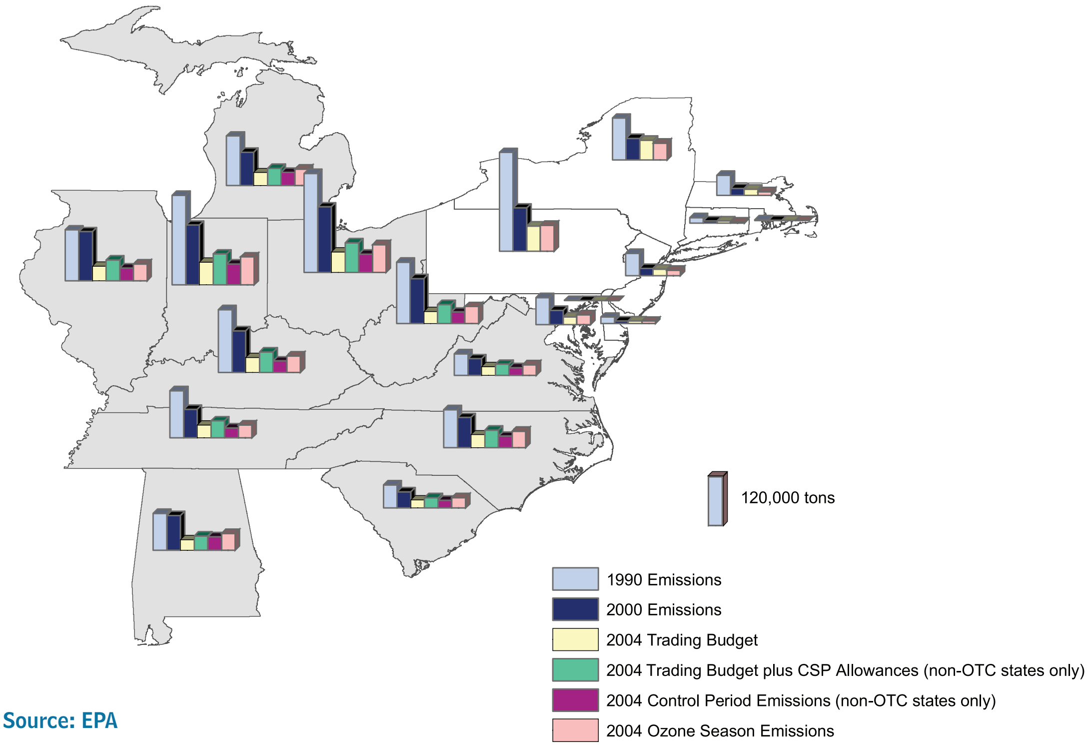
Two non-OTC states—Alabama and Michigan—had control period emissions that exceeded their trading budgets in 2004. However, all non-OTC states had 2004 control period emissions below their 2004 trading budgets when CSP allowances were included (see Figure 10).

Although the ozone season emissions in most of the individual OTC states were below their trading budgets in 2004 (see Figure 10), emissions in Pennsylvania and Maryland were higher. For Pennsylvania (emissions exceeded allocations by 1,300 tons), the amount reflects about 3 percent of the state's total budget. This type of variability can be expected in a regional trading program and can reflect a number of different factors, including company-specific compliance decisions.

Emissions in Maryland exceeded allocations by 4,500 tons (about 30 percent greater than budget levels) and increased slightly from 2003 to 2004. These results indicate a clear decision to purchase a significant number of allowances in 2004 as opposed to controlling emissions close to budget levels. In future years, the situation in Maryland likely will change as the result of a federal consent decree.[5]

[5] By 2008, under a federal consent decree, one of the companies with affected units in Maryland will be required to cap emissions from three Maryland plants and one Virginia plant to 6,000 tons per ozone season. The three Maryland plants alone emitted more than 13,000 tons in the 2004 ozone season. The emissions cap in this consent decree should reduce emissions from existing plants in Maryland well below budget levels.

Figure 10:
Ozone Season NO_X Emissions: 1990, 2000, and 2004 Emissions and Trading Budgets



Source: EPA

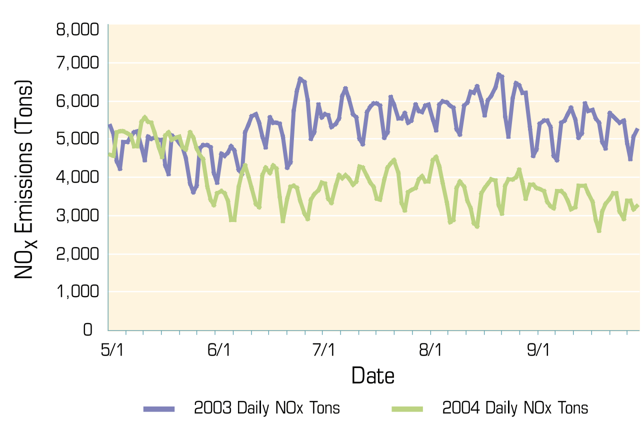
Notes:
- The Non-OTC states are shaded.
- In 2004, the control period for non-OTC States was from May 31 through September 30.

Daily Emission Trends

Studies indicate that many of the health effects associated with ozone are linked to daily exposures. The 8-hour ozone standard was developed to protect against such exposures. Although the NBP ensures significant regional NO_X reductions throughout the course of the ozone season, there have been concerns that a seasonal cap would not sufficiently reduce short-term, peak NO_X emissions that can occur on hot, high electricity demand days when ozone formation is often a concern.

Figure 11 compares daily NO_X emissions for 2003 versus 2004 for the NBP region. The results show that the NBP significantly reduced both the average and highest daily emission levels. Average emissions during the control period in 2004 (May 31 to September 30), decreased nearly 35 percent from the same period in 2003. The highest daily emissions in the 2004 control

Figure 11:
Daily Emissions Under the NO_X Budget Trading Program, 2003 and 2004



Source: EPA

period were more than 30 percent lower than the highest daily emissions during the same period in 2003.

The NBP has had a significant impact on daily emissions (see Figure 11). The highest total daily emissions in 2004 rarely exceeded the lowest total daily emissions in 2003 except from May 1 to May 30, when the 2004 control period was not in effect for non-OTC states. These results show that, while reducing total emissions in 2004, the trading program also reduced peak daily emission levels.

Ozone Season Emission Reductions from All Sources

In response to the NO_X SIP Call, the power industry dramatically reduced ozone season NO_X emissions after 2002. Other major NO_X and VOC source categories do not show this significant drop in emissions.

As Figure 12 shows, ozone season NO_X emissions from the power industry dropped 6 percent per ozone season, on average, from 1997 to 2002. Reductions were much greater after 2002—an average of 19 percent per ozone season from 2002 to 2004. Onroad mobile and other categories show continuing NO_X emission reductions; however, those reductions are not as dramatic after 2002 as the reductions from power industry sources.

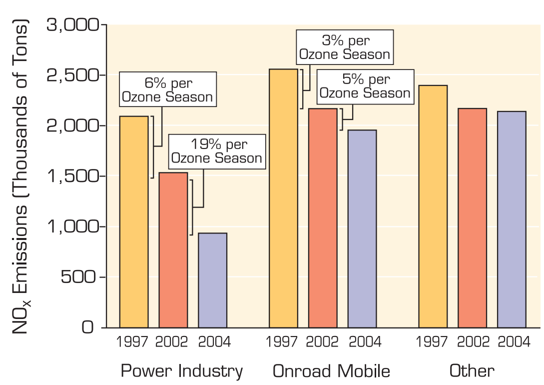
Similarly, VOC emissions dropped somewhat between 1997 and 2002, but there were few additional reductions after 2002 (Figure 13). VOC emissions from onroad mobile sources, for example, dropped an average of 5 percent per ozone season for both time periods.

Location of Largest Emission Reductions

Knowing the location of NO_X and VOC emission reductions also helps EPA understand the effectiveness of emission control programs. Figure 14 shows ozone season NO_X emission reductions between 1997 and 2004. The largest reductions occurred in the central portion of the eastern United States.

Within this region, Illinois, Kentucky, North Carolina, Ohio, Pennsylvania, and Tennessee each experienced NO_X emission reductions greater than 110,000 tons. Following close behind were Alabama, Indiana, Michigan, New York, and West Virginia—all of which had reductions greater than 73,000 tons.

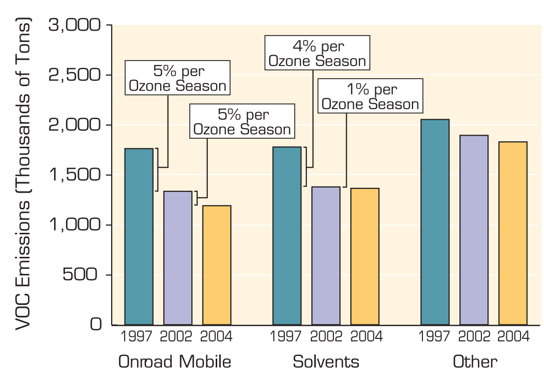
Figure 12: Ozone Season NO_X Emissions in the Eastern United States by Category, 1997, 2002, 2004



Source: EPA

Note: Other includes emissions from nonroad, industrial processes, and small power industry sources.

Figure 13: Ozone Season VOC Emissions in the Eastern United States by Category, 1997, 2002, 2004



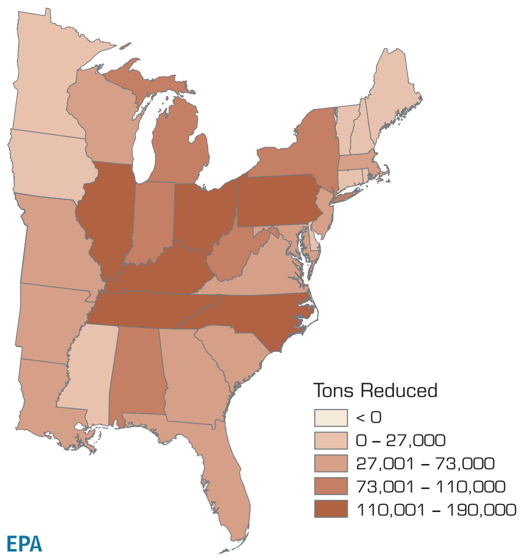
Source: EPA

Note: Other includes emissions from nonroad, power industry, and nonsolvent industrial processes.

