NO_x Budget Trading Program

2005 Program Compliance and Environmental Results

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Executive Summary

The NO_x Budget Trading Program (NBP) is a market-based cap and trade program created to reduce emissions of nitrogen oxides (NO_x) from power plants and other large combustion sources in the eastern United States. NO_x is a prime ingredient in the formation of ground-level ozone (smog), a pervasive air pollution problem in many areas of the eastern United States. The NBP was designed to reduce NO_x emissions during the warm summer months, referred to as the ozone season, when ground-level ozone concentrations are highest. This report evaluates progress under the NBP in 2005 by examining emission reductions, comparing changes in emissions to changes in ozone concentrations, and reviewing compliance results and market activity.

2005 Key Results

- **The NBP has successfully reduced ozone season NO_x emissions throughout the region. In 2005, NBP ozone season NO_x emissions were:**
  - 11 percent lower than in 2004 even as power generation increased by 7 percent (primarily due to moving up the seasonal compliance period for 11 Midwestern and Southern states to May 1);
  - 57 percent lower than in 2000 (before implementation of the NBP); and
  - 72 percent lower than in 1990 (before implementation of the Clean Air Act Amendments).
- **Ground-level ozone has improved since the implementation of the NBP.**
  - Ozone formation depends greatly on weather conditions, which can vary significantly from year to year. To get a truer picture of how emission changes impact ozone formation, EPA adjusts ozone concentrations to account for the influences of weather.
  - Average ozone levels in the NBP region have decreased by about 8 percent since 2002. Ground level ozone has improved since the NBP began in 2003.
  - There is a strong association between areas with the greatest reductions in NO_x emissions and nearby downwind sites exhibiting the greatest improvements in ozone.
  - In 2004, EPA officially designated 103 areas in the eastern United States as 8-hour ozone "nonattainment areas". These areas were required to improve their ozone air quality with the goal of attaining and maintaining the national air quality standards for ground-level ozone. Based on 2003 to 2005 air monitoring data, ozone air quality improved in all of these areas. Nearly 70 percent of them (68 areas) now have air quality that is better than the level of the standard. The NBP is the major contributor to these improvements.
- **Through a wide range of pollution control strategies and an active NO_x allowance market in 2005, sources achieved over 99 percent compliance with the NBP.**
  - There were 2,570 units affected under the NBP in 2005. Only three NBP sources (four units total) did not hold sufficient allowances.
  - Overall, trading activity increased from 2004 to 2005 with an active market, and allowance prices were slightly lower and somewhat less volatile than in 2004.
  - The flexibility of the NBP provides sources options to reduce NO_x emissions, such as adding NO_x emission control technologies, replacing existing controls with more advanced technologies, or optimizing existing controls.
- **The Clean Air Interstate Rule (CAIR), issued in March 2005, will continue the progress demonstrated by the NBP. CAIR extends this successful cap and trade program to control both ozone and fine particles in 28 eastern states and the District of Columbia**.

Introduction

For more than three decades, the U.S. Environmental Protection Agency (EPA) has worked with state, local, and tribal representatives to reduce emissions that contribute to the formation of ground-level ozone. This pollutant contributes to a number of serious health and ecological effects.

Early ozone management policies focused on reducing ozone by reducing emissions of one of its two 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 and heat.

Ozone levels have decreased substantially, by 20 percent, since 1980 (www.epa.gov/ozone.html). 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, might 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 in 1998, designed to reduce the regional transport of ozone and ozone-forming pollutants in the eastern half of the United States. All 19 affected states and the District of Columbia 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.

The 2004 NBP report, Evaluating Ozone Control Programs in the Eastern United States: Focus on the NO_x Budget Trading Program, concluded that emissions from affected sources decreased by about 50 percent since 2000, before the NBP was implemented. In addition, the report showed that reductions in ozone concentrations in most of the eastern United States more than doubled after implementation of the NBP, beginning in 2003. This 2005 NBP report builds on the previous analyses by assessing continued progress under the program. The report:

- Describes ozone formation, its health and environmental effects, and provides background on the NBP.
- Evaluates the effectiveness of the NBP in 2005 by reviewing emission reductions and corresponding changes in ozone concentrations.
- Examines progress and compliance under the NBP, including market activity, allowance banking and progressive flow control, and compliance options employed by sources under the program.
- Outlines the additional NO_x reductions and ozone improvements expected under CAIR and how it will affect NBP states.

Section 1 — Background: Ozone and Major Control Programs

Ozone Formation and Health and Ecological Effects

Beneficial ozone occurs naturally in the 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 nitrogen oxides (NO_x) and volatile organic compounds (VOCs) react in sunlight and heat. Major sources of NO_x and VOC emissions include motor vehicles, gasoline stations, drycleaners, industrial facilities, and electric power plants (see Figure 1).

Meteorology plays a significant role in both the formation and transport of ozone. The complex photochemical reactions that transform emissions of NO_x and VOCs into ozone require warm, sunny conditions. Because ground-level ozone is highest when sunlight is most intense, the warm summer months (May 1 to September 30) are typically referred to as the "ozone season."

Ozone levels can be high where there are concentrated local sources of NO_x and VOCs, such as urban and suburban areas. The location and concentration of ozone pollution are also affected by regional transport — the movement of ozone and/or its precursors by the wind. Although, in general, urban ozone concentrations are higher than rural areas, ozone levels can be elevated in some rural areas where there are few local emission sources because of the transport of ozone.

Ozone Impacts on Human Health and Ecosystems

Exposure to ozone has been linked to a number of health effects. At levels found in many urban areas, ozone can aggravate respiratory diseases, such as asthma, emphysema, and bronchitis, and can reduce the respiratory system's ability to fight off bacterial infections. Long-term, repeated exposures to sufficient levels of ozone can cause permanent damage to the lungs. Recent research suggests that acute exposure to ozone likely contributes to premature death.

Ground-level ozone also 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 can damage the foliage of trees and other plants, adversely affect-

Weather Plays a Significant Role in Determining Ozone Pollution in a Given Area

Ozone is rarely emitted directly into the air. Instead, ground-level ozone forms when NO_x and VOCs react under the right atmospheric conditions. A dry, hot, sunny day is most favorable for ozone production. In general, ozone concentrations increase during the day, peak in the afternoon when the temperature and sunlight intensity are the highest, and drop back down again in the evening.

Wind transports ozone and/or its precursors. Therefore, depending on its direction, the wind can bring in more pollution to an area, sometimes from hundreds of miles away. Weather also determines how quickly ozone moves away or disperses from an area. Very light winds or no wind can allow ozone and the pollutants that create ozone to build up, providing a more favorable environment for the chemical reactions necessary to create ozone.

When looking at changes in ozone levels (see Section 3, Environmental Results), EPA uses a statistical model to account for the impact of weather on ozone concentrations. While no model can account for all complex meteorological factors that influence ozone, this adjustment provides a better estimate of the underlying ozone trend (i.e., the impact of emission changes).

8-Hour Ozone Standard

To better protect public health, EPA revised its national air quality standards for ozone in 1997, establishing an 8-hour standard. 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. For more information on the 8-hour ozone standard and ozone nonattainment areas in the United States, visit <www.epa.gov/air/oaqps/greenbk/map8hrnm.html>.

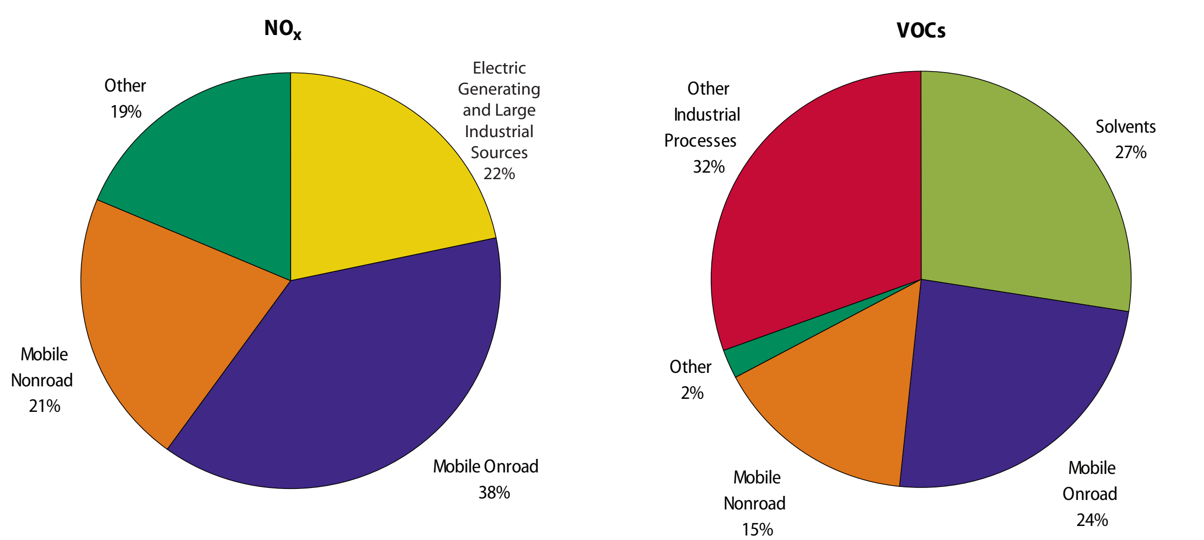
ing the landscape of cities and national parks, forests, and recreation areas. For example, the United States Forest Service observed ozone-induced injury to the leaves of certain ozone sensitive plants (from 1997 to 2002) in many areas of the country, with the highest occurrences in the Northeast. Refer to Section 3, Environmental Results, for more information.

For more information on ground-level ozone, including health and ecological effects, visit <www.epa.gov/epahome/ozone.htm>.

Overview: Major Control Programs for NO_x and VOCs

The majority of NO_x and VOC emissions in the eastern United States come from mobile sources, industrial processes, and the power industry. Mobile onroad and nonroad sources (59 percent) and electric generating units and large industrial sources (22 percent) were responsible for the majority of annual NO_x emissions in the eastern United States in 2005 (see Figure 1). This report examines improvements in NO_x emissions and air quality under the NO_x Budget Trading Program (NBP), which reduces NO_x emissions from electric generating units and large industri-

Figure 1: Manmade Sources of NO_x and VOC Annual Emissions in the Eastern United States, 2005

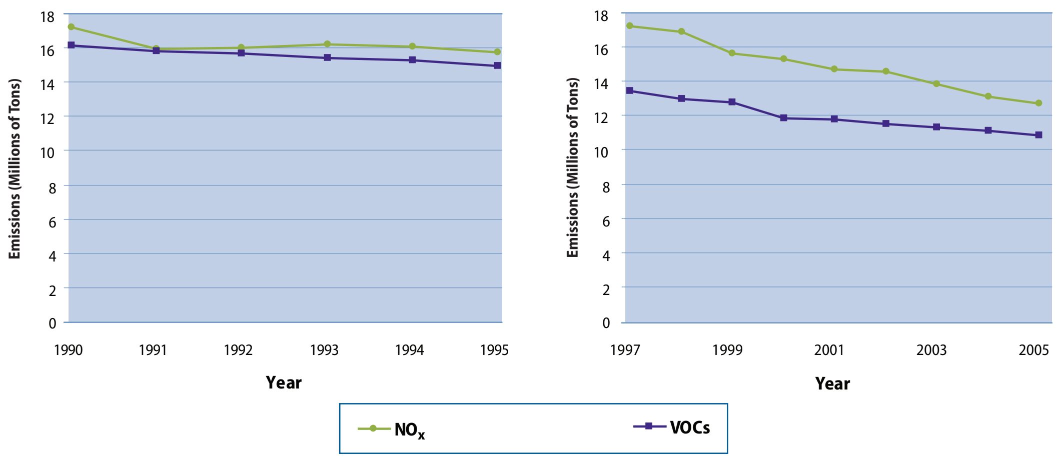


Notes:

- Emissions are from Minnesota, Iowa, Missouri, Arkansas, Louisiana, and states east.
- The Other category for NO_x emissions includes some large industrial sources outside the NO_x Budget Trading Program (NBP), small industrial sources, and other smaller sources such as residential fuel combustion.
- The emission data presented in this figure are measured or estimated values from EPA's National Emissions Inventory (NEI). The NEI incorporates power industry data measured by the continuous emission monitoring system (CEMS); emissions for other sources were estimated by interpolating between the 2002 final NEI data and a projected 2010 emission inventory developed to support the Clean Air Interstate Rule (CAIR).