Figure 15 shows the location of ozone season NO_X reductions for the power industry and onroad mobile sources. Overall, power industry sources accounted for larger NO_X emission reductions than did onroad mobile sources. Note the following:

- States along the Ohio River Valley from Pennsylvania to Tennessee generally experienced the largest reductions in power industry NO_X emissions. Emissions dropped the most in Ohio (153,000 tons), Illinois (111,000 tons), and Kentucky (104,000 tons). Pennsylvania achieved similar reductions by implementing control measures prior to 1997.
- Emission reductions from onroad mobile sources were smaller than from the power industry and occurred primarily in states with large urban areas.
- No state realized reductions greater than 42,000 tons from onroad mobile sources.

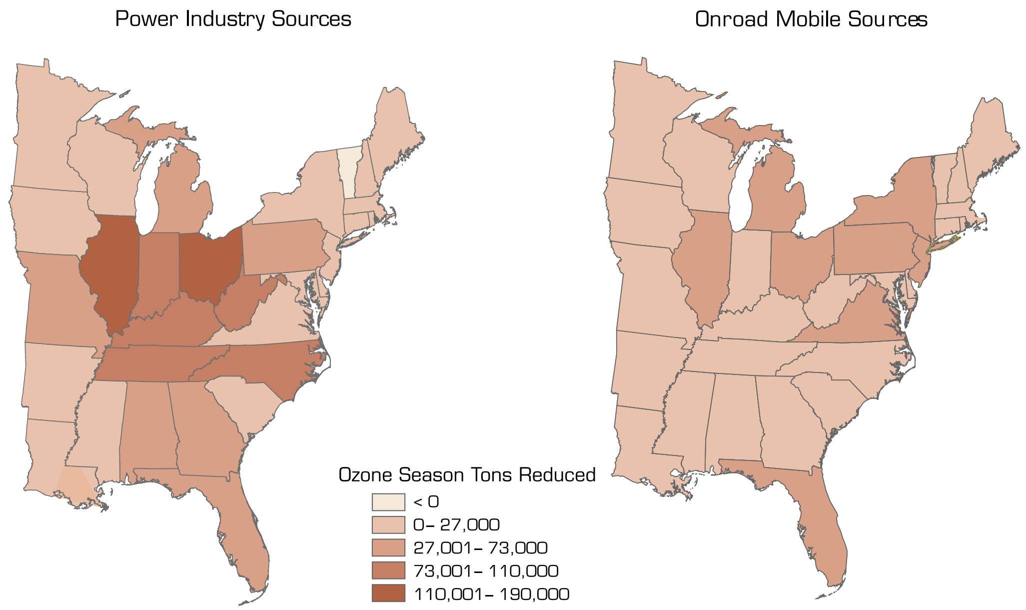
Figure 14: Ozone Season NO_X Emissions Reduced, 1997 vs. 2004



Source: EPA

Note: Darker states show larger NOx reductions.

Figure 15: Ozone Season NO_X Emissions Reduced, Power Industry and Mobile Sources, 1997 vs. 2004



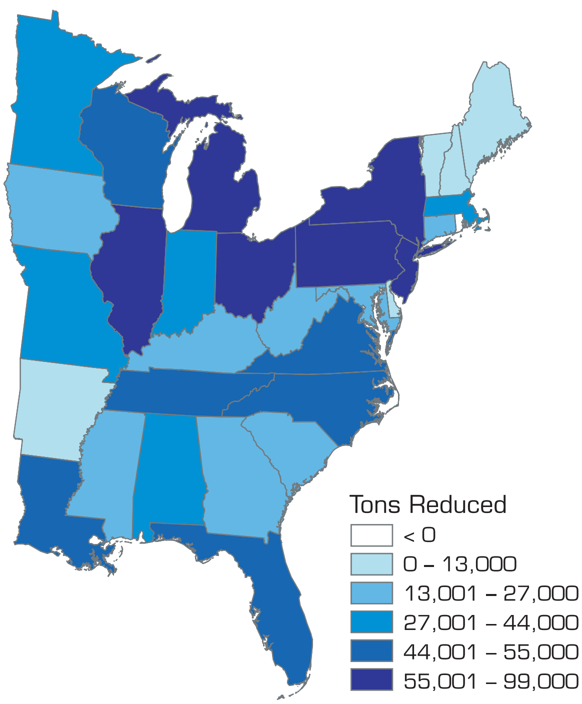
Source: EPA

Notes:

- Due to earlier reductions prior to 1997, Pennsylvania reduced its emissions by the same magnitude as Ohio.
- Darker states show larger NO_X reductions.
- Vermont showed an increase of about 45 tons of NO_X from power industry sources.

Figure 16 shows where reductions in ozone season VOC emissions occurred between 1997 and 2004. Reductions in VOC emissions were neither as large (in tons) as reductions in NO_X emissions between the two years, nor were they concentrated in the same states (see Figure 14). The largest reductions occurred in New York (99,000 tons), Illinois (97,000 tons), and Ohio (88,000 tons).

Figure 16: Ozone Season VOC Emissions Reduced, 1997 vs. 2004



Source: EPA

Notes:

- **Rhode Island showed an increase of about 872 tons.**
- **Figure does not include emissions from natural sources.**
- **Darker states show larger VOC reductions.**

Natural Sources of VOCs

Emissions generated by human activity account for only a portion of total VOC emissions. VOCs also come from trees and other vegetation.

In many parts of the world, VOC emissions from natural sources are larger than manmade VOC emissions. In the eastern United States, for example, nearly 60 percent of the total 2001 ozone season VOC emissions came from natural sources.

VOC emissions from natural sources are higher on warm sunny days, which also provide the best conditions for ozone formation. While VOCs from natural sources do contribute to ground-level ozone formation, it is difficult to assess the impact changes these emissions have on ozone concentrations.

EPA did not analyze VOC emissions from natural sources for this report, as the amount of data available was too limited. As more data become available in the future, EPA will analyze the effects of natural VOC emissions on ozone formation.

Chapter 3: Control Program Effectiveness: Changes in Ozone

To better understand how major control programs affect ozone, EPA looked at overall changes since 1997, and then focused on ozone improvements after 2002 (after implementation of the NO_X SIP Call). These analyses also consider the impact of weather, because variations in weather conditions play an important role in determining ozone levels. This chapter examines the results of these analyses in relation to the original NO_X SIP Call program design by comparing the anticipated changes in emissions and ozone to actual changes.

General Trends: Changes in Ozone Concentrations since 1997

Like NO_X and VOC emissions, ozone concentrations in urban and rural areas have decreased between 1997 and 2004 in response to control programs. Figure 18 shows the percent reductions (adjusted for weather conditions) in seasonal ozone. Seasonal ozone was calculated as the average of daily maximum 8-hour ozone concentrations from May 1 through September 30. Ozone reductions

Ozone Monitoring Networks

For this report, EPA assembled data for 29 urban areas from the Air Quality System (AQS) and 34 rural sites from the Clean Air Status and Trends Network (CASTNET) to provide a more complete picture of the nation's air quality than would be otherwise possible. Sufficient ambient and meteorological data for these sites were available to perform detailed analyses of air quality changes over time.

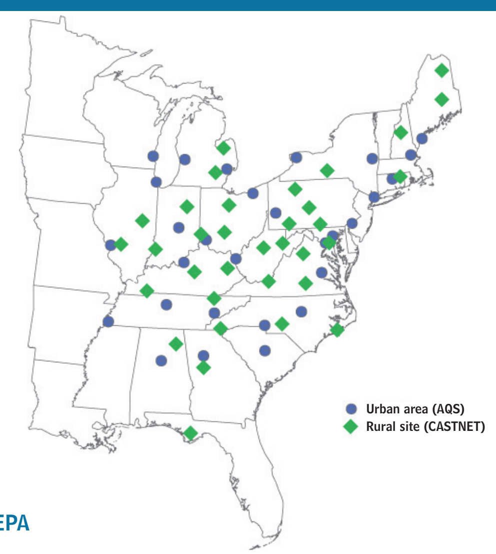
Air Quality System (AQS)

AQS is EPA's repository for state and local data from monitoring networks specifically designed to assess air quality trends and to support regulatory programs, such as nonattainment area designations and development of State Implementation Plans. These networks include the State and Local Air Monitoring Stations (SLAMS) and National Air Monitoring Stations (NAMS). There are more than 700 SLAMS/NAMS monitoring sites in the eastern United States. For more information, see <www.epa.gov/ttn/airs/airsaqs>.

Clean Air Status and Trends Network (CASTNET)

CASTNET is a national network of rural monitoring sites, with more than 50 sites in the eastern United States. EPA established the network primarily to provide data needed to track and evaluate national and regional air pollution control programs. These data provide information necessary to study and investigate the effects of atmospheric pollution on sensitive ecosystems, particularly those effects caused by long-range transport of emissions from regional sources. Data gathered from the network are compiled in a central database and made available on EPA's CASTNET Web site at <www.epa.gov/castnet>.

Urban and Rural Locations



Source: EPA

Note: Urban areas represent multiple monitoring sites. Rural areas represent single monitoring sites.

were greater than 10 percent across a broad geographic region; the average reduction was 14 percent.

Role of Meteorology

Variations in weather conditions play an important role in determining ozone levels. Daily temperature, relative humidity, and wind speed can affect ozone levels. In general, warm dry weather is more conducive to ozone formation than cool wet weather. EPA uses a statistical model to account for the impact of weather on ozone concentrations. Because weather varies over space and time, this adjustment provides a better estimate of the underlying ozone trend and the impact of emission changes (see "Meteorology Matters" on page 17).

To illustrate the overall impact of weather on ozone levels in outdoor air, EPA compared changes in ozone before and after adjusting for weather, as Figures 17 and 18 show. Adjusting for weather made only a small difference (1 percent) in overall ozone change in the eastern United States—an average reduction of 13 percent before adjustment, compared to 14 percent after adjustment. Some states showed notable differences. For example, adjusting for weather at sites in North Carolina, Virginia, and eastern Tennessee resulted in significantly smaller reductions, while adjustments in Ohio, Pennsylvania, and West Virginia showed larger ozone reductions.

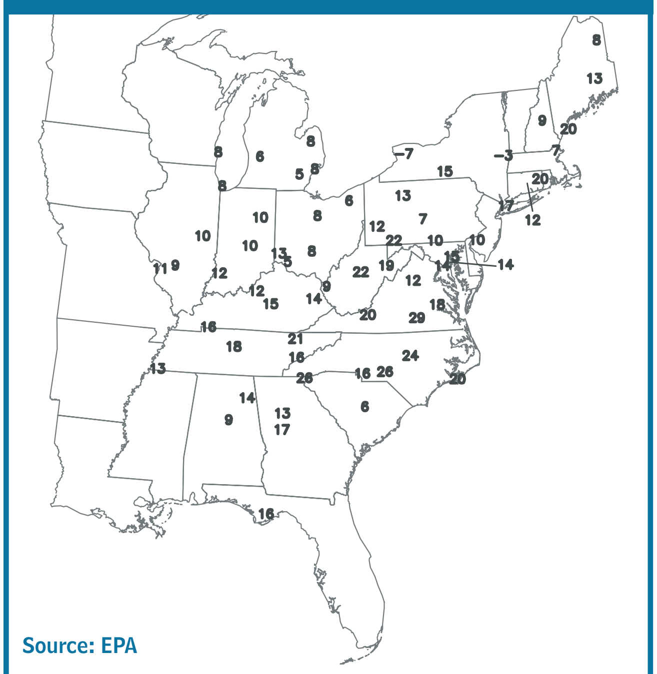
Focus on the NO_X SIP Call: Changes in Ozone

EPA examined geographic patterns and ozone behavior before and after the NO_X SIP Call, and then compared EPA's projections to what actually occurred.

To analyze ozone changes, EPA selected two baseline years—1997 and 2002. These two years were selected to coincide with the period of NO_X reductions attributable to the Acid Rain Program and the OTC NO_X Budget Program (1997 through 2002) and the implementation of the NO_X SIP Call (2002 through 2004).

Ozone improvements were larger after implementation of the NO_X SIP Call. The average reduction in ozone

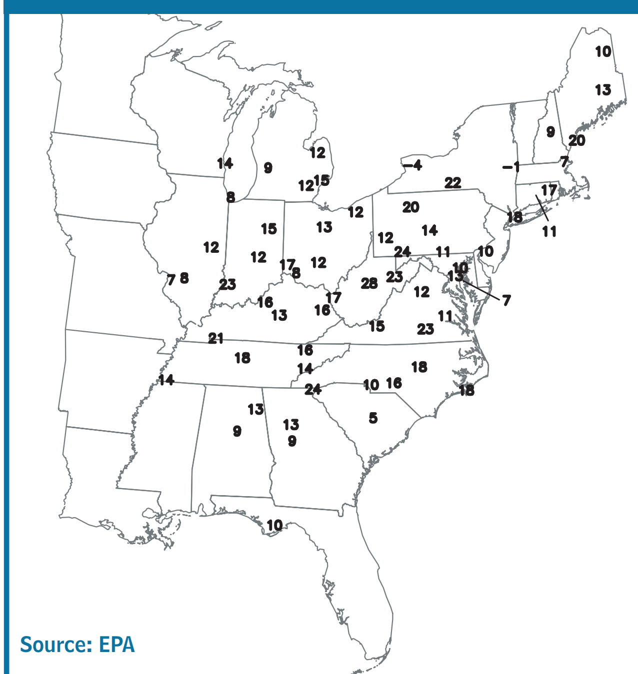
Figure 17: Percent Reduction in Seasonal 8-Hour Ozone, 1997 vs. 2004 (Not Adjusted for Meteorology)



Source: EPA

Note: Margin of error is ± 5 percent.

Figure 18: Percent Reduction in Seasonal 8-Hour Ozone, 1997 vs. 2004 (Adjusted for Meteorology)



Source: EPA

Note: Margin of error is ± 5 percent.

Meteorology Matters

Meteorology plays a major role in both the formation and transport of ozone. For example, the photochemical reactions that transform emissions of NO_X and VOCs into ozone are complex and require warm temperatures and dry conditions. These graphics illustrate how the summers of 1997, 2002, and 2004 compare with historical records (a 30-year average using data from 1971 to 2000) for temperature and precipitation in the eastern United States.

Note: Meteorology can vary significantly from one site to the next.

1997

(normal ozone-forming potential)

Temperature – In general below normal, except Florida and New England (near normal)

Precipitation – Mixed (slightly above normal in some places and slightly below normal in others)

2002

(above normal ozone-forming potential)

Temperature – Mostly above normal, except South (near normal to slightly below normal)

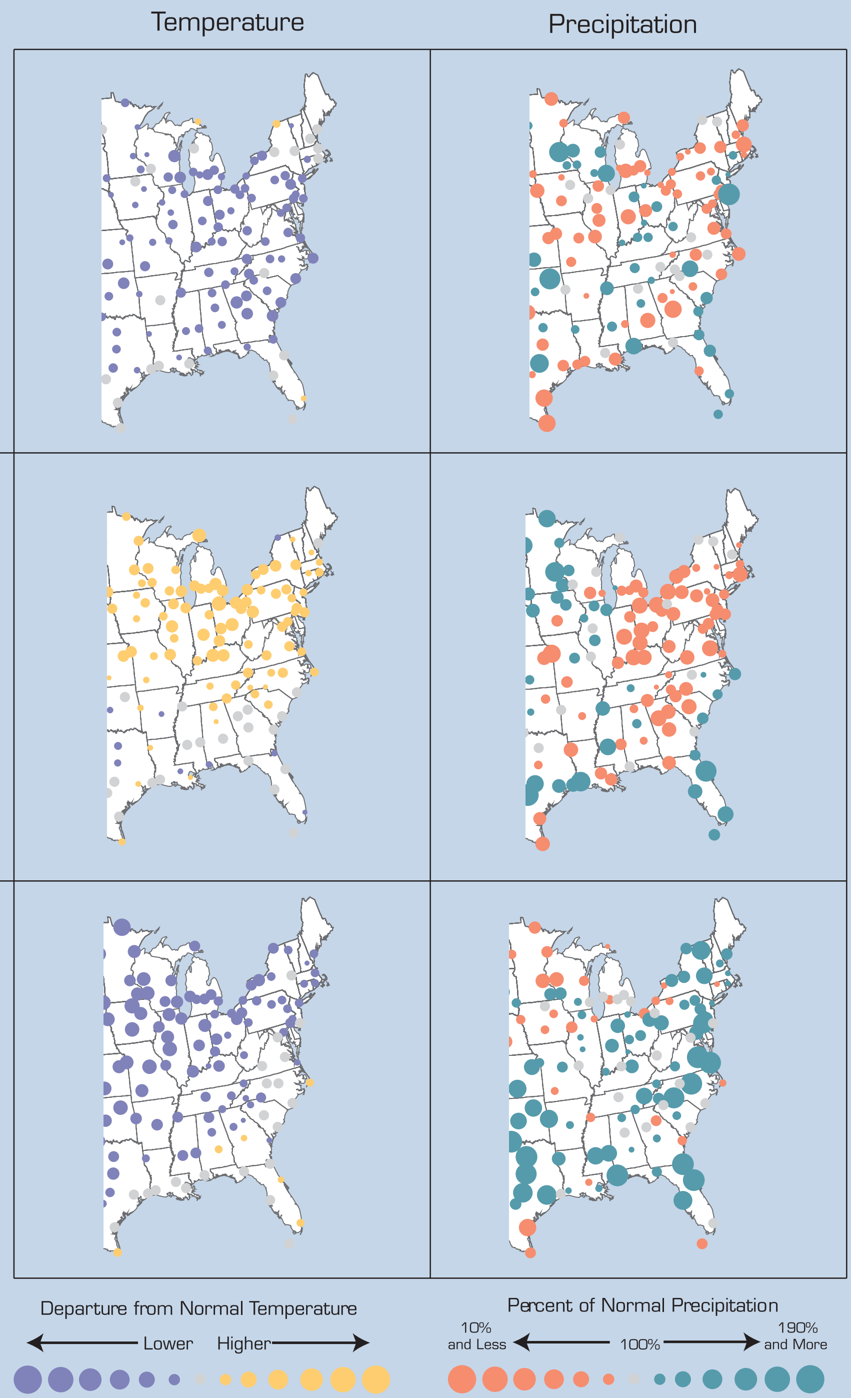
Precipitation – Mostly below normal except South and Midwest (above normal)

2004

(below normal ozone-forming potential)

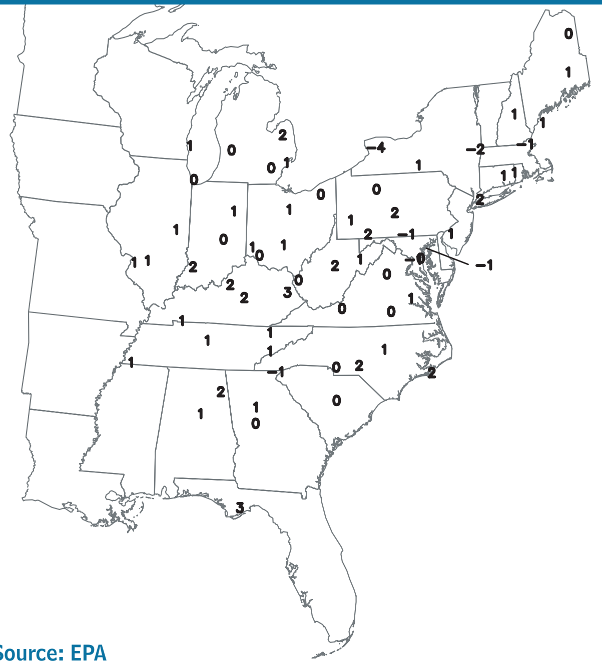
Temperature – Mostly cooler to much cooler except Southeast (normal to slightly above normal)

Precipitation – Mostly above normal except upper Midwest (below normal)



Sources: National Oceanic and Atmospheric Administration (NOAA), EPA

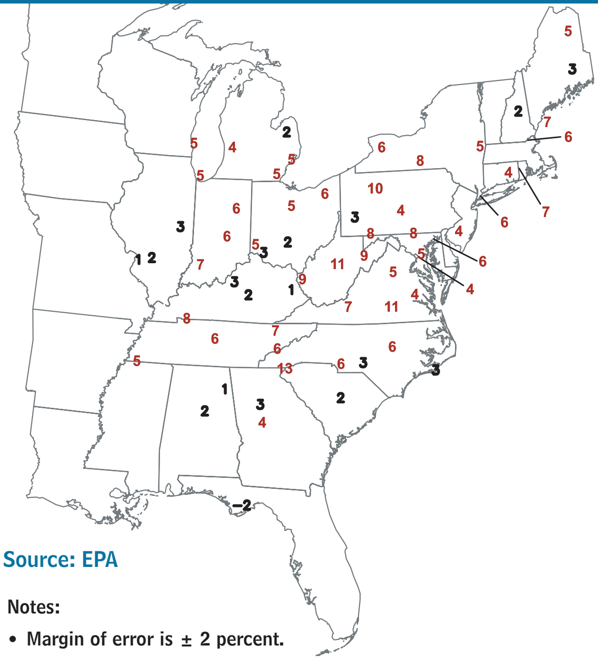
Figure 19: Percent Reduction in Seasonal 8-Hour Ozone Per Year, 1997-2002 (Adjusted for Meteorology)



Source: EPA

Note: Margin of error is ± 1 percent.