Source: EPA

Figure 2: Manmade Annual NO_x and VOC Emissions in the Eastern United States, 1990-1995, 1997–2005



Notes:
- Emissions are from Minnesota, Iowa, Missouri, Arkansas, Louisiana, and states east.
- 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.
- The emission data presented in this figure are measured or estimated values from EPA's National Emissions Inventory (NEI). From 1990 to 2002, the final version of the NEI was used. Starting in 1997, the NEI incorporated power industry data measured by continuous emission monitoring systems (CEMS). For this analysis, EPA used CEMS data for the power industry for 2003 through 2005. Emissions for other sources for 2003 through 2005 were estimated by interpolating between the 2002 final NEI data and a projected 2010 emission inventory developed to support the Clean Air Interstate Rule (CAIR).

Source: EPA

al boilers and turbines. Given that these sources accounted for about 22 percent of NO_x emissions in 2005 in the eastern United States, future improvements in air quality as a result of reductions from these sources will be limited by their contribution.

Figure 1 shows that 98 percent of VOC emissions came from industrial processes (including solvents) and mobile sources. A significant portion of VOC emissions might also come from natural sources, such as trees, especially during the ozone season. Note that the results presented in this report do not include emissions from natural sources.

EPA has developed more than a dozen programs since 1990 to improve ozone air quality by reducing emissions of NO_x and VOCs from major sources. These programs complement state and local efforts to improve ozone air quality and meet national standards. Together, these programs have achieved significant emission reductions across the eastern United States. Figure 2 shows that total NO_x and VOC emissions have decreased since 1990, with the largest reductions occurring after 1997.

This report focuses on electric generating units and large industrial boilers and turbines covered under the NBP. For information on control programs for other major sources of NO_x and VOCs, such as mobile sources and industrial processes, refer to the 2004 NO_x Budget Trading Program Report at <www.epa.gov/airmarkets/fednox>.[1]

[1] "Evaluating Ozone Control Programs in the Eastern United States: Focus on the NO_x Budget Trading Program, 2004," <www.epa.gov/airmarkets/fednox>.

Snapshot: National and Regional Power Industry NO_x Control Programs

Acid Rain Program (ARP) — Congress established the ARP as part of the Clean Air Act Amendments of 1990. This annual, national program reduces sulfur dioxide (SO_2) from electric generating units through a cap and trade program. The ARP also reduces NO_x emissions from some of these units, but unlike the SO_2 portion of the ARP, there is no NO_x allowance trading or cap on NO_x emissions. Instead, the ARP NO_x provisions apply boiler-specific NO_x emission limits (lb/mmBtu) on certain coal-fired boilers that are subject to the SO_2 requirements of the ARP. NO_x limits under the ARP applied beginning in 1996 for some of the largest boilers subject to the SO_2 requirements; a second phase to reduce NO_x emissions from additional coal-fired generating units began in 2000. For more information, visit <www.epa.gov/airmarkets/arp>.

Ozone Transport Commission (OTC) NO_x Reduction Programs — The OTC was established under the 1990 Clean Air Act Amendments. States in the Northeast collaborated to help reduce summertime ground-level ozone in the region by achieving ozone season NO_x reductions in several phases. In 1995, sources were required to reduce their annual NO_x emission rates to meet Reasonably Available Control Technology (RACT) requirements. From 1999 to 2002, states achieved reductions in NO_x from fossil fuel-fired electric generating units and large industrial boilers and turbines through Phase I of an ozone season cap and trade program, known as the OTC NO_x Budget 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 State Implementation Plan Call (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. (Maine, Vermont, and Virginia did not join the OTC trading program. New Hampshire is not subject to requirements of the NOx SIP Call). For more information on the OTC, visit <www.epa.gov/airmarkets/otc>.

NO_x SIP Call and the NO_x Budget Trading Program (NBP) — In 1995, EPA and the Environmental Council of the States formed the Ozone Transport Assessment Group to begin addressing the problem of ozone transport across the entire eastern United States. Based on the group's findings and other technical analyses, EPA issued a regulation in 1998 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. The NO_x SIP Call does not mandate which sources must reduce emissions. Rather, it requires states to meet emission budgets and gives them flexibility to develop control strategies to meet those budgets.

Under the NO_x SIP Call, EPA developed the NBP to allow states to meet their emission budgets in a highly cost-effective manner through participation in a region-wide cap and trade program for electric generating units and large industrial boilers and turbines. All 19 affected states and the District of Columbia chose to meet their NO_x SIP Call requirements through participation in the NBP. While EPA administers the trading program, states share responsibility with EPA by allocating allowances, inspecting and auditing sources, and enforcing the program. Compliance with the NO_x SIP Call was scheduled to begin on May 1, 2003 for the full ozone season. However, litigation delayed implementation until May 31, 2004. Refer to the "NO_x Budget Trading Program: Affected States and Compliance Dates" on page 9 for more information.

Clean Air Interstate Rule (CAIR) — On March 10, 2005, EPA promulgated CAIR, a rule that will achieve the largest reduction in air pollution in more than a decade. In addition to addressing ozone attainment, CAIR assists states in attaining the PM 2.5 National Ambient Air Quality Standards (NAAQS) by reducing transported precursors, SO_2 and NO_x. CAIR accomplishes this by creating three separate programs: an ozone season NO_x program and annual NO_x and SO_2 programs. Each of the three programs uses a two-phased approach, with declining emission caps in each phase based on highly cost effective controls on power plants. Similar to the NO_x SIP Call, CAIR gives states the flexibility to reduce emissions using a strategy that best suits their circumstances and provides an EPA-administered, regional cap and trade program as one option. States are now choosing the strategy that best enables them to achieve these mandated reductions and plans are due to be submitted to EPA for approval by the fall of 2006.

Overview: NO_x Budget Trading Program, 2005

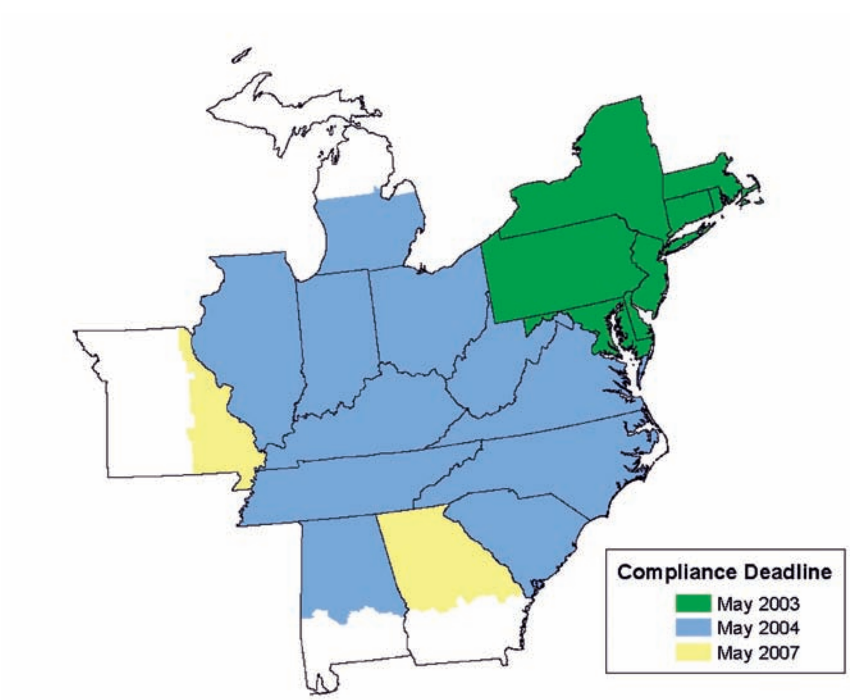
Over the past 3 years, the NO_x SIP Call has achieved significant NO_x reductions, contributing to improvements in regional air quality across the Northeast and mid-Atlantic regions. The primary mechanism for achieving these reductions is the NBP.

NO_x Budget Trading Program: Affected States and Compliance Dates

In 2005, all NBP affected sources were required to comply for the full ozone season, May 1 through September 30.

When reviewing results under the NBP, it is important to understand program implementation and compliance dates. Compliance with the NO_x SIP Call was scheduled to begin on May 1, 2003 for the full ozone season. However, litigation delayed implementation until May 31, 2004. The states previously in the OTC NO_x Budget Program adopted the original compliance date in transitioning to the NO_x SIP Call and therefore began participating in the NBP on May 1, 2003 (see Figure 3). These states include Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Rhode Island, and the District of Columbia. Due to the litigation, the first compliance period did not begin until May 31, 2004, a month into the normal ozone season for states not previously in the OTC NO_x Budget Program (see Figure 3). These states include Alabama, Illinois, Indiana, Kentucky, Michigan, North Carolina, Ohio, South Carolina, Tennessee, Virginia, and West Virginia. The affected portions of Missouri and Georgia are required to comply with the NO_x SIP call as of May 1, 2007. However, EPA has stayed 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.

Figure 3: NO_x SIP Call Program Implementation



Source: EPA

Key Components of the NBP

The NBP is an ozone season (May 1 to September 30) cap and trade program for electric generating units and large industrial boilers and turbines. The program has several important features:

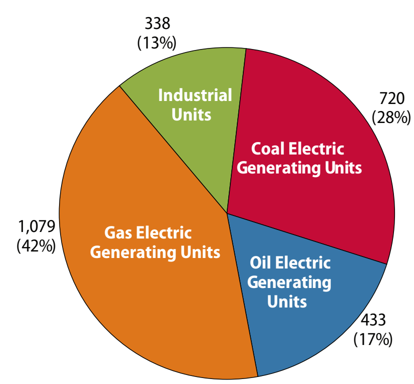
- Under the NBP, the region-wide cap is the sum of the state emission budgets EPA established under the NO_x SIP Call to help states meet their air quality goals.
- Authorizations to emit, known as emission allowances, are then allocated to affected sources based on state trading budgets. The NO_x allowance market enables sources to trade (buy and sell) allowances throughout the year.
- At the end of every ozone season, each source must surrender sufficient allowances to cover its ozone season NO_x emissions (each allowance represents 1 ton of 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. The NBP also has "progressive flow control" provisions, which were designed to discourage extensive use of banked allowances in a particular ozone season. When the bank in any given year exceeds 10 percent of the regional trading budget for the next year, flow control is triggered and determines the amount of NO_x emissions a banked allowance can offset. More information on flow control is available in Section 4, Compliance and Market Activity.
- To accurately monitor and report emissions, sources use continuous emission monitoring systems (CEMS) or other approved monitoring methods under EPA's stringent monitoring requirements (40 CFR Part 75).

For more information on the NBP, including state trading budgets, allowance allocations, and compliance supplement pool (CSP) allowances, refer to <www.epa.gov/airmarkets/fednox>.

NO_x Budget Trading Program: Affected Units in 2005

There were 2,570 units affected under the NBP in 2005. 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 87 percent of all regulated NBP 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 include steam plants at institutional settings, such as large universities or hospitals. Some states have included other types of units, such as petroleum refinery process heaters and cement kilns.

Figure 4: Number of Units in the NO_x Budget Trading Program by Type, 2005



Notes:
- Total affected units in 2005 = 2,570.
- For a breakdown of NBP units by ozone season generation, refer to Section 4, Compliance and Market Activity.

Source: EPA

Section 2 — Changes in Emissions

To assess the effectiveness of the NO_x Budget Trading Program (NBP) in 2005, this section compares nitrogen oxides (NO_x) emission levels in 2005 to levels in 1990 and 2000 (baseline years), and 2003 and 2004. These results include emissions from affected sources in states included in the NBP (see Figure 3).

Ozone Season NO_x Reductions under the NO_x Budget Trading Program

Figure 5 shows the total ozone season NO_x emissions for all affected sources in the NBP region in 2005 compared to 1990, 2000, 2003, and 2004. In 2005, NBP sources emitted about 530,000 tons of NO_x, reducing emissions by about 11 percent from 2004, 57 percent from 2000, and 72 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 largely reflects reductions achieved by the Ozone Transport Commission (OTC) and NBP.

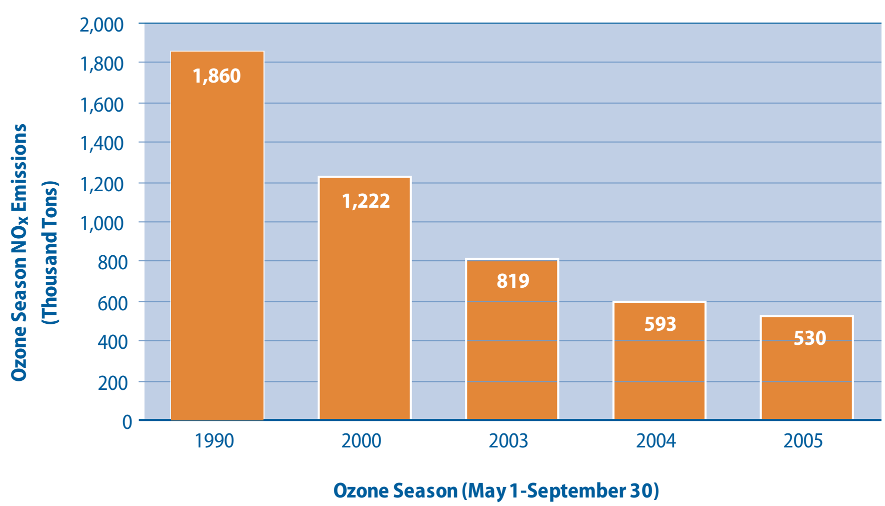
NO_x emissions in 2005 were lower than in 2004, despite a 7 percent increase in total heat input as sources continue to reduce average NO_x emission rates, expressed as pounds of NO_x emitted per

Baseline Years for Measuring Progress under the NO_x Budget Trading 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 due to the implementation of earlier NO_x regulatory programs under the 1990 Clean Air Act Amendments had already occurred by 2000, but sources were not yet implementing the NBP at that time.

Figure 5: Ozone Season Emissions under the NO_x Budget Trading Program



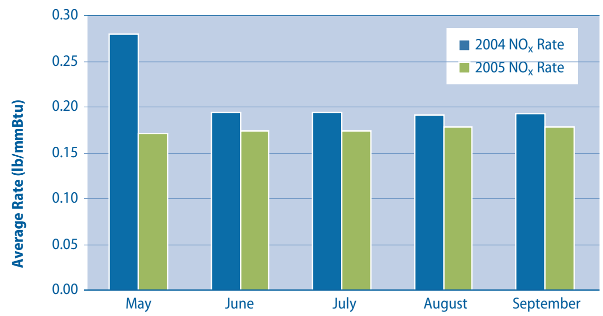
Source: EPA

What Is Heat Input?

Heat input is the heat derived from the combustion of fuel in a unit. It is a simple way to track ozone season power generation or utilization of affected units. The overall ozone season heat input to affected NBP sources increased by about 7 percent between 2004 and 2005, although there was no significant change in the number of NBP sources. However, despite the increase in ozone season power generation in 2005, NBP sources still achieved substantial NO_x emission reductions (11 percent).

million Btu of heat input (lb/mmBtu). Figure 6 shows the average monthly emission rates for the 2004 and 2005 ozone seasons. The average rate decreased each month when comparing 2004 to 2005, with the most notable reductions occurring in May. Between the 2004 and 2005 ozone seasons, emission rates in May dropped almost 39 percent. This sharp decline occurred primarily because sources in the non-OTC states did not have to comply until May 31, 2004. Excluding May, the average emission rate decreased each month during the 2005 ozone season by 0.02 lb/mmBtu, or almost 10 percent from 2004.

Figure 6: Comparison of Average Monthly NO_x Emission Rates in the NO_x Budget Trading Program, 2004 and 2005



Source: EPA

Table 1: Comparison of 2003, 2004, and 2005 Ozone Season NO_x Emissions, Heat Input, and NO_x Emission Rates in the NO_x Budget Trading Program

Units by Fuel Type	Ozone Season NO_x Emissions (tons)			Ozone Season Heat Input (mmBtu)			Ozone Season NO_x Emission Rate (lb/mmBtu)		
	2003	2004	2005	2003	2004	2005	2003	2004	2005
Coal	770,000 (94%)	548,000 (93%)	475,000 (90%)	4.72 billion (84%)	4.71 billion (83%)	4.90 billion (81%)	0.33	0.23	0.19
Oil	25,000 (3%)	25,000 (4%)	32,000 (6%)	260 million (5%)	260 million (5%)	310 million (5%)	0.19	0.19	0.21
Gas	24,000 (3%)	20,000 (3%)	23,000 (4%)	590 million (11%)	690 million (12%)	840 million (14%)	0.08	0.06	0.05
Total	819,000	593,000	530,000	5.57 billion	5.66 billion	6.05 billion	0.29	0.21	0.18

Notes:

- The NO_x tons are rounded to the nearest 1,000 tons and the heat input values are rounded to the nearest 10 million mmBtus. Totals represent the sum of the rounded values. The 2003 through 2005 data represent the full ozone season, May 1 to September 30, for each year.
- The average emission rate is based on dividing total reported ozone season NO_x 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.

Source: EPA

Ozone Season Generation and Emission Reductions by Fuel Type

Table 1 provides the total emissions and heat input for NBP units by fuel type for the 2003, 2004, and 2005 ozone seasons. Coal-fired units accounted for all of the emission reductions from 2004 to 2005, decreasing emissions by about 73,000 tons. The majority of these reductions (about 67,000 tons) came from coal-fired units that operated add-on controls during the 2005 ozone season (see Section 4, Compliance and Market Activity).

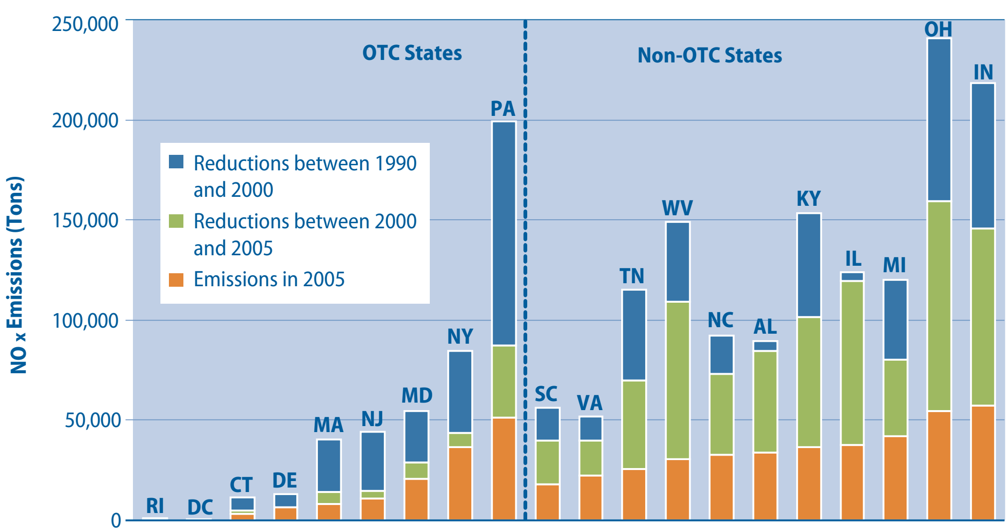
The most dramatic result is the continued decrease in NO_x emission rates leading to these reductions for coal-fired units, despite an increase in heat input from these units between 2004 and 2005. The largest increase in heat input came from oil-fired and gas-fired units, which increased emissions by about 10,000 tons between 2004 and 2005 largely due to increased utilization.

State-by-State Reductions

The NBP states have achieved significant reductions in ozone season NO_x emissions since the baseline years 1990 and 2000 (as shown in Figure 7). All states have achieved reductions since 1990 as a result of programs implemented under the Clean Air Act Amendments, with many states reducing their emissions by more than half since 1990. The decrease in NO_x emissions after 2000 largely reflects reductions achieved by the OTC and NBP.

While the NBP achieved an 11 percent decrease in NO_x emissions overall from 2004 to 2005, Figure 8 shows that the emission reductions from 2004 to 2005 varied somewhat from state to state. Given that 2005 was the first full ozone season compliance period for states outside the OTC, those states saw the most significant reductions from 2004.

Figure 7: NO_x Budget Trading Program State-by-State Ozone Season NO_x Emission Reductions from 1990 and 2000

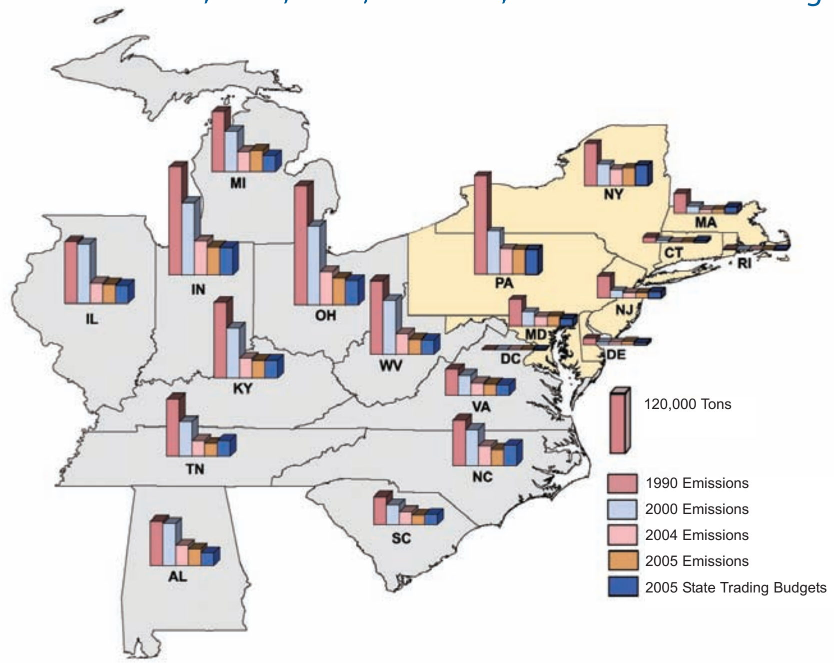


Notes:

- Because emissions in the District of Columbia and Delaware increased between 2000 and 2005 by approximately 146 and 1,282 tons, respectively, there is no green bar shown in the figure for those states.
- For each state, the total bar (i.e., the sum of the orange, green, and blue stacked bars) depicts emissions in 1990. The sum of the green and orange stacked bars depicts emissions in 2000, and the orange bar depicts emissions in 2005.
- Results in Alabama and Michigan represent ozone season emissions from only the affected portion of each state (see Figure 3).

Source: EPA

Figure 8: NO_x Budget Trading Program Ozone Season NO_x Emissions from 1990, 2000, 2004, and 2005, and 2005 State Trading Budgets



Notes:

- The non-OTC states are shaded in gray; OTC states are shown in yellow.
- Results in Alabama and Michigan represent ozone season emissions from only the affected portion of each state (see Figure 3).

Source: EPA

Eight states (Connecticut, Massachusetts, New Jersey, New York, North Carolina, Rhode Island, South Carolina, Tennessee) had ozone season emissions below their trading budgets in 2005 (see Figure 8 and Table 2). Three of these states, Connecticut, Massachusetts, and Rhode Island, were below their trading budgets by at least 30 percent. Emissions in eight other states (Alabama, Illinois, Indiana, Kentucky, Ohio, Pennsylvania, Virginia, and West Virginia) remained above their trading budgets. However, all of these states reduced emissions from 2004 levels, and most were within 1 to 6 percent of their respective budgets. In addition, Indiana, Ohio, and West Virginia accounted for more than 50 percent of the total reductions from 2004 to 2005 (about 35,000 tons).

Cap and Trade: Guaranteed Environmental Results

Cap and trade programs deliver results with a mandatory cap on emissions while providing sources flexibility in how they comply. Cap and trade programs have proven highly effective in reducing emissions from multiple sources on a regional or larger scale. The mandatory cap on emissions is critical to protect public health and the environment and to sustain that protection into the future. Under cap and trade programs, affected sources are allocated authorizations to emit in the form of emission allowances, but the total number of allowances cannot exceed the cap. The cap also serves to provide stability and predictability to the allowance trading market.

Table 2: NO_x Budget Trading Program Ozone Season NO_x Emissions for 1990, 2000, 2004, and 2005, and 2005 State Trading Budgets

State	1990 Emissions (tons)	2000 Emissions (tons)	2004 Emissions (tons)	2005 Emissions (tons)	2005 State Trading Budgets (tons)
CT	11,203	4,697	2,194	3,022	4,477
DC	576	134	36	280	233
DE	13,180	5,256	5,066	6,538	5,227
MA	40,367	14,324	7,483	8,276	12,861
MD	54,375	28,954	19,943	20,988	15,466
NJ	44,359	14,630	10,796	11,163	13,022
NY	84,485	43,583	34,161	36,645	41,350
PA	199,137	87,329	52,172	51,135	50,843
RI	1,099	288	177	222	936
OTC States	**448,781**	**199,195**	**132,028**	**138,269**	**144,415**
AL	89,758	84,560	40,564	33,631	25,497
IL	124,006	119,460	40,976	37,829	35,557
IN	218,333	145,722	68,375	57,260	55,729
KY	153,179	101,601	40,394	36,734	36,224
MI	120,132	80,425	39,848	42,264	31,247
NC	92,059	73,082	39,821	32,943	41,547
OH	240,768	159,578	67,352	54,358	49,499
SC	56,153	39,674	25,354	18,196	19,678
TN	115,348	69,641	31,399	25,721	31,333
VA	51,866	40,043	25,443	22,309	21,195
WV	149,176	109,198	41,333	30,408	29,043
Non-OTC States	**1,410,778**	**1,022,984**	**460,859**	**391,653**	**376,549**
Total NBP States	**1,859,559**	**1,222,179**	**592,887**	**529,922**	**520,964**

Note: Results in Alabama and Michigan represent ozone season emissions from only the affected portion of each state (see Figure 3).