Figure 20: Percent Reduction in Seasonal 8-Hour Ozone Per Year, 2002-2004 (Adjusted for Meteorology)



Source: EPA

Notes:

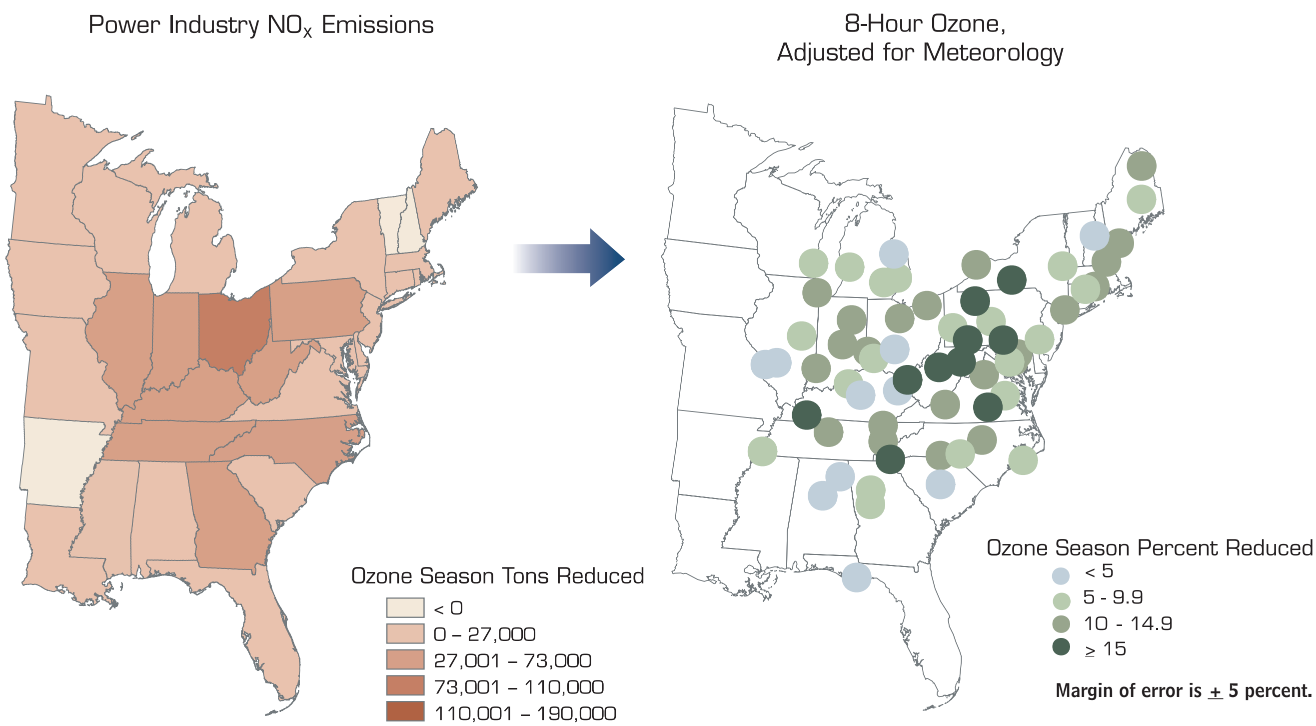
- Margin of error is ± 2 percent.
- Locations with ozone changes greater than 3 percent per ozone season are highlighted in red.

between 1997 and 2002 was about 4 percent (adjusted for weather), compared with more than 10 percent between 2002 and 2004. Meteorological adjustment was especially important for this analysis because of the significant difference in the ozone-forming potential between 2002 and 2004. The difference in ozone levels between 2002 and 2004 was about 17 percent before adjusting for weather, compared with about 10 percent after adjustment.

Figures 19 and 20 illustrate how reductions in ozone levels changed before and after the NO_X SIP Call (after adjusting for weather). These figures show average percent changes per ozone season between two time periods: 1997 through 2002 (the five-year period before the NO_X SIP Call) and 2002 through 2004 (the two-year period after the NOx SIP Call). This analysis of emissions and ozone shows that the NO_X SIP Call achieved an additional 4 percent reduction per ozone season. Before the NO_X SIP Call was in place, ozone declined about 1 percent per ozone season in most areas in the East, although some states (Kentucky and Florida) realized average reductions as large as 3 percent per ozone season (see Figure 19). After implementation of the NO_X SIP Call (see Figure 20), the ozone reduction was larger—5 percent per ozone season on average—with many areas exceeding 5 percent.

EPA expects that NO_X and VOC emissions will continue to decrease in 2005. Despite these improvements, ozone levels in 2005 could be higher than in 2004, depending on weather conditions. (Weather conditions in 2004 were not conducive to ozone formation.) To accurately estimate trends in ozone air quality, meteorological effects must be taken into account.

Figure 21: Reductions in Ozone Season Power Industry NO_X Emissions and 8-Hour Ozone, 2002 vs. 2004



Source: EPA

Notes:

- **Darker states show larger NO_X reductions.**
- **Arkansas (268 tons), New Hampshire (611 tons), and Vermont (16 tons) show small increases in ozone season emissions from 2002 to 2004.**

Comparison of Power Industry NO_X Emission Reductions and Ozone Changes

Figure 21 shows the relationship between reductions in power industry NO_X emissions and reductions in ozone after implementation of the NO_X SIP Call. Generally, there is a strong association between areas with the greatest NO_X emission reductions (such as the Midwest) and downwind sites exhibiting the greatest improvement in ozone. This suggests that the effect of NO_X transport has been reduced in the eastern United States. While this report does not attribute all ozone reductions after 2002 to the NO_X SIP Call, it does show that the NO_X SIP Call played a major role in reducing ozone concentrations.

Trends in Ambient NO_X Concentrations

Ambient concentrations of NO_X gases have fallen as NO_X emissions have declined. EPA examined data from both urban and rural monitoring sites, looking at NO_X from air quality monitors in the AQS network and total nitrate measurements from CASTNET sites. The results indicate that ambient concentrations of ozone-forming gases and total particulate nitrates have decreased over the past seven years, further evidence that NO_X emissions have been reduced.

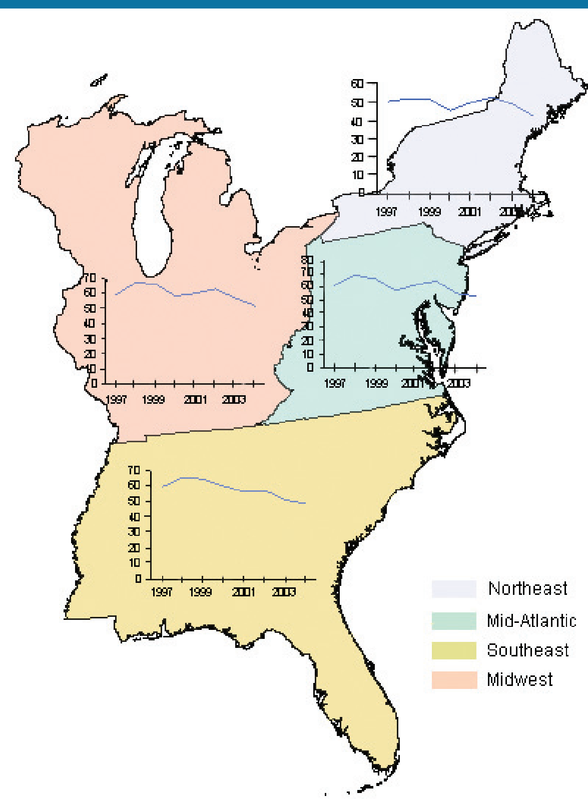
Ozone Reduction in Rural Areas Shows Regional Improvements

The primary goal of the NO_X SIP Call is to reduce regional transport of ozone across state boundaries by reducing NO_X. EPA's Clean Air Status and Trends Network (CASTNET) provides long-term data on ozone air quality at more than 50 monitoring sites in rural areas across the eastern United States. The monitoring information collected at rural sites is a good indicator of background ozone concentrations, because rural areas are not as influenced by local emissions sources. The rural network is particularly relevant to assessing progress under the NO_X SIP Call, because it represents levels of ozone and precursor gases that are being transported from one area to another.

Due to changing weather conditions, air quality trends often show high year to year variability over time. Some of this variability can be overcome through the use of consistent and continuous long-term monitoring data. The results presented here show the variability over time in actual observed ozone concentrations at rural sites on a regional level.

The figure below shows a gradual decline in seasonal average 8-hour daily maximum ozone levels from 1997 to 2004 for all four eastern regions. The largest improvements occurred after 1998 and again after 2002. The downward trend is especially evident in the Southeast, which has experienced a steady decline in ozone in rural areas since 1998. These results have not been adjusted for weather; however, the overall downward trend is consistent with trends that have been adjusted for the influences of weather.