Source: EPA

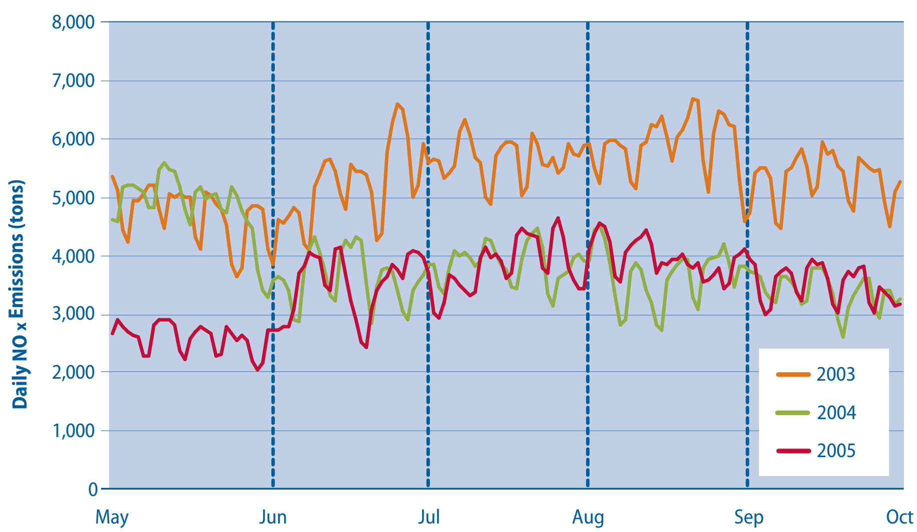
The District of Columbia, Delaware, Maryland, and Michigan had 2005 ozone season NO_x emissions that exceeded both the state trading budgets and 2004 emission levels. Delaware, Maryland, and Michigan had emission increases of 1,472, 1,045, and 2,416 tons above 2004 emission levels, respectively. The District of Columbia's emissions tend to fluctuate greatly from year to year as the affected electric generating units provide peaking power to meet seasonal demand (as opposed to more consistently operating base load units). After 2000, the District of Columbia's NO_x emissions have remained low at less than 300 tons per ozone season. State-specific factors have strongly affected NO_x emissions in these states. For example, Delaware experienced a significant jump in both heat input and emissions, primarily associated with two plants. In Maryland, three plants were responsible for over 65 percent of NO_x emissions in 2005, and emission controls are planned at these plants in upcoming years as required by a federal consent decree and recently passed state legislation.[2] In Michigan, while emissions increased 6 percent from 2004, heat input increased 9 percent during 2005 — the largest increase within the non-OTC region.

Daily Emission Trends

Studies indicate that many of the health effects associated with ozone are linked to daily exposure. EPA developed the 8-hour ozone standard to protect against such exposure. 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.

In practice, the NBP has had a significant impact on daily emissions since the program began in 2003. Figure 9 compares daily NO_x emissions during 2003, 2004, and 2005 for the NBP region. In 2005, daily NO_x emission levels for June through September remained comparable to those in 2004. NO_x emissions in May 2005 decreased nearly 47 percent from May 2004, illustrating the significant reductions achieved by the non-OTC states as they began participating in the program on a full ozone season basis.

Figure 9: Comparison of Daily NO_x Emission Levels, 2003–2005



Source: EPA

[2] 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 6,150 tons per ozone season. The emissions cap in this consent decree should reduce emissions from existing plants in Maryland well below budget levels. The emissions from these four plants totaled over 14,800 tons in the 2005 ozone season. In addition, Maryland recently passed legislation, the Healthy Air Act, which will further lower future NO_x emissions.

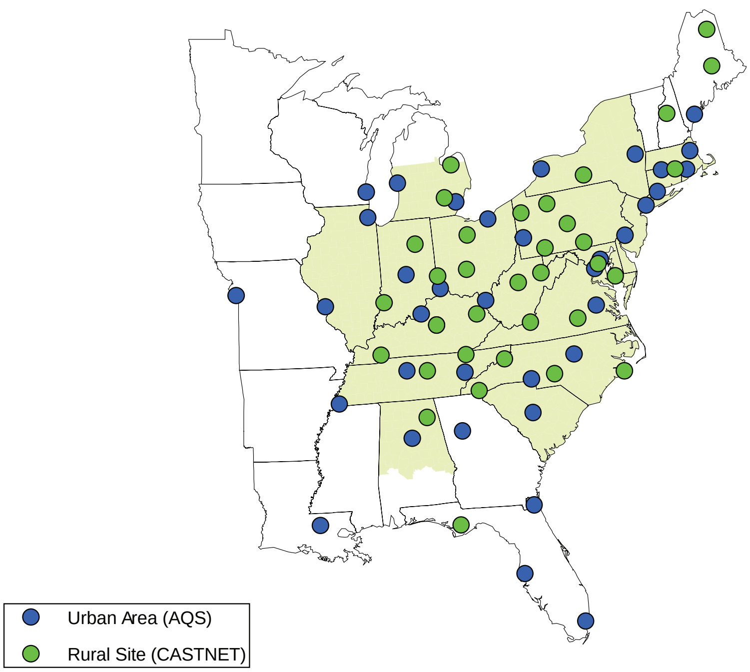
Section 3 — Environmental Results

To better understand how the NO_x Budget Trading Program (NBP) affects ozone, this section examines ozone air quality across the NBP states since 1997 and then looks at changes in ozone concentrations before and after implementation of the NBP. In addition, this section compares geographic patterns in ozone concentrations to reductions in nitrogen oxides (NO_x) emissions under the NBP. These analyses consider the impact of weather, because variations in weather conditions play an important role in determining ozone levels.

Ozone Monitoring Networks

For this report, EPA assembled data from 36 urban areas from the Air Quality System (AQS) and 35 rural sites from the Clean Air Status and Trends Network (CASTNET) to provide a more complete picture of air quality in the eastern United States (see Figure 10). EPA only used sites with sufficient meteorological and ozone data within each time period. For a monitor or area to be included in this analysis, 50 percent of the days for the ozone season had to have complete and valid data.

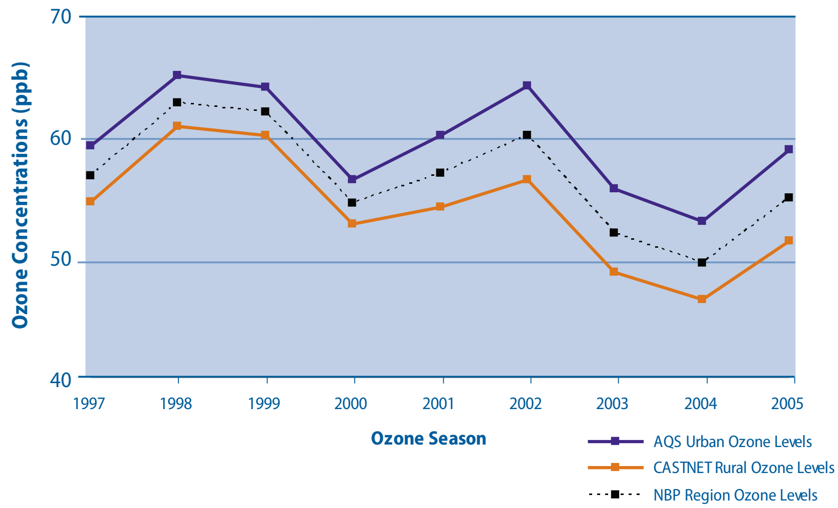
Figure 10: Location of Urban and Rural Ozone Monitoring Networks



Notes:
- States participating in the NBP in 2005 are shaded in green (referred to as the "NBP region").
- Urban areas represent multiple monitoring sites. Rural areas represent single monitoring sites.
- For more information on AQS, visit <www.epa.gov/ttn/airs/airsaqs>. For more information on CASTNET, visit <www.epa.gov/castnet>.

Source: EPA

Figure 11: Trends in Seasonal Average 8-Hour Ozone Concentrations in the NO_x Budget Trading Program Region (Not Adjusted for Meteorology)



Note: Data presented in this figure are unweighted averages of 8-hour daily maximum ozone concentrations during the ozone season for sites within the NBP region, shaded in green in Figure 10.

Source: EPA

General Trends: Changes in Eastern Ozone Concentrations since 1997

Figure 11 shows trends in the "seasonal average" 8-hour ozone concentrations in the NBP region from 1997 to 2005, showing the variability over time in measured ozone concentrations at urban and rural sites. The seasonal average ozone concentration is the average of daily maximum 8-hour ozone concentrations from May 1 through September 30. On average, 2005 ozone concentrations in the NBP region remain below 2002 levels, but are higher than in 2004 (not adjusted for meteorology). In general, weather conditions were more conducive to ozone formation in 2005 than in 2004.

Figure 11 also shows that on average, ozone in rural areas is lower than ozone in urban areas but follows a similar trend. These results provide a seasonal average for NBP states and do not show variations in ozone concentrations for specific urban or rural areas. Although urban and metropolitan areas typically experienced higher ozone concentrations, non-urban areas can also experience high ozone levels due to transport and local emission sources (e.g., mobile sources).

For example, the National Park Service reported that based on a 3-year average of the fourth highest daily maximum 8-hour ozone concentration (in parts per billion, or ppb) for the years 2002 to 2004, three National Park Units in the eastern United States (Acadia, Cape Cod, and Great Smoky Mountains) experienced high ozone concentrations that exceeded 85 ppb.[3]

Ozone Changes after Adjusting for Meteorology

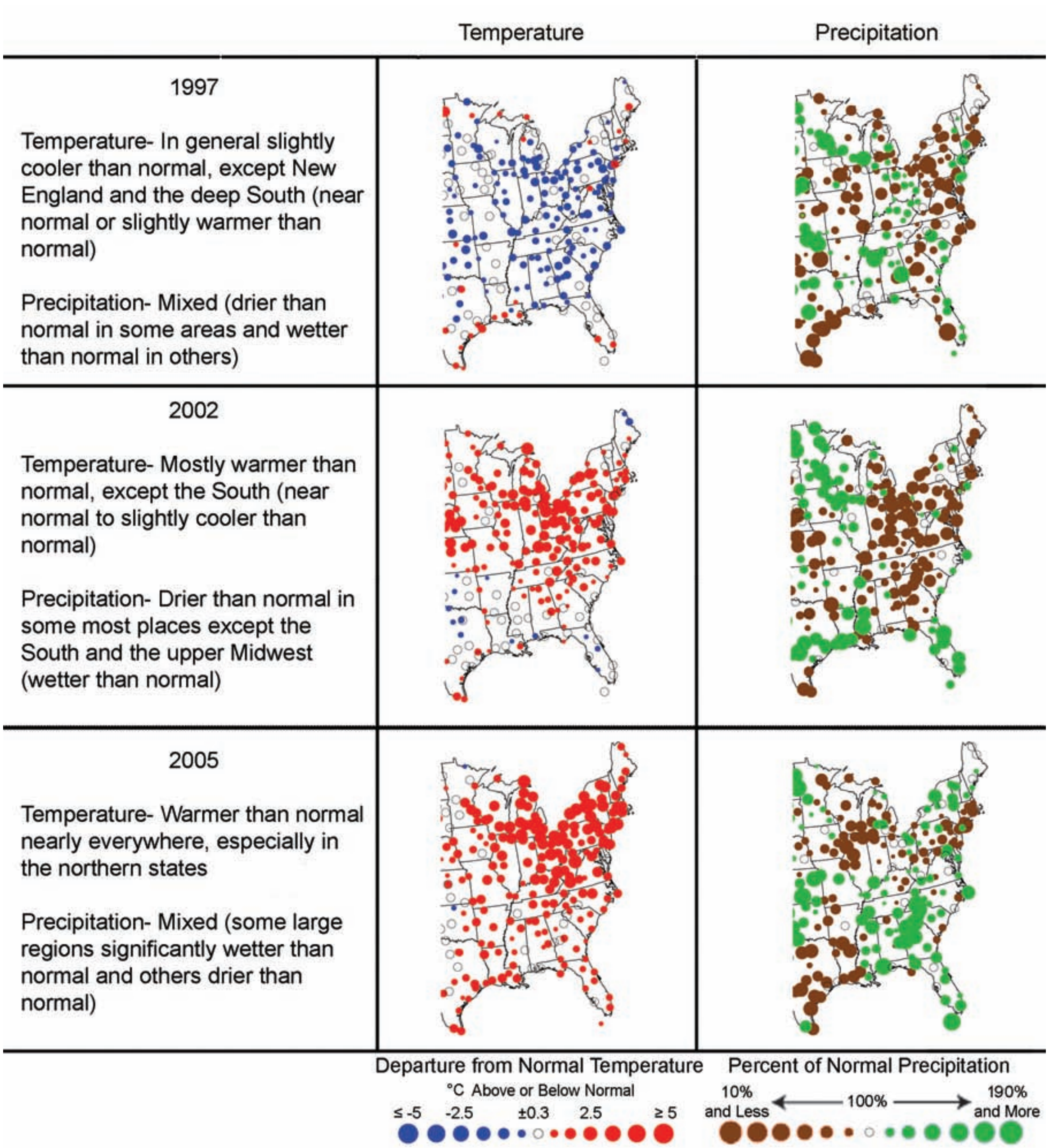
Variations in weather conditions play an important role in determining ozone levels. EPA uses a statistical model to account for the weather-related variability of seasonal ozone concentrations to provide a more accurate assessment.[4]

[3] National Park Service Air Resources Division. "Annual Data Summary, 2004 Gaseous Pollutant Monitoring, Program Ozone, Sulfur Dioxide, Meteorological Observations." U.S. Department of the Interior. <www2.nature.nps.gov/air/pubs/pdf/ads/2004/GPMP-XX.pdf>.

[4] Cox, William M. and Shao-Hang Chu. (1996). "Assessment of Interannual Ozone Variation in Urban Areas from a Climatological Perspective." *Atmospheric Environment*, 30.14, 2615-2625.

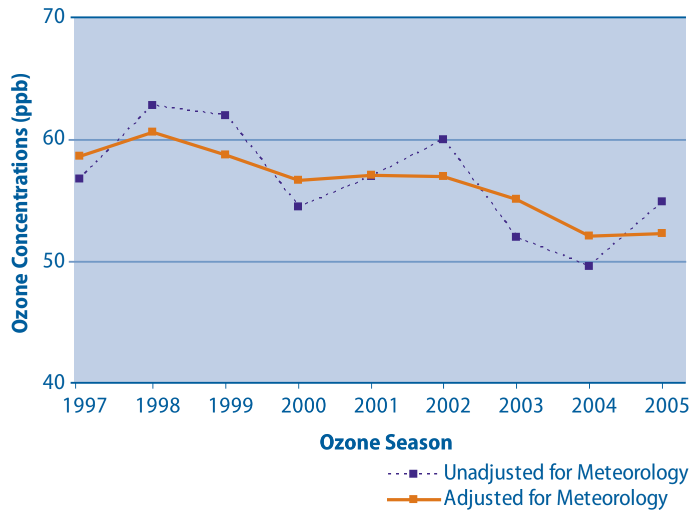
Meteorology Matters

The graphics below show how the summers of 1997, 2002, and 2005 deviate from normal summer conditions for temperature and precipitation (a surrogate for humidity). Normal conditions are determined by averaging 30 years of temperature and precipitation data (1971 to 2000) at each site for June through August. The information presented below is useful in evaluating the ozone forming potential for a particular ozone season.



Source: National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center <http://www.ncdc.noaa.gov/oa/climate/research/2002/CMB_prod_us_2002.html>

Figure 12: Seasonal Average 8-Hour Ozone Concentrations in the NO_x Budget Trading Program Region before and after Adjusting for Weather



Note: Data presented in this figure are unweighted averages of 8-hour daily maximum ozone concentrations during the ozone season for sites within the NBP region, shaded in green in Figure 10.

Source: EPA

This report uses an assessment approach that accounts for the impacts of weather by normalizing weather variations to provide a better estimate of the underlying ozone trend and the impact of NO_x emission reductions. The resulting estimates represent ozone levels anticipated under typical weather conditions. This methodology and the ozone estimates were provided by EPA's Office of Air Quality Planning and Standards (OAQPS), Air Quality Assessment Division, www.epa.gov/airtrends.

Figure 12 shows trends in the seasonal average 8-hour ozone concentrations before and after adjusting for meteorology. The blue dotted line shows the trend in unadjusted, observed values at monitoring sites. The orange solid line illustrates the underlying ozone after removing effects of weather to provide a more accurate ozone trend for assessing changes in emissions. When comparing two years with significantly different weather conditions and ozone forming potential (e.g., 1997 vs. 2002), it is important to account for the variation caused by meteorology. For example, in general, lower temperatures depressed ozone formation in 1997 while higher temperatures increased ozone formation in 2002. Removing the effects of weather using this type of meteorological adjustment approach results in a higher than observed ozone estimate for 1997 and a lower than observed ozone estimate for 2002.

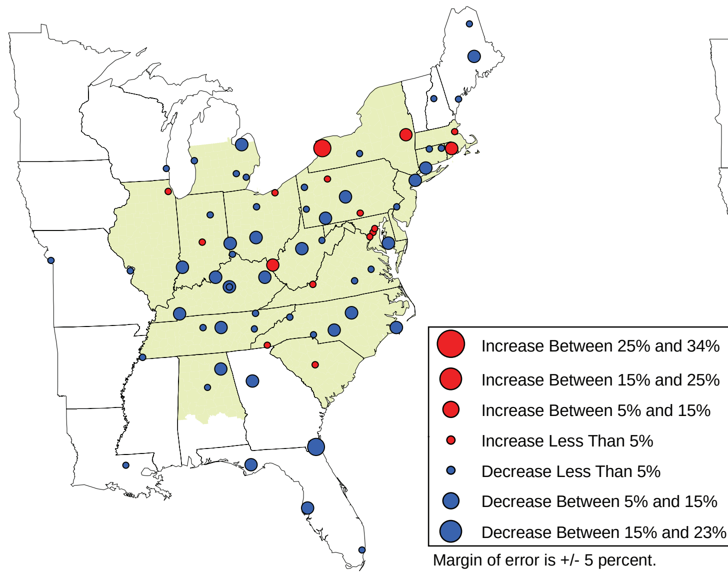
Ozone Changes: Focus on the NO_x Budget Trading Program

The 2004 NBP report, Evaluating Ozone Control Programs in the Eastern United States: Focus on the NO_x Budget Trading Program, concluded that the average reduction in ozone in the eastern United States between 1997 and 2002 was about 4 percent (adjusted for meteorology), compared with more than 10 percent between 2002 and 2004.[5]

Figures 13 and 14 illustrate changes in ozone concentrations between 1997 and 2002 and 2002 and 2005, after adjusting for meteorology. The average reduction in ozone in the NBP region between

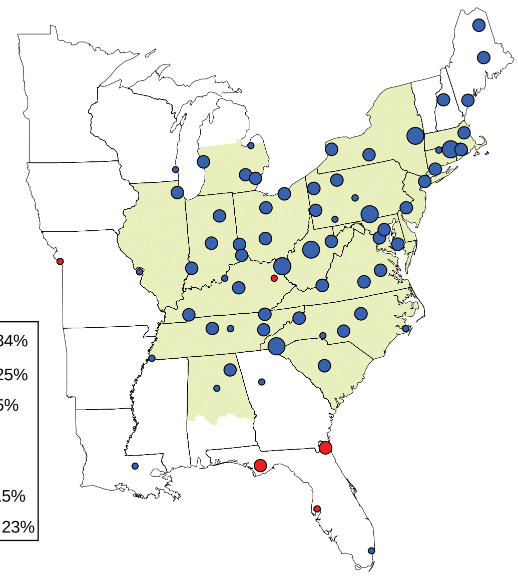
[5] "Evaluating Ozone Control Programs in the Eastern United States: Focus on the NO_x Budget Trading Program, 2004," <www.epa.gov/airmarkets/fednox>.

Figure 13: Percent Change in Seasonal 8-Hour Ozone, 1997 vs. 2002 (Adjusted for Meteorology)



Note: Shaded region shows areas affected under the NBP as of 2005.
Source: EPA

Figure 14: Percent Change in Seasonal 8-Hour Ozone, 2002 vs. 2005 (Adjusted for Meteorology)



Note: Shaded region shows areas affected under the NBP as of 2005.
Source: EPA

2002 and 2005 was about 8 percent. While, on average, there was no improvement in ozone in the NBP region between 2004 and 2005 (about 0.5 percent increase as shown in Figure 12), these results show that the majority of the ozone progress made between 2002 and 2004 was retained. In general, weather conditions in 2005 were similar to weather conditions in 2002 (i.e., both years had higher than average ozone forming potential). Before adjusting for meteorology, the average reduction in ozone between 2002 and 2005 was also about 8 percent.

Figure 15 shows the relationship between reductions in power industry NO_x emissions and reductions in ozone after implementation of the NBP. Between 2002 and 2005, there were decreases in ozone across all NBP states, with the largest reductions occurring in Connecticut, New York, North Carolina, Pennsylvania, and West Virginia. There were some increases in the southern United States, specifically in Florida (which is not in the NBP). Generally, there is a strong association between areas with the greatest NO_x emission reductions and downwind sites exhibiting the greatest improvement in ozone. This suggests that levels of transported NO_x emissions have been reduced in the eastern United States. While this report does not attribute all ozone reductions after 2002 to the NBP, it does show that the NBP has played a key role in reducing ozone concentrations.

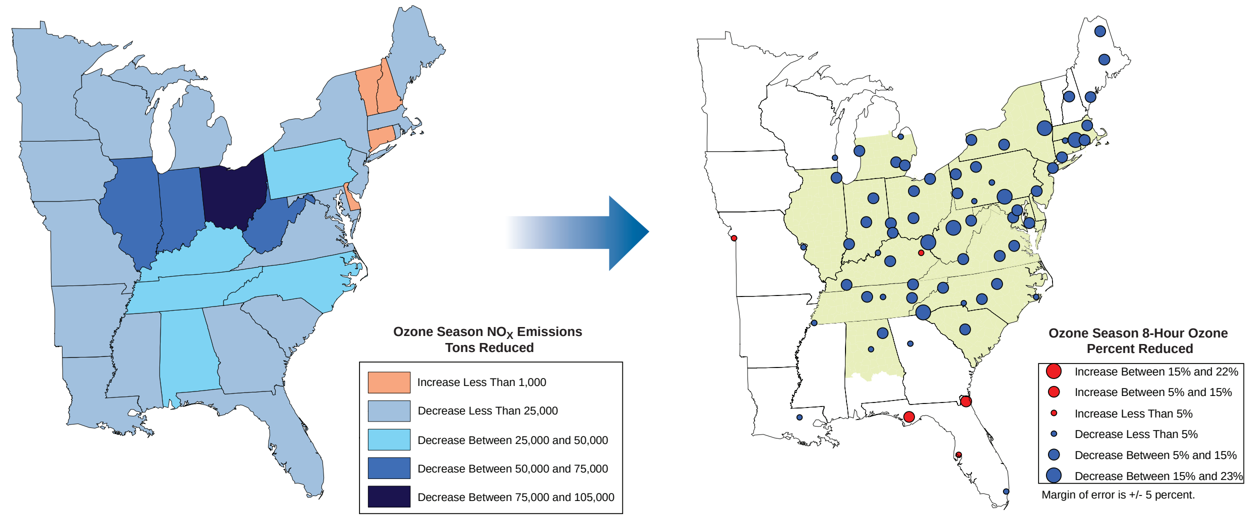
Other recent studies support the key findings of this report. Gégo et al. examined the effectiveness of the NO_x SIP Call by quantifying changes in daily maximum 8-hour ozone concentrations at monitoring sites in the eastern United States before (1997 to 1998) and after (2003 to 2004) implementation of the program.[6] The researchers primarily used CASTNET data for this analysis because these measurements are taken in rural areas where ozone production depends strongly on NO_x con-

[6] Gégo, Edith P, et. al. "Observation-based assessment of the impact of nitrogen oxides emissions reductions on ozone air quality over the eastern United States." *Journal of Applied Meteorology and Climatology*, special issue on the NOAA-EPA Golden Jubilee Symposium (submitted).

Figure 15: Reductions in Ozone Season Power Industry NO_x Emissions and 8-Hour Ozone, 2002 vs. 2005

Power Industry NO_x Emission Reductions

8-Hour Ozone, Adjusted for Meteorology



Note: From 2002 to 2005, Delaware (943 tons), New Hampshire (216 tons), Connecticut (76 tons), and Vermont (44 tons) show small increases in ozone season NO_x emissions.