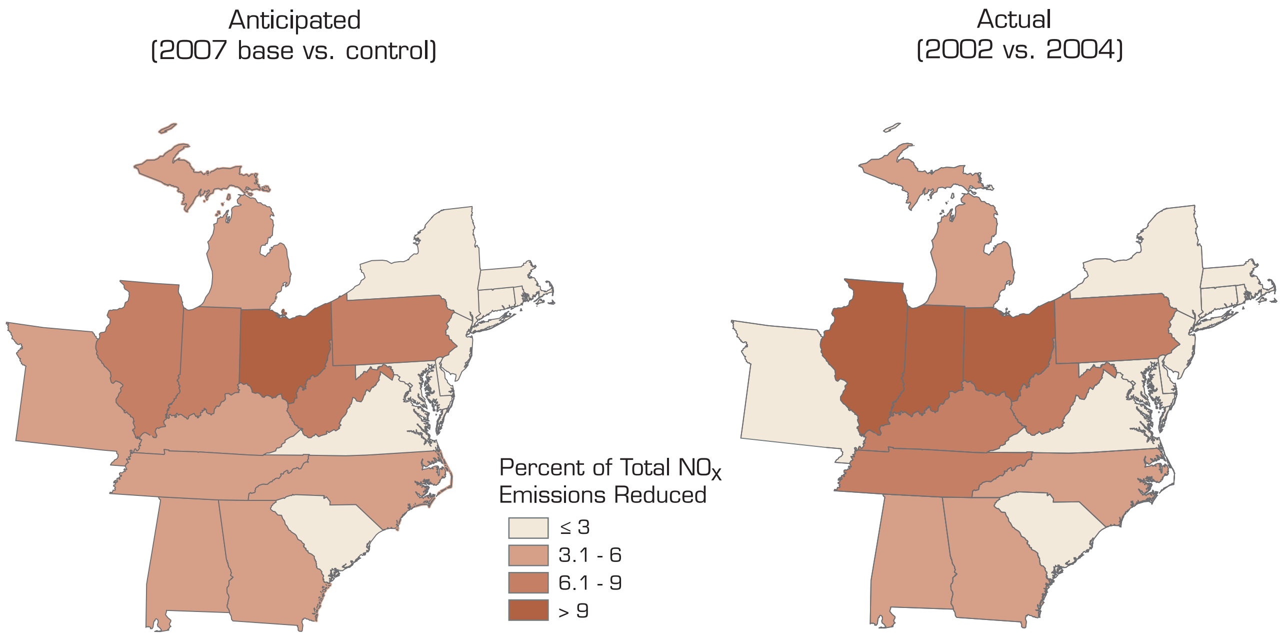
Rural Seasonal Average 8-hour Daily Maximum Ozone by Region, 1997-2004



Source: EPA

Note: Ozone concentrations are in parts per billion (ppb)

Figure 22: Ozone Season Power Industry NO_X Emissions Reduced, Anticipated and Actual



Source: EPA

Notes:

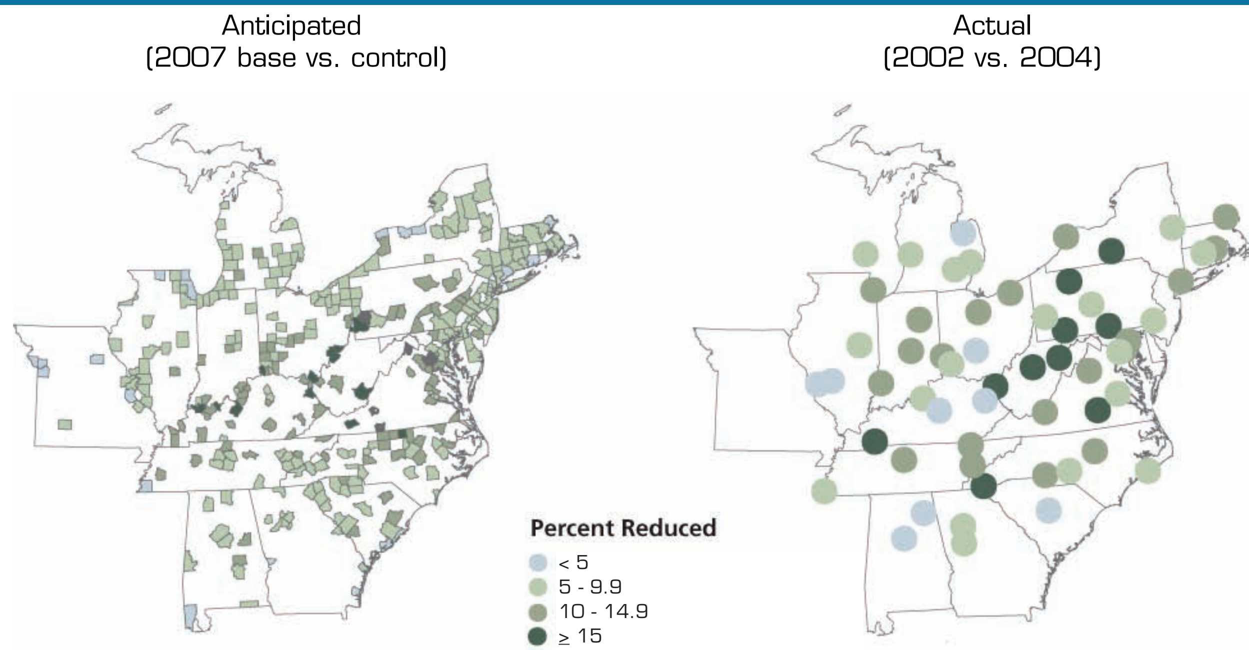
- **Darker states show larger NO_X reductions.**
- **Percent of total NO_X emissions reduced is an individual state's emissions reduced, divided by total reductions across all states (in tons).**
- **Anticipated results are the estimated difference in power industry emissions between the 2007 base case and 2007 with the NOx SIP Call for the days modeled, which represent the ozone season.**
- **Actual results are the difference in state total ozone season power industry emissions between 2002 and 2004, as reported to EPA.**

Comparison of NO_X SIP Call Results to Program Design

EPA uses air quality models to help predict the impacts of new or proposed programs (see "Estimating the Impact of Proposed Control Programs" on page 22). For the NO_X SIP Call, EPA used models to estimate changes in NO_X emissions and their effects on ozone levels. Figure 22 shows the state-by-state percentage of total NO_X emission reductions anticipated from the NO_X SIP Call and the actual reductions achieved by the power industry between 2002 and 2004. Because the majority of the states subject to the NO_X SIP Call were required to meet their emission caps by 2004, EPA expects few additional reductions after 2004 as the compliance supplement pool is used up, and in response to growth in fossil fuel generation to meet increasing electric demand.

Figure 22 shows that actual NO_X emission reductions occurred where anticipated. The largest reductions took place in states along the Ohio River Valley. States are color-coded based on the percent of total emissions reduced, which is calculated as an individual state's emission reductions, divided by total reductions across all states (in tons). Anticipated reductions are based on tons reduced across days modeled, which represent the ozone season. Actual reductions are based on tons reduced across ozone season days.

Figure 23: Percent Reductions in Seasonal 8-Hour Ozone, Anticipated and Actual



Source: EPA

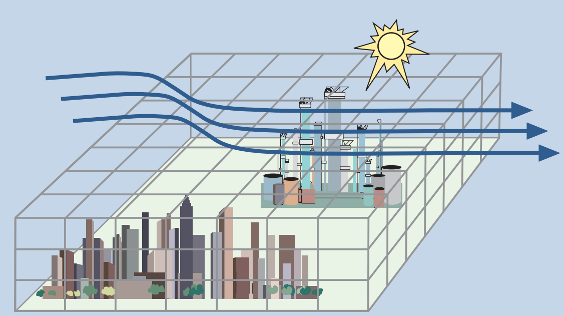
Notes:

- **EPA used projections of 2007 emissions—both with and without the NO_X SIP Call—to evaluate the rule's impact on ozone concentrations. Although EPA's modeling used 2007 as a base year, the regulation required the majority of these reductions to be implemented prior to May 31, 2004 (in all affected states, except portions of Missouri and Georgia).**
- **For this report, EPA compared model-predicted changes in seasonal average 8-hour ozone to actual ambient changes, before and after the NO_X SIP Call.**

Similarly, Figure 23 illustrates where ozone reductions were anticipated and where actual ozone reductions were achieved. Both maps use average daily maximum 8-hour ozone concentrations. Anticipated improvements are based on model predictions, and actual improvements are based on measurements taken during the ozone season. As with NO_X emissions, the anticipated and actual changes in ozone generally are similar (e.g., both show largest reductions along the Ohio River Valley), indicating that the NO_X SIP Call appears to have achieved its goal of reducing ozone in the eastern United States.

Estimating the Impact of Proposed Control Programs

EPA uses air quality models to predict how emissions from a specific source or combination of sources will contribute to ozone concentrations at downwind sites. Using estimates of hourly emissions and meteorology, these models simulate the physical and chemical processes that contribute to ozone formation and transport. These models allow EPA to test hypotheses about how ozone levels will respond to reductions in VOC and NO_X emissions resulting from an individual control program or combination of control programs.



Photochemical grid models simulate atmospheric chemistry and transport throughout the geographic area of interest.

Chapter 4: NO_X Budget Trading Program Compliance, Market Activity, and Banking

A review of the second year of cap and trade under the NO_X Budget Trading Program (NBP) shows that the market continues to mature. In 2004, for the first time, a substantial number of sources in 11 states began to comply with the emission reduction requirements under the program. Many of these sources had to make significant reductions to achieve compliance, and the market appears to have played a significant role as participants determined what control strategies to pursue and on what timetable. At the same time, a number of units added controls to meet emission reduction requirements in the non-OTC states between the end of the 2003 and the beginning of the 2004 ozone season.

This chapter examines compliance under the NBP in 2004 and examines trends in this maturing market, including those in allowance pricing and transactions. It also addresses how the high level of banking in 2004 will affect future restrictions on the use of banked allowances for compliance. In addition, this chapter reviews the monitoring and control methods employed by sources to meet program requirements.

2004 Compliance Results

Under the NBP, sources must hold sufficient allowances to cover their ozone season emissions each year. Sources can maintain the allowances in compliance accounts (established for each unit) or in an overdraft account (established for each facility with more than one unit). The overdraft account allows greater flexibility in "bubbling" between units, managing banked allowances from previous years, managing transferred allowances from other sites, and managing allowances purchased from other NBP participants. The sources have a two-month window after the end of the control period to move allowances between accounts (and to buy or sell additional allowances) to ensure their emissions do not exceed allowances held. After the two-month period, allowances may not be transferred into or out of these accounts while EPA reconciles emissions with allowance holdings for program compliance.

Nearly all of the NBP sources that participated in 2004—both electric generating units and industrial units—held sufficient allowances to cover their emissions at the time.

EPA performed reconciliation and identified a single facility with two units that had an allowance deficiency of nine allowances. In cases where the source does not hold enough allowances to cover its emissions, the program requires an automatic penalty deduction (three allowances for each excess ton of emissions) from the source's allocations for the next control period. Table 2 summarizes the allowance reconciliation process for 2004.

NO_X Allowance Trading in 2004

Allowance trading generally comprises three main types of transfers:

1. Transfers within a company or between related entities (e.g., holding company transfers to a small operating subsidiary).
2. Transfers between separate economic entities. These transfers are categorized broadly as "economically significant trades."
3. Transfers from or to the state as allowance allocations or allowance surrenders.

In 2004, economically significant trades represented approximately 40 percent of the total transfers between entities other than a state. The economically significant trades provide the strongest indicator of true market activity, because they represent an actual exchange of assets between unaffiliated participants.

There were more than 230,000 allowances involved in economically significant trades in 2004, slightly lower than in 2003. However, overall trading activity remained robust. As in the earlier OTC trading program, industrial sources have actively traded allowances. These sources traded more than in 2003 and participated in approximately 13 percent of the economically significant trade volume.

Table 2: NO_X Allowance Reconciliation Summary—2004

Total Allowances Held for Reconciliation	676,574
Allowances Held in Compliance and Overdraft Accounts	609,249
Allowances Held in Other Accounts*	67,325
Allowances Deducted for 2004 Emissions	468,824
Termination of 2003 Early Reduction Credit (or Compliance Supplement Pool) Allowances**	125
Banked Allowances	**207,625**
Allowances Held in Compliance and Overdraft Accounts	133,857
Allowances Held in Other Accounts***	73,768
Penalty Allowances Deducted** (from future year allowances)**	**27**

Source: EPA

* Other Accounts refers to general accounts in the NO_X Allowance Tracking System (NATS) that can be held by any source, individual, or other organization, as well as state accounts.

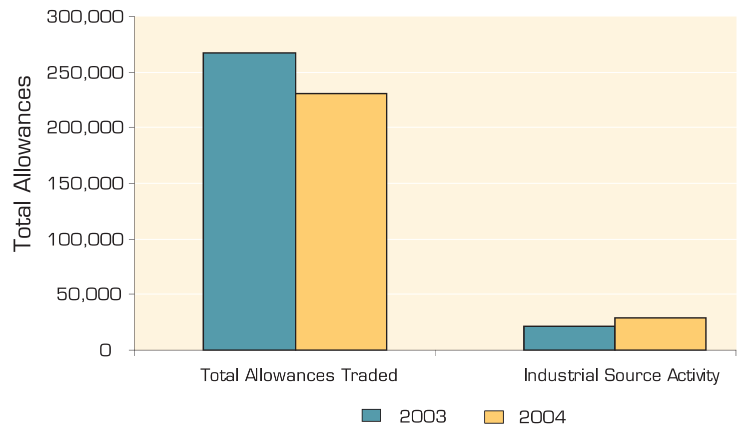
** Compliance Supplement Pool (CSP) allowances can only be used for two years. In the OTC states, CSP allowances not used for reconciliation in 2003 or 2004 have been retired permanently.

*** Total includes 6,477 new unit allowances returned to state holding accounts.

**** These penalty deductions are made from future vintage year allowances, not 2004 allowances.

During certain periods, the price for NO_X allowances can reflect market uncertainties as companies evaluate ongoing trends in control installations, energy demand, and other external factors that affect the overall costs of control. In addition, program elements such as progressive flow control and the retirement of compliance supplement pool allowances enter into transfer decisions, as do questions about the integration of the NBP with the recently finalized (March 2005) Clean Air Interstate Rule (CAIR). Despite these uncertainties, allowance prices stabilized in 2004 and are down appreciably from early 2003 (see Figure 25), which is one indication that the cap and trade market has matured.

Figure 24: Economically Significant Trades



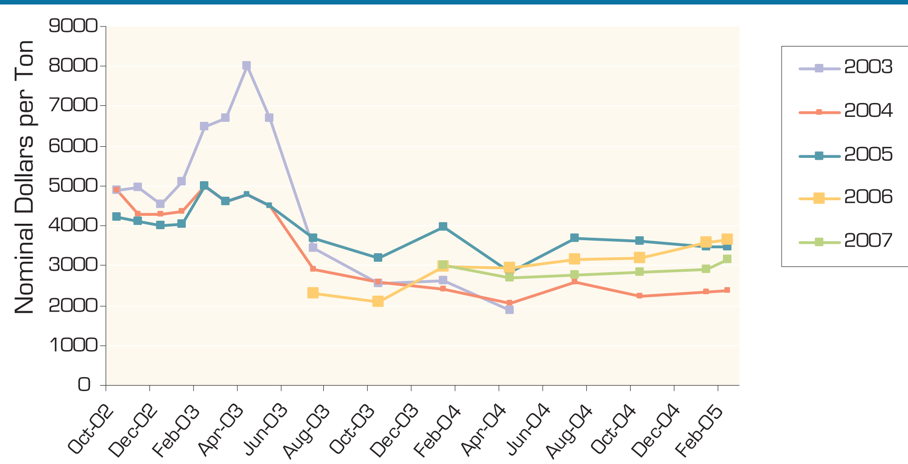
Source: EPA

Banking in 2004 and Flow Control Next Season

Under the NBP, banking provisions allow companies to decrease emissions more than what was required early in the program, and then save unused allowances for future use. Banking results in environmental and health benefits earlier than required by the NBP and provides a pool of allowances available to address unexpected events or smooth the transition into deeper emission reductions.

If sources use a large number of banked allowances in one year, the elevated emissions could potentially reduce the environmental effectiveness of the NBP. The NBP's progressive flow control provisions were designed to discourage extensive use of banked allowances in a particular ozone season. Flow control is triggered when the total number of allowances banked for all sources exceeds 10 percent of the total regional budget for the next year. When this occurs, EPA calculates the flow

Figure 25: Vintage Year NO_X Allowance Prices by Month of Sale



Source: Evolution Markets, LLC and Cantor Environmental Brokerage control ratio by dividing 10 percent of the total trading budget by the number of banked allowances (a larger bank will result in a smaller flow control ratio). The resulting flow control ratio indicates the percentage of banked allowances that can be deducted from a source's account in a ratio of one allowance per ton of emissions. The remaining percentage of banked allowances, if used, must be deducted at a rate of two allowances per one ton of emissions.

With a large number of additional sources in 2004 and the addition of Compliance Supplement Pool (CSP) allowances to states' budgets, the level of banked allowances in the NBP increased to nearly 208,000, well beyond the previous year's total of more than 28,000. These banked allowances represent 40 percent of the total allocations for the 2005 ozone season. Because this ratio exceeds 10 percent, flow control will be triggered in 2005.

Continuous Emissions Monitoring System Results

In order for NO_X allowances to be accurately tracked and traded, NBP sources must use consistent monitoring procedures to determine their emissions. Accurate and consistent monitoring ensures that all allowances in the NBP have the same value (i.e., a ton of NO_X emissions from one NBP source is equal to a ton of NO_X emissions from any other source in the program). Analysis of the continuous emissions monitoring data reported by NBP sources in 2004 convincingly demonstrates the high quality of the data (see Figure 26).

Industrial sources, many of which have been monitoring under EPA's detailed monitoring procedures (40 CFR Part 75) only since 2003, were able to perform at nearly the same level as electric generating units, most of which have been monitoring under Part 75 for about a decade. In 2004, both the electric generating units and industrial units passed more than 98 percent of the quality assurance tests required of their monitoring systems. These tests included:

- Daily calibration error tests, which use reference gases of known concentrations, or (for flow monitors) reference signals with known values, to test a monitor at a zero point and an upscale point.
- Quarterly linearity checks (for gas monitors, only), which are similar to the daily calibration procedure but performed at three intermediate gas concentrations across the range of the analyzer.

Flow Control Will Apply in 2005—How Will It Affect Sources?

• 2005 Regional Budget:	516,245 allowances
• Banked Allowances after 2004:	207,625 allowances
• Flow Control Trigger:	207,625/516,245 > 10 percent, triggering flow control for 2005

- The flow control ratio will be 0.25 (determined by dividing 10 percent of the total trading program budget by the total number of banked allowances, or 51,625/207,625).
- The flow control ratio is applied to banked allowances in each source's compliance and overdraft allowance accounts at the time of compliance reconciliation.
  - For example, if a source holds 1,000 banked allowances at the end of 2005, it will be able to use 250 of them on a 1-for-1 basis, but will have to use the remaining 750, if necessary, on a 2-for-1 basis for compliance.
- If the source used all of its 1,000 banked allowances for 2005 compliance, the banked allowances could be used to cover only 625 tons of NO_X emissions (250 + 750/2).

- Semiannual or annual relative accuracy test audits which compare data from the monitoring system to concurrent measurements of the stack emissions with an EPA reference test method.

NBP sources also reported quality-assured emissions data for more than 99 percent of their operating hours in 2004 (see Figure 26). Part 75 requires conservatively high substitute data values to be reported for missing data periods, but substitute data were used less than 1 percent of the time in 2004 and therefore had little impact on the cumulative NO_X mass emissions reported by the NBP sources.

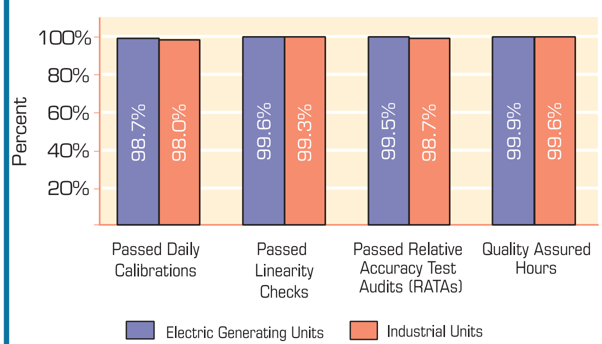
Compliance Options under the NOx Budget Trading Program

In a way that best fits their own circumstances, sources can choose from a variety of compliance options to meet the emissions reduction targets of the NBP. These include decreasing generation from certain units (such as units with high NO_X emissions), modifying or optimizing the basic combustion process to control the formation of NO_X, using add-on controls, or purchasing additional allowances from other market participants.

Many electric generating units installed combustion controls to meet the NO_X emission limits of the Acid Rain Program. In addition, some industrial units added combustion controls to meet state NO_X emission limits. For boilers, furnaces, and heaters, these controls include low NO_X burner and overfire air technologies, which modify the combustion process to reduce formation of NO_X from nitrogen present in the combustion air and fuel. Advances in combustion control technologies continue to provide cost-effective options to reduce emissions even further for some units.