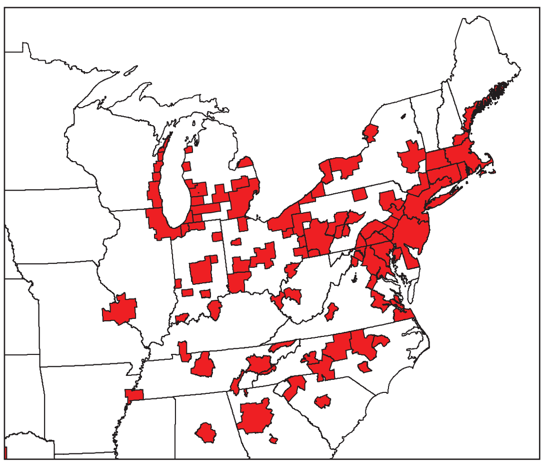
Source: EPA

centrations and is nearly independent of VOCs. After adjusting for meteorology, this study found that ozone concentrations are on average 13 percent less (ranging from 4 to 27 percent across all sites) than they were before the program. This study also used a back trajectory analysis and found that NO_x emission reductions in the Ohio River Valley resulted in substantial improvements in ozone air quality in downwind regions, especially east and northeast of the Ohio River Valley. This study concluded that the NO_x SIP Call has been effective in reducing interstate ozone transport and helping to improve ozone air quality in the eastern United States.

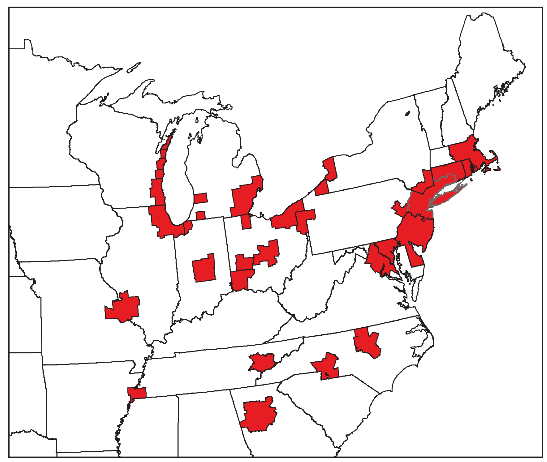
Improvements in 8-Hour Ozone Concentrations

In April 2004, based generally on 2001 to 2003 data, EPA designated 126 areas as nonattainment for the 8-hour ozone standard.[7] Of those areas, 103 are in this part of the eastern United States (see figures below) and are home to about 100 million people (US Census, 2000). Based on 2003 to 2005 data, 68 of the 103 areas (nearly 70 percent) either have ozone air quality that is better than the level of the 8-hour standard or meet the standard and have been redesignated to attainment. These improvements bring cleaner air to about 20 million people living in these 68 areas. Several of these areas have reviewed or are reviewing the requirements for redesignation as described in the Clean Air Act Section 107. Nearly 81 million people live in the remaining 31 areas in this part of the eastern United States. On average, ozone concentrations in these areas improved by 8 percent. Given that the only major relevant emission reduction that occurred after 2003 is the NBP, it is clear that the NBP is the major contributor to these improvements in ozone air quality.

8-Hour Ozone Nonattainment Areas, April 2004 (2001–2003 Air Quality Data)



Areas Remaining Above Standard (2003–2005 Air Quality Data)



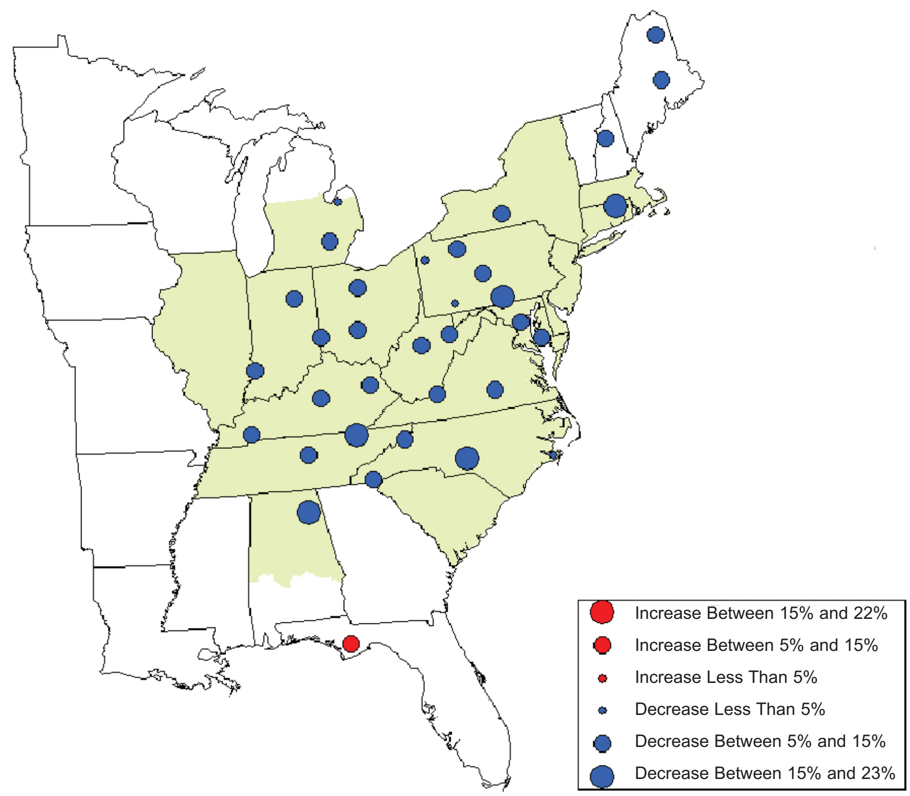
Note: Included on the maps, but excluded from the analysis, are four areas with incomplete data for 2003 to 2005 (Cass Co, MI; Dayton-Springfield, OH; Essex Co (Whiteface Mtn), NY; La Porte, IN).

[7] 40 CFR Part 81, Air Quality Designations and Classification for the 8-Hour Ozone National Ambient Air Quality Standards (NAAQS).

Space-Time Modeling Approach to Adjusting for Meteorological Influences on Ozone

There are different approaches to account for the influences of meteorology on ozone formation. This analysis presents results from a space-time modeling approach developed by EPA's Office of Research and Development. The method can provide the uncertainties surrounding ozone trend estimates and can be expanded to predict ozone at any location (e.g., even between ozone monitoring sites) and for any time period. The graphic below shows the percent change in seasonal average ozone concentrations at rural CASTNET sites using the space-time modeling approach. The results from this analysis corroborate the findings presented throughout the report; on average ozone concentrations have decreased across the eastern United States since 2002 (see figure below). By exploring and developing new methodologies for assessing ozone, EPA hopes to continue advancing assessment capabilities into the future.

Percent Change in Seasonal 8-Hour Ozone, 2002-2004



Source: EPA

Ozone Impacts on Forest Health

As with human health, EPA is concerned about the impacts of air pollution on ecological systems. Ground-level ozone-induced effects on trees and forests include reduced growth and/or reproduction and increased susceptibility to disease, pests, and other environmental stresses (e.g., harsh weather). Ground-level ozone can also cause visible injury to leaves and foliage.

The United States Forest Service Forest Health Monitoring Program (FHM) uses visible foliar injury as an indicator that ground-level ozone is impacting trees and forests. The Ozone Biosite Index (see Table 3) was developed based on the proportion of damaged leaves and the severity of symptoms to the number of non-injured leaves within a defined forested area.[8] The Forest Service uses the Ozone Biosite Index to survey forested areas in the United States. The most recent data are presented as an average value from 1999 to 2002 (see Figure 16). This analysis shows that foliar injury occurred more extensively in the eastern United States than the western United States in this time period, especially in the Mid-Atlantic and the Southeast. These data show visible foliar injury before the NO_x emission reductions under the NBP took effect. Recent improvements in ozone due to emission control programs have occurred in many areas where forest ecosystems had experienced the most visible foliar injury from ozone exposure. While it will take time for forest ecosystems to respond to ozone improvements, as data become available (i.e., 2002 to 2005 data), EPA will continue to examine the impacts of ozone on forest indicators.

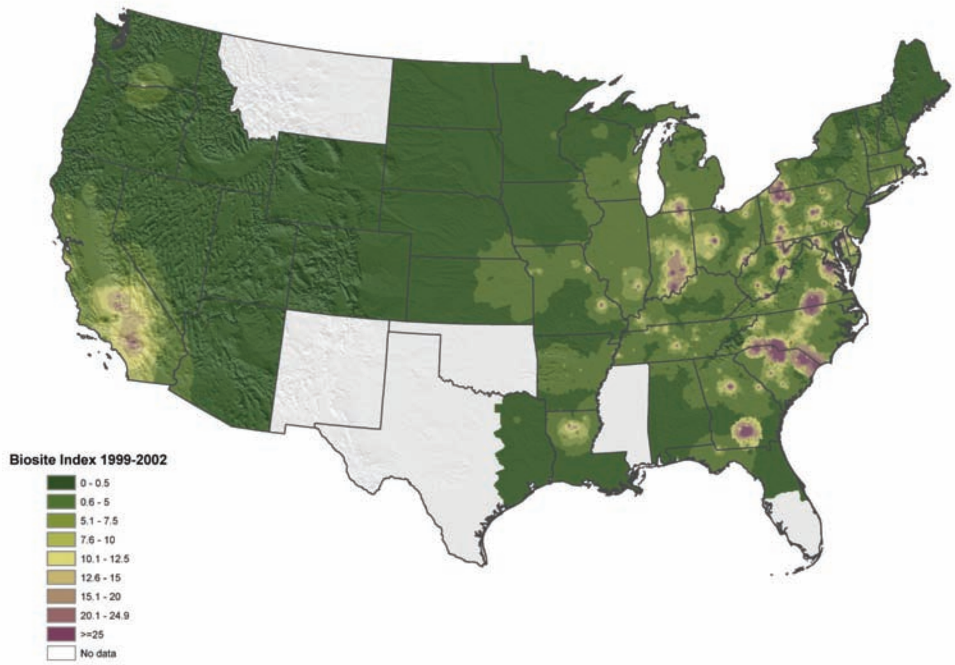
Table 3: Ozone Biosite Index Categories, Risk Assumption, and Possible Impact

Biosite Index	Bioindicator Response	Assumption of Risk to Forest Resource	Possible Impact
0 to < 5.0	Little or No Foliar Injury	None	Visible injury to isolated genotypes of sensitive species; e.g., common milkweed, black cherry.
5.0 to < 15.0	Light to Moderate Foliar Injury	Low	Visible injury to highly sensitive species, e.g., black cherry; effects noted primarily at the tree level.
15.0 to < 25.0	Moderate to Severe Foliar Injury	Moderate	Visible injury to moderately sensitive species, e.g., tulip poplar; effects noted primarily at the tree level.
≥ 25	Severe Foliar Injury	High	Visible injury leading to changes in structure and function of the ecosystem.

Source: Smith, G.C. FHM second ozone bioindicator workshop – summary of proceedings. Unpublished manuscript. 12 p. On file with: USDA Forest Service, Forest Health Monitoring Program, P.O. Box 12254, Research Triangle Park, NC 27709

[8] Ambrose, MJ.; Conkling, B.L., eds. In press. Forest Health Monitoring 2005 national technical report. Gen. Tech. Rep. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station.

Figure 16: Average Annual Biosite Index by Ecoregion Section, 1999–2002



Note: Table 3 provides a description of each category in the Ozone Biosite Index.

Source: Forest Health Monitoring 2005 National Technical Report[9]

[9] Ambrose, MJ.; Conkling, B.L., eds. In press. Forest Health Monitoring 2005 national technical report. Gen. Tech. Rep. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station.

Section 4 — Compliance and Market Activity

Sources achieved over 99 percent compliance with the NO_x Budget Trading Program (NBP) in 2005. This section examines compliance under the NBP in 2005 and reviews allowance trading and pricing trends in this maturing market. In addition, this section reviews the monitoring and control methods employed by sources to meet program requirements.

2005 Compliance Results

Under the NBP, sources must hold sufficient allowances to cover their ozone season nitrogen oxides (NO_x) 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 sources have a 2-month period following the end of the control period to buy or sell allowances and/or move allowances between accounts to ensure their emissions do not exceed allowances held. After the 2-month period, EPA reconciles emissions with allowance holdings to determine program compliance. Sources may not transfer allowances until annual reconciliation is complete.

There were 2,570 units affected under the NBP in 2005. Only three NBP sources (4 units total) did not hold sufficient allowances to cover their emissions. Table 4 summarizes the allowance reconciliation process for 2005.

Table 4: NO_x Allowance Reconciliation the Summary for the NO_x Budget Trading Program, 2005

Total Allowances Held for Reconciliation (2003 through 2005 Vintages)	729,326
Allowances Held in Compliance or Overdraft Accounts	700,782
Allowances Held in Other Accounts*	28,544
Allowances Deducted in 2005	534,005
Allowances Deducted for Actual Emissions	529,830
Additional Allowances Deducted under Progressive Flow Control (PFC)	4,168
Termination of 2004 Early Reduction Credits (or Compliance Supplement Pool) Allowances**	7
Banked Allowances (Carried into 2006 Ozone Season)	195,321
Allowances Held in Compliance or Overdraft Accounts	160,604
Allowances Held in Other Accounts***	34,717
Penalty Allowances Deducted**** (from Future Year Allocations)	12

* 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 2 years. CSP allowances not used for reconciliation in 2005 have been retired permanently.