Add-on control technologies, such as selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR), are frequently applied for NO_X control. SNCR and SCR are control technologies that achieve NO_X reductions by injecting ammonia, urea, or another NO_X reducing chemical into the flue gas within or downstream of the combustion unit to react with NO_X, forming nitrogen and water. SCR adds a catalyst to allow this reaction to occur in a lower temperature

Figure 26: 2004 NO_X Budget Trading Program Quality Assurance Performance of Continuous Emissions Monitors, Electric Generating and Industrial Units



Source: EPA

Note: These results include approximately 1,300 electric generating and 275 industrial units that reported under the NBP using CEMS in 2004.

What Monitoring Options Can Sources Use?

EPA has developed detailed procedures (40 CFR Part 75) to ensure that sources monitor and report emissions with a high degree of precision, accuracy, reliability, and consistency. Coal-fired units are required to use continuous emission monitoring systems (CEMS) for NO_X and stack gas flow rate (and if needed, CO_2 or O_2 and moisture), to measure and record their NO_X mass emissions. Oil and gas-fired units may alternatively use a NO_X CEMS in conjunction with a fuel flowmeter to determine NO_X mass emissions. For oil and gas-fired units that are either operated infrequently to provide power during periods of peak demand or that have very low NO_X emissions, Part 75 provides low-cost alternatives to estimate NO_X mass emissions. Figure 26 presents only the results for units that use CEMS.

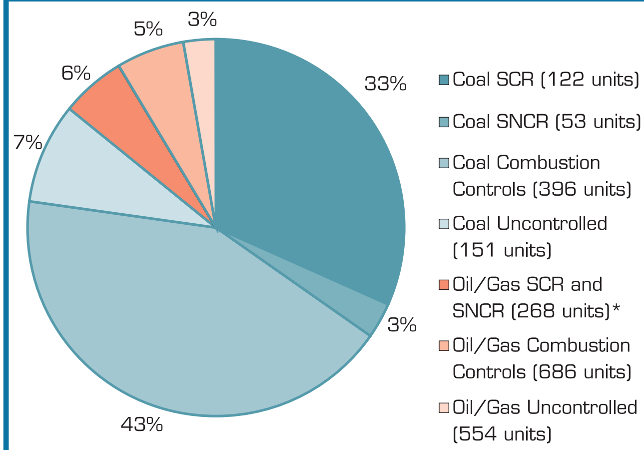
range. While SNCR is mainly applicable to boilers, furnaces, heaters, and kilns, SCR can be used for a wider range of electric generating and industrial units. Sources report pollution control information, including installation dates, in monitoring plans submitted to EPA.

Figure 27 shows the breakdown of how electric generating sources have employed emission controls as of the 2004 ozone season, by both number of units and the percent of total ozone season generation. In the 2004 ozone season, there were about 2,200 electric generating units affected under the NBP. Coal-fired electric generating units with combustion controls (about 400 units) represented 43 percent of total generation during the ozone season. Coal-fired electric generating units with SCR (122 units) constituted about 5 percent of electric generating units, but represented more than 30 percent of the total ozone season generation. In contrast, oil- and gas-fired electric generating units (over 1,500 units) constituted nearly 70 percent of all electric generating units but accounted for less than 15 percent of total ozone season generation.

Figure 28 shows similar information for industrial units, but based on steam output rather than electric generation. In the 2004 ozone season, there were 340 industrial units affected under the NBP. Most industrial units either identify combustion controls in their monitoring plans or do not identify any type of add-on controls. There are only a few exceptions where SCR or SNCR is employed. There are no cases where coal-fired industrial units employ SCR. Except for turbines that can use a relatively simple form of SCR, the use of SCR is typically limited to larger coal-fired electric generating units that can achieve significant emission reductions in a highly cost effective way.

In addition to adding controls, decreasing generation from certain units (e.g., those with high NO_X emissions) and making operational or fuel changes are other methods sources can use to achieve emission reductions. Table 3 shows that the total heat input for all NBP sources increased slightly (less than 2 percent) from 2003 to 2004. The heat input from coal-fired units decreased a small amount, while the heat input from gas-fired units increased. Although there were small differences between fuel types, the overall heat input change suggests that there was no substantial shift from coal-fired units to lower emitting oil- or gas-fired units in 2004.

Figure 27: Percent of Total 2004 Ozone Season Electric Generation by Fuel and Control Type



Source: EPA

* In 2004, only 14 oil/gas units had SNCR, making up less than 1 percent of ozone season generation.

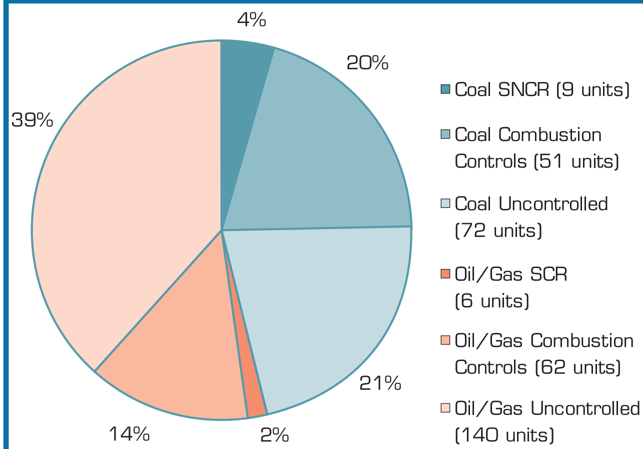
Coal-fired Units Account for Nearly All Emission Reductions since 2003

Table 3 indicates that coal-fired units accounted for nearly all of the 226,000 tons of emission reductions achieved by NBP units from 2003 to 2004. This analysis first examines emission reductions from units that added new controls in 2004 and then focuses on those units that achieved emission reductions with no reported change in controls.

By the end of the 2004 ozone season, 122 coal-fired units reported using SCR controls to meet the NBP requirements, an increase of more than 30 units since the end of the 2003 ozone season. Seven units reported adding SNCR systems during this period, and 17 units reported the installation of new or upgraded combustion controls. Overall, units that installed new controls (since the end of the 2003 ozone season) reduced emissions by about 91,000 tons from 2003 levels. Additional reductions were achieved by units that installed add-on controls in the 2003 ozone season or earlier but operated those controls more in the 2004 ozone season. These units (primarily units with SCR controls) reduced emissions by about 28,000 tons in the 2004 ozone season.

Coal-fired units with no add-on controls and no reported change in their control status after the 2003 ozone season were nonetheless able to reduce mass emissions by more than 100,000 tons from 2003 ozone season levels. To assess how those reductions may have occurred, EPA analyzed these units based on 2003 NO_X rates, ordered by highest to lowest emitters. This analysis excludes coal-fired units in OTC states because those units already had to meet trading program budget requirements in 2003 and did not reduce emissions significantly from 2003 to 2004. In 2004, units with the highest 2003 NO_X emission rates (the top 25 percent) decreased total ozone season heat input by about 15 percent from 2003 levels. The remaining units had only a moderate decrease in heat input (generation), approximately 2 percent. Mass emission reductions were also attributable to emission rate reductions. For example, the units with the highest 2003 emission rates (the top 25 percent) experienced a median emission rate reduction of about 0.12 lb/mmBtu. The remaining units realized a more moderate NO_X rate reduction (the median reduction was about 0.05 lb/mmBtu). While discrepancies in the reported information on types of NO_X controls installed likely explain rate reductions for some of these units, these types of rate reductions also can occur as a result of operational changes or fine-tuning of the existing combustion controls, which sources do not report to EPA.

Figure 28: Percent of Total 2004 Ozone Season Steam Output for Industrial Units by Fuel and Control Type



Source: EPA

Note: Industrial units generally provide generation data as steam output load. Some industrial units provide electrical output data because they provide electrical energy for on-site use. That electrical load data was converted to a steam equivalent (1,000 pounds per hour) to allow consistent comparison of data.

Heat input is the heat derived from the combustion of fuel in a unit. It is a simple way to track utilization of affected units. The overall heat input levels from affected sources in the NBP states increased slightly between 2003 and 2004 without the addition of a significant number of sources. This indicates that, on a systemwide basis, sources in the region were able to maintain their preexisting generation levels while still complying with the NBP.

Table 3:
Comparison of 2003 and 2004 Ozone Season NO_X Mass Emissions, Heat Input, and NO_X Emission Rates in the NO_X Budget Trading Program

Units by Fuel Type	Ozone Season NO_X Mass Emissions (tons)		Ozone Season Heat Input (mmBtu)		Ozone Season NO_X Emissions Rate (lb/mmBtu)	
	2003	2004	2003	2004	2003	2004
Coal	770,000 (94%)	548,000 (93%)	4.7 billion (84%)	4.7 billion (83%)	0.33	0.23
Oil	25,000 (3%)	25,000 (4%)	260 million (5%)	260 million (5%)	0.19	0.19
Gas	24,000 (3%)	20,000 (3%)	590 million (11%)	690 million (12%)	0.08	0.06
Total	819,000	593,000	5.57 billion	5.65 billion	0.29	0.21

Source: EPA

Notes:

- Tons rounded to the nearest 1,000 tons. Totals may not equal the sum of the values for each fuel type due to rounding. The data presented here are for the ozone season May 1-September 30.
- The Average emission rate is based on dividing total reported ozone season NOx mass emissions for each fuel category by the total ozone season heat input reported for that category. The average emission rate expressed for the "Total" is the heat input weighted average for the three fuel categories.