*** Total includes 6,173 new unit allowances returned to state holding accounts.

**** These penalty deductions are made from future vintage year allowances, not 2005 allowances. An additional 264 penalty allowances are owed by one source and will be deducted in the future.

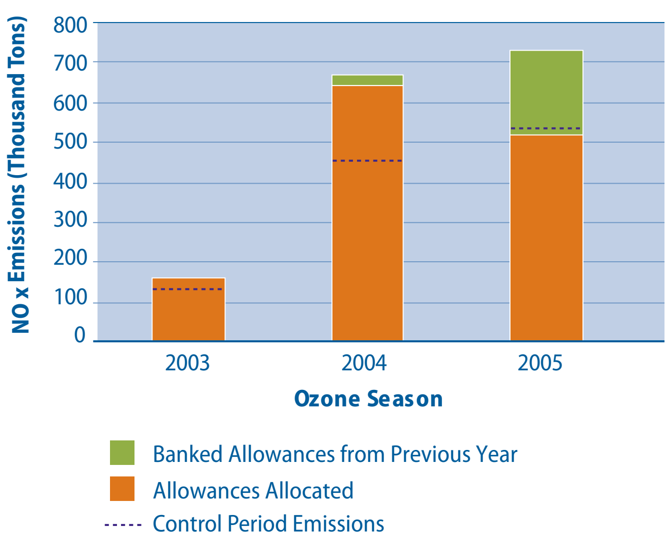
Banking in 2005 and Flow Control in 2006

Under cap and trade programs in general, and the NBP specifically, banking allows companies to decrease emissions below the amount of allowances they hold and then save the unused allowances for future use. Banking results in environmental and health benefits earlier than required and provides an available pool of allowances that could address unexpected events, or smooth the transition into deeper emission reductions.

Figure 17 shows the number of allowances allocated each year, the allowances banked from the previous year, and the total ozone season emissions for NBP sources from 2003 to 2005. Sources banked over 195,000 allowances in the 2005 ozone season (see Table 4), which will be available for use in 2006 for program compliance. This is about 6 percent lower than the nearly 208,000 allowances sources banked by the end of the 2004 ozone season, which were available for use in 2005 (as shown in Figure 17).

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 control ratio by dividing 10 percent of the total regional NO_x trading budget by the number of banked allowances (a larger bank will result in a smaller flow control ratio). The resulting flow control ratio establishes the percentage of banked allowances that can be deducted from a source's account on a ratio of one allowance per ton of emissions. The remaining banked allowances, if used, must be deducted at a rate of two allowances per one ton of emissions. In 2005, the flow control ratio was 0.25, and 4,168 additional allowances were deducted from the allowance bank under the flow control provisions. Flow control will be triggered again in 2006, at a slightly higher ratio of 0.27 (see "Flow Control Will Apply in 2006," page 29, for details).

Figure 17: NO_x Allowance Allocations and the Allowance Bank, 2003–2005



Notes:

- The 2003 emissions and allocations totals includes only the OTC states. The 2004 emissions total includes the OTC states emissions (from May 1 to September 30) plus the non-OTC states emissions (from May 31 to September 30).
- Allowances allocated include base budget, compliance supplement pool (CSP), and opt-in allowances. CSP allowances may not be used beyond the 2005 ozone season. For more information on allowance allocations, visit www.epa.gov/airmarkets/fednox.

Source: EPA

Flow Control Will Apply in 2006 — How Will It Affect Sources?

2006 Regional Budget:	520,957 Allowances
Banked Allowances after 2005:	195,321 Allowances
Flow Control Trigger:	195,321/520,957 = .375 (> than 10 percent), Triggering Flow Control for 2006

- The 2006 flow control ratio = 0.27 (determined by dividing 10 percent of the total regional trading budget by the total number of banked allowances, or 52,096/195,321).
- The flow control ratio applies 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 2006, it can use 270 of those allowances on a 1-for-1 basis and the remaining 730 allowances on a 2-for-1 basis.
  - If the source used all 1,000 banked allowances for 2006 compliance, the banked allowances could cover only 635 tons of NO_x emissions (i.e., 270 + 730/2).

NO_x Allowance Trading in 2005

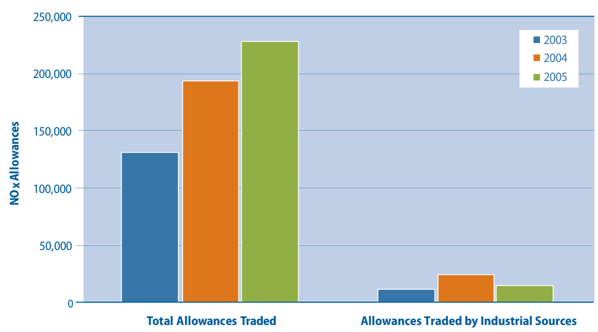
There are three main types of allowance transactions:

- Transfers within a company or between related entities (e.g., holding company transfers to a small operating subsidiary), including transfers between a unit compliance account and any account held by a company with an ownership interest in the unit.
- Transfers between separate economic entities. This may include companies with contractual relationships such as power purchase agreements, but excludes parent-subsidiary types of relationships. These transfers are categorized broadly as "economically significant trades."
- Transfers from or to a state as allowance allocations or allowance surrenders.

In 2005, economically significant trades represented about 30 percent of the total transfers between entities other than a state. There were approximately 228,000 allowances involved in economically significant trades in 2005, an increase of about 34,000 allowances from 2004 (see Figure 18). The economically significant trades provide a strong indicator of true market activity, because they represent an actual exchange of assets between unaffiliated participants.

Industrial sources accounted for over 6 percent of the economically significant trade volume in 2005, which was down from 2004 levels. This level of activity is proportional to the industrial units' regional emissions contribution of slightly less than 7 percent. The high level of 2004 trading activity for industrial sources was the result of a significant number of allowances purchased by this group of sources. In 2005, that trend was reversed as the industrial sources transferred far more allowances to others than they received. In most trades, industrial sources are trading with electric generating companies, with only a few trades involving industrial sources on both sides of the transaction.

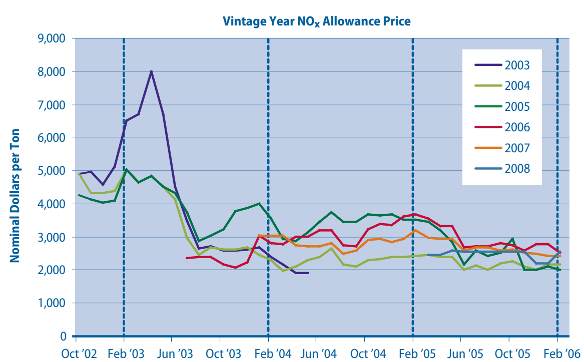
Figure 18: Estimated Volumes of Economically Significant Trades under the NO_x Budget Trading Program, 2003–2005



Note: As part of compiling this information for the 2005 report, EPA has reexamined all allowance transfer data from 2003 and 2004, and has revised the numbers for 2003 and 2004 presented in previous reports. Generally, EPA's estimate of economically significant trade volume in those years has decreased based on further analysis of outside data sources (such as company Web sites and Securities and Exchange Commission filings) to identify corporate relationships and ownership interests in units. The 2003 data also have been adjusted to correct a computational error. Because trades are not reported by market participants with respect to whether they are economically significant, EPA presents these data as a general estimate only.

Source: EPA

Figure 19: Vintage Year NO_x Allowance Prices by Month of Sale for the NO_x Budget Trading Program



Source: Evolution Markets, LLC and Cantor Environmental Brokerage

NO_x allowance prices in 2005 were slightly lower and somewhat less volatile than during 2004 (see Figure 19). Potential reasons for the price decline may include sources' need to use remaining compliance supplement pool (CSP) allowances before their 2005 expiration and increased confidence from understanding the impacts of the Clean Air Interstate Rule (CAIR) finalized in March 2005. In addition, the general price differential between vintage years 2004 and 2005 versus 2006 through 2008 reflects the discount applied to banked allowances as a result of flow control.

NO_x allowance prices 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. Additional influences on allowance pricing include progressive flow control and integration with other emission control programs, such as CAIR.

Continuous Emission Monitoring System (CEMS) Results

In order for NO_x allowances to be accurately tracked and traded, NBP sources must use consistent emissions 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). Sources are required to conduct stringent quality assurance tests of their monitoring systems, such as daily calibrations, quarterly linearity checks, and semi-annual or annual relative accuracy test audits (RATAs). These tests not only verify that the monitoring systems are measuring accurately, but also compare measured data to a standard reference method. Analysis of the quality-assured CEMS data reported by NBP sources in 2005 convincingly demonstrates the accuracy of the emission data.

In 2005, both the electric generating units and industrial units passed at least 98 percent of the quality assurance tests required of their monitoring systems. Industrial sources, many of which have only been monitoring under EPA's detailed monitoring procedures (40 CFR Part 75) since 2003, were able to perform at nearly the same level as electric generating units, many of which have been monitoring under Part 75 for more than a decade.

The NBP sources reported quality-assured emission data for more than 99 percent of their operating hours in 2005. 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 2005 and therefore had little impact on the NO_x emissions reported by NBP sources.

Monitoring Options Available to Sources

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 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 emissions. Oil- and gas-fired units may alternatively use a NO_x CEMS in conjunction with a fuel flowmeter to determine NO_x 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 CEMS for estimating NO_x emissions.

Compliance Options Used by NO_x Budget Trading Program Sources in 2005

Sources may select from a variety of compliance options to meet the emission reduction targets of the NBP in ways that best fit their own circumstances, such as:

- Decreasing or stopping generation from units with high NO_x emission rates, or shifting to lower emitting units, during the ozone season.
- Using NO_x combustion controls that modify or optimize the basic combustion process to control the formation of NO_x.
- Using add-on emission controls, such as selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR).
- Purchasing additional allowances from other market participants whose emissions were lower than their allocations.

Before implementation of the NBP, a large number of electric generating units and some industrial units added combustion controls to meet applicable NO_x emission limits of either the Acid Rain Program (ARP) or state regulations. For boilers, furnaces, and heaters, NO_x combustion controls include low NO_x burner and overfire air technologies, which modify the combustion process to reduce formation of NO_x from nitrogen found in the combustion air and fuel.

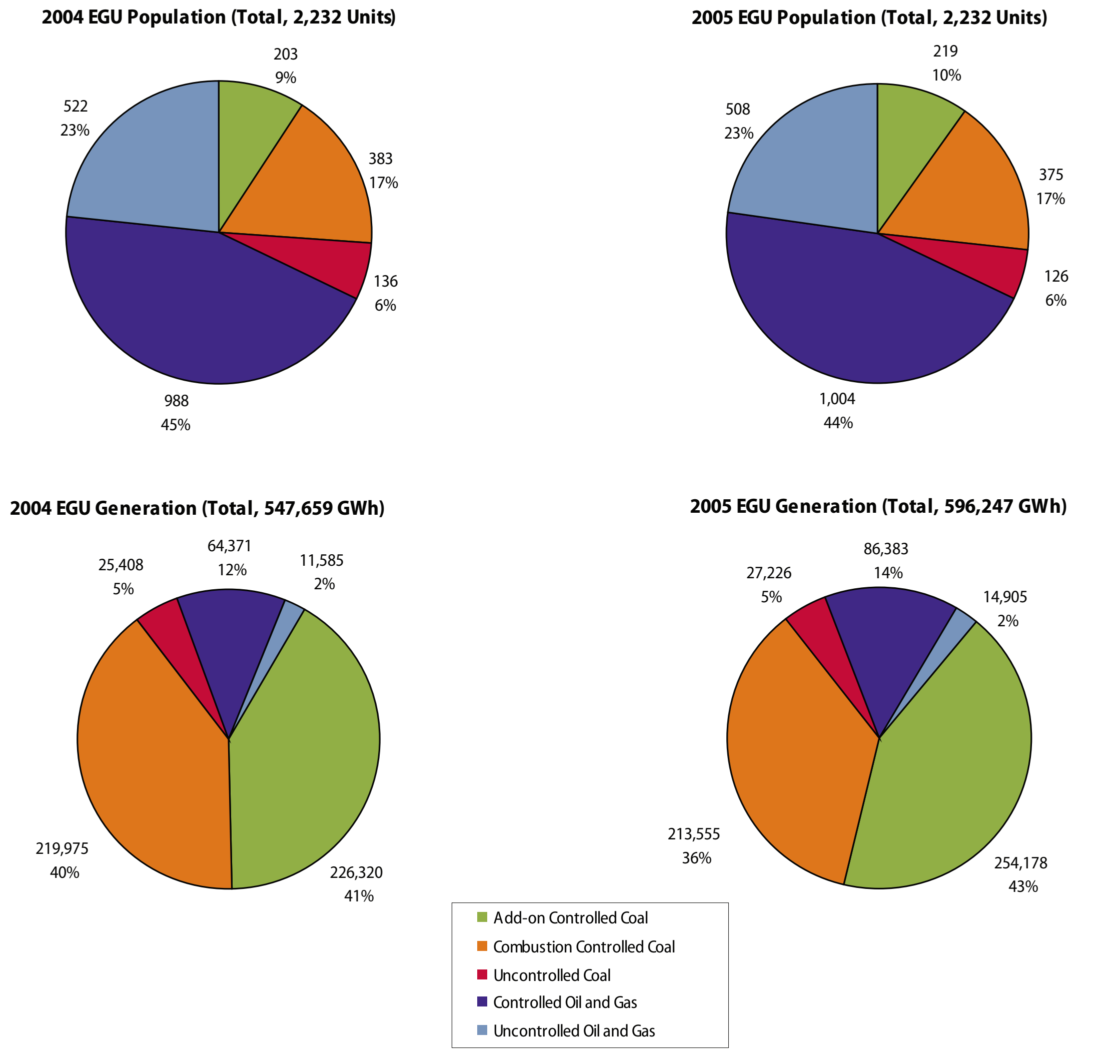
Add-on control technologies, such as SCR or SNCR, have also been frequently installed for NO_x control. The majority of units that install add-on controls use them in conjunction with their existing combustion controls to achieve greater emission reductions. SCR and SNCR are control technologies that achieve NO_x reductions by injecting ammonia, urea, or another NO_x-reducing chemical into the flue gas downstream of the combustion unit to react with NO_x, forming elemental nitrogen (N_2) and water. SCR, which adds a catalyst to allow the reaction to occur in a lower temperature range, can be applied to a wider range of sources than SNCR and is capable of greater NO_x removal rates.