Chapter 5: Future NO_X Reductions and Ozone Improvements

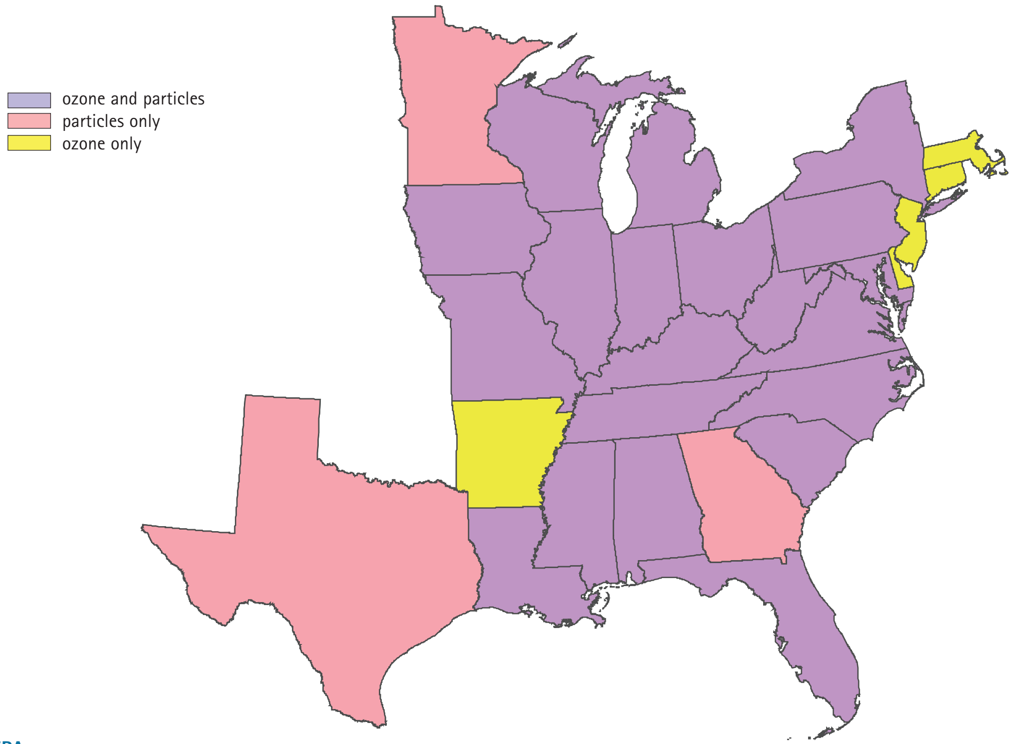
Despite improvements in ozone air quality in many areas of the country, ozone continues to be a pervasive air pollution problem. More than 100 million people in the eastern United States are still living in nonattainment areas that do not meet the 8-hour ozone standard. Continued reductions anticipated under the NO_X SIP Call will help reduce emissions of NO_X and improve air quality. Recent national mobile source regulations will help reduce ozone by reducing NO_X and VOCs from new passenger vehicles, heavy-duty diesel engines, and other mobile sources.

In addition, EPA's Clean Air Interstate Rule (CAIR) will help further reduce ozone in the East. This landmark rule, issued March 10, 2005, will permanently cap power industry emissions of sulfur dioxide (SO_2) and NO_X in the eastern United States, achieving large reductions of these pollutants. CAIR will build on the ozone season emission reductions from the NO_X SIP Call. In 2015, CAIR, the NO_X SIP Call, and other programs in the CAIR region will reduce power industry ozone season NO_X emissions by about 50 percent and

How Does the Clean Air Interstate Rule (CAIR) Affect NO_X Budget Trading Program States?

The NO_X SIP Call requirements will remain in place, but in 2009, EPA will stop administering the existing regional ozone season NO_X trading programs. States can meet their NO_X SIP Call obligations using the CAIR's ozone season NO_X trading program. CAIR allows states to include all of their NO_X SIP Call trading sources in the CAIR ozone season trading program. If a state includes industrial units, the trading budget for those units remains the same as the NOx SIP Call. The 2009 CAIR ozone season NO_X electric generating unit budgets are at least as stringent as the NO_X SIP Call budgets, and in some states are tighter. In 2015, the ozone season emission cap will be further reduced. In addition, because CAIR allows sources to use pre-2009 NO_X SIP Call allowances for compliance on a 1:1 basis with the CAIR ozone season NO_X program (i.e., the allowances can be banked and carried into the CAIR), NO_X Budget Trading Program (NBP) sources have an incentive to begin reducing their emissions now. Also, as with the NO_X SIP Call, the CAIR annual NO_X program includes a compliance supplement pool to provide incentives for sources to reduce non-ozone season NO_X emissions prior to CAIR. For more information, visit <www.epa.gov/cair>.

Figure 29: States Covered by the Clean Air Interstate Rule (CAIR)



Source: EPA

Note: EPA proposed in March 2005 to add Delaware and New Jersey to the states in CAIR covered for fine particles.

annual NO_X emissions by about 60 percent from 2003 levels. In addition by 2015, CAIR and other existing air programs will reduce the number of 8-hour ozone nonattainment areas, and will bring remaining areas closer to attainment.

In 2015, EPA predicts that with CAIR and existing federal and state programs, only six ozone nonattainment areas will remain in the East: Chicago; Houston; Philadelphia, New York City; Baltimore and Washington, D.C. States are working to identify and implement local controls to move these remaining six areas toward attainment.

CAIR is similar to the NO_X SIP Call in that it requires states to submit SIPs and meet a budget to reduce emissions. CAIR reduces NO_X through two budgets: ozone season NO_X budgets in 25 states and Washington, D.C., and annual budgets to reduce fine particle pollution (PM 2.5) in 23 states and Washington, D.C. In March 2005, EPA proposed to add Delaware and New Jersey to the states in CAIR covered for fine particles. Many states are affected by CAIR for both ozone season NO_X and annual NO_X and SO_2 (see Figure 29). Like the NO_X SIP Call, CAIR establishes EPA-administered, interstate cap and trade programs that states can choose to use to obtain the required emission reductions. EPA anticipates that most, if not all, affected states will join these trading programs.

Ozone and Particle Pollution in the Future

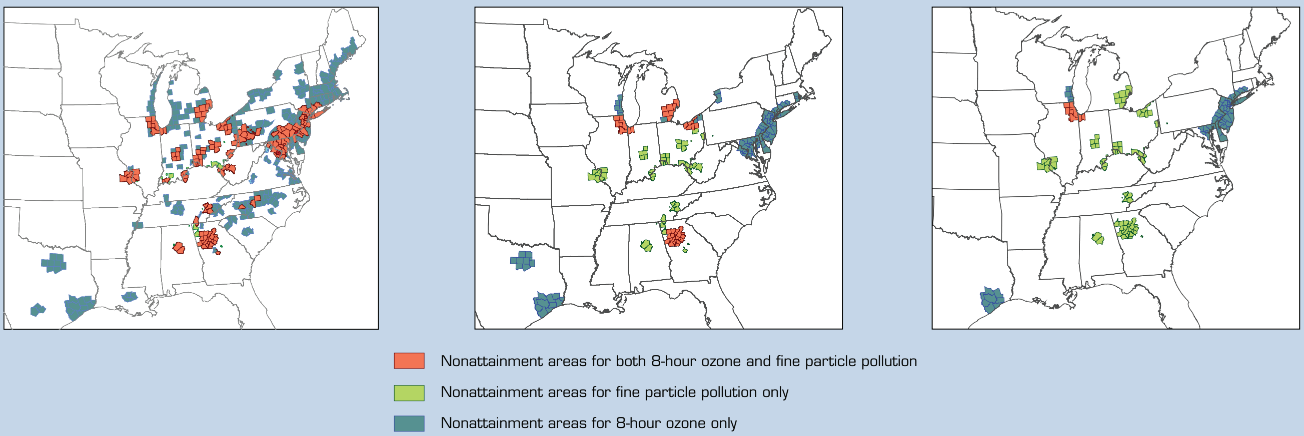
The Clean Air Interstate Rule (CAIR), Together With Other Clean Air Programs, Will Bring Cleaner Air to Areas in the East.

On March 10, 2005, EPA issued CAIR. This rule will achieve the greatest air quality improvement, and the deepest cut in emissions of SO_2 and NO_X in more than a decade. Key compliance dates are 2009 (Phase I cap on NO_X), 2010 (Phase I cap on SO_2) and 2015 (Phase II cap on NO_X and SO_2).

Ozone and Fine Particle Nonattainment Areas (April 2005)

Projected Nonattainment Areas in 2010 after Reductions from CAIR and Existing Clean Air Act Programs

Projected Nonattainment Areas in 2015 after Reductions from CAIR and Existing Clean Air Act Programs



Source: EPA

Note: Projections concerning future levels of air pollution in specific geographic locations were estimated using the best scientific models available. They are estimations, however. Actual results may vary significantly if any of the factors that influence air quality differ from the assumed values used in the projections shown here.

Online Resources

General Information:

- **Office of Air and Radiation:** www.epa.gov/oar
  - **Office of Air Quality Planning and Standards:** www.epa.gov/oar/oaqps
  - **Office of Atmospheric Programs:** www.epa.gov/air/oap.html
- **National Academies:** www4.nationalacademies.org/nas/nashome.nsf
- **Mobile Sources:** www.epa.gov/otaq
- **Cap and Trade and Related Programs:** www.epa.gov/airmarkt/index.html

NO_X Control Programs:

- **Acid Rain Program:** www.epa.gov/airmarkets/arp/index.html
- **Ozone Transport Commission (OTC) NO_X Budget Program:** www.epa.gov/airmarkets/otc/index.html
- **NO_X Budget Trading Program:** www.epa.gov/airmarkets/fednox/index.html
- **Clean Air Interstate Rule (CAIR):** www.epa.gov/cair/index.html

Ozone Information:

- **Formation of Ozone:** www.epa.gov/air/urbanair/ozone/what.html
- **Health and Ecological Effects:** www.epa.gov/air/urbanair/ozone/hlth.html
- **Ozone Depletion:** www.epa.gov/ozone
- **8-hour and 1-hour Ozone Trends and Factbook:** www.epa.gov/airtrends

Emissions Data and Monitoring Information:

- **National Emissions Inventory (NEI):** www.epa.gov/ttn/chief/net/
- **Emissions Data for the Power Industry:** http://cfpub.epa.gov/gdm
- **Emissions Development:** www.epa.gov/ttn/chief/trends/procedures/neiproc_99.pdf
- **NO_X and VOC Limitation:** www.cgenv.com/Narsto/american.chem.council.html

Ozone Monitoring Networks and Data:

- **Clean Air Status and Trends Network (CASTNET):** www.epa.gov/castnet
- **Air Quality System (AQS):** www.epa.gov/ttn/airs/airsaqs

Other Emissions and Air Quality Resources:

- **General Information on EPA Air Quality Monitoring Networks:** www.epa.gov/ttn/amtic
- **Clean Air Mapping and Analysis Program (C-MAP):** www.epa.gov/airmarkets/cmap/index.html
- **The Emissions and Generation Resource Integrated Database (eGRID):** www.epa.gov/cleanenergy/egrid/index.html
- **AIRNow:** www.epa.gov/airnow

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