NO_x Controls Used in 2005

Sources subject to the NBP are required to report pollution control equipment information, including installation dates, in monitoring plans submitted to EPA. For this report, EPA verified the source-reported EPA emission control equipment data with state agencies, with an emphasis on coal-fired units, to confirm the findings.[10]

[10] Two affected states are still gathering data; all others have provided updated control status information.

Figure 20: Number of Affected Electric Generating Units (EGUs) and Percent of Total Ozone Season Electric Generation by Fuel and Control Type for 2004 and 2005



Note: Add-on controls for coal units include SCR and SNCR. Combustion controls include various low NO_x burner control technologies, over-fire air, water injection, and others.

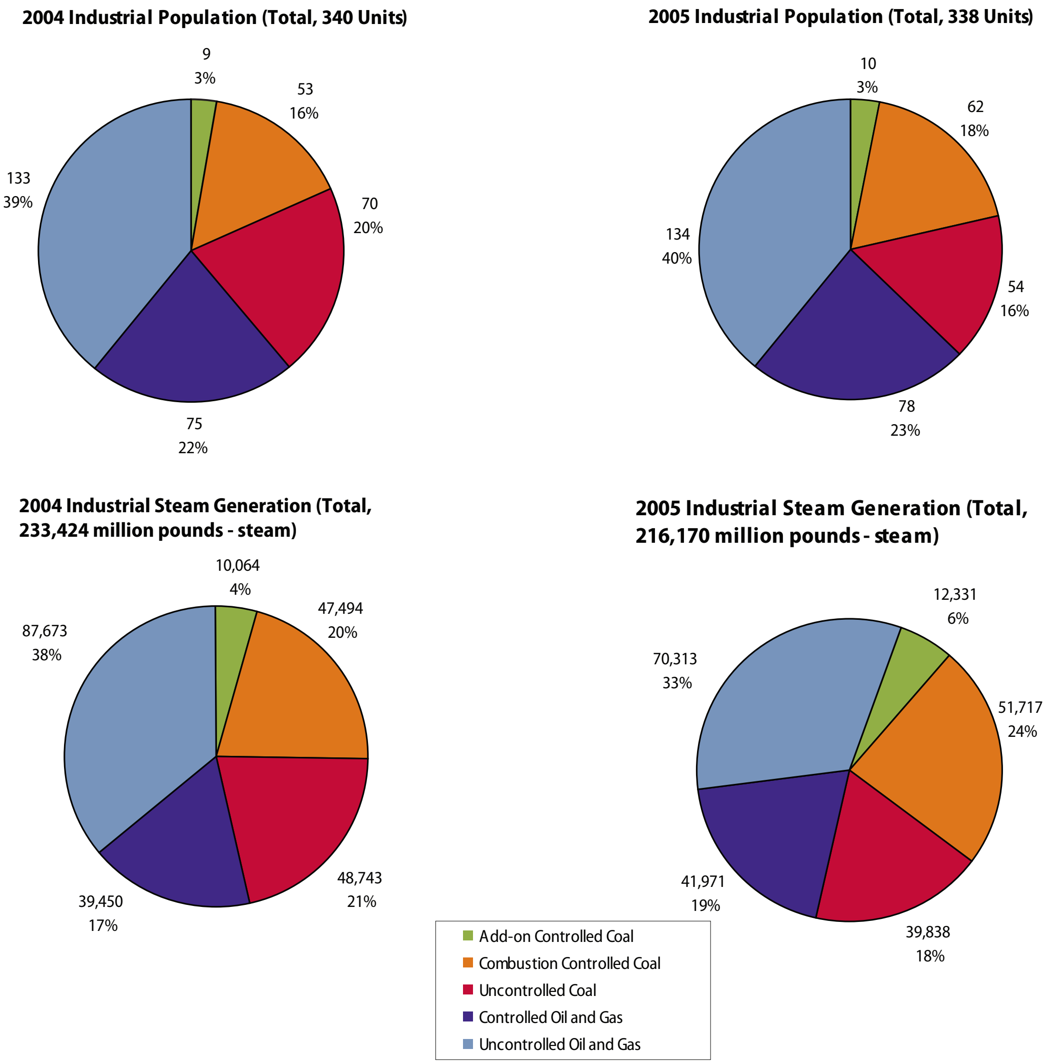
Source: EPA

EPA used the input from the state agencies to update data where needed. EPA continues efforts to verify that control equipment data are accurate and complete.

Figure 20 shows the breakdown of how electric generating units have employed emission controls as of the 2005 ozone season compared to the 2004 ozone season. The charts include the results broken down both by number of units and by the percent of total ozone season generation.

In the 2005 ozone season, there were 2,232 electric generating units affected under the NBP. The results show that although the number of coal-fired units with NO_x emission controls (i.e., add-on controls and/or combustion controls) represents less than 30 percent of the total number of electric generating units, this sector represented almost 80 percent of total generation. Uncontrolled units, either coal or gas and oil, represent about one-third of all units, but less than

Figure 21: Number of Affected Industrial Units and Percent of Total Ozone Season Steam Output by Fuel and Control Type for 2004 and 2005



Source: EPA

10 percent of the total generation.

Figure 21 shows similar information for industrial units based on steam output rather than electric generation. In the 2005 ozone season, there were 338 industrial coal-fired units affected under the NBP. Based on reported monitoring plan data, it appears that only about 3 percent of the industrial coal-fired units use add-on NO_x controls; there were no cases where a coal-fired industrial unit reported using SCR. Except for turbines that can use a relatively simple form of SCR, the technology is typically limited to larger coal-fired electric generating units that can achieve significant emission reductions in a cost-effective way.

Overall, the number of electric generating units and industrial units with NO_x controls increased from the 2004 to the 2005 ozone season. For example, the number of controlled coal-fired units (which includes units that added combustion and/or add-on controls) increased by 18 from 2004 to 2005. The majority of coal-fired units with new add-on controls in 2005 had pre-existing combustion controls.

Focus on Acid Rain Program Units in the NBP

EPA conducted a study that examined the NO_x rate performance of 465 units in the NBP region. These units were selected for this study because they were also required under 40 CFR Part 76 of the Acid Rain Program to meet NO_x emission rate limits. The specific group of units for this study consisted of dry bottom wall fired and tangentially fired boilers which had NO_x combustion controls in both the 2000 and 2005 ozone seasons but did not have add-on controls at the start of 2000. This study first quantified the average ozone season NO_x rate reductions among this group of units between 2000 (when the Phase II limits took effect) and 2005. Next, EPA examined how these units achieved those reductions. For this study, EPA used reported control equipment data, and then contacted a subgroup of about 60 units to obtain more specific information on the methods used to lower NO_x rates. The results are summarized below.

Reductions in Average NO_x Rates Between 2000 and 2005

Between 2000 and 2005, the average ozone season NO_x emission rate for all 465 units decreased by more than 50 percent, while the units' heat input remained comparable. The average ozone season NO_x rate for wall-fired boilers dropped by 55 percent, while tangentially fired boilers achieved reductions of 47 percent. In 2005, both wall-fired and tangentially fired boiler types operated at emission rates below the limits set in Part 76. The graph and table summarize the NO_x rate reductions by boiler type.

Source: EPA

Unit Type	ARP Phase II NO_x Rate limits (lb/mmBtu)	2000 Average Ozone Season NO_x Rate (lb/mmBtu)	2005 Average Ozone Season NO_x Rate (lb/mmBtu)	Percent Reduction from 2000 to 2005
All Units (465)	NA	0.403	0.194	52%
Dry Bottom Wall-Fired Boilers (221)	0.46	0.432	0.193	55%
Tangentially Fired Boilers (244)	0.40	0.373	0.196	47%

How Sources Achieved These Reductions

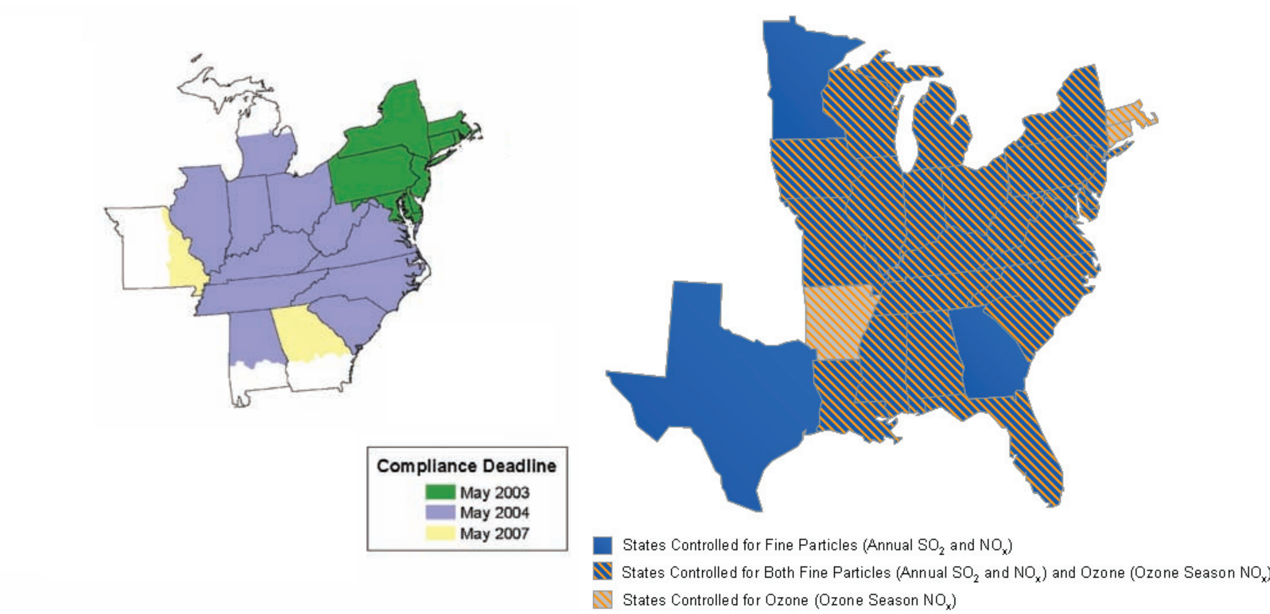
Based on the reported control equipment data and the additional contact with a subset of sources, EPA found that out of 465 units:

- 154 units installed add-on controls (SCR or SNCR). Between the 2000 and 2005 ozone seasons, the average NO_x rate for this group of units declined by 70 percent (from 0.416 to 0.123 lb/mmBtu) from their levels prior to installing add-on controls. This is equal to a decrease of over 267,000 tons of NO_x emissions.
- 311 units operated with existing, modified, and/or additional advanced NO_x combustion controls. Between the 2000 and 2005 ozone seasons, the average NO_x rate for this group of units declined by 26 percent (from 0.388 to 0.288 lb/mmBtu). This is equal to a decrease of over 82,000 tons of NO_x emissions. From the telephone contact, EPA found that several approaches were used by these sources including: installing advanced low NO_x burner technology; adding overfire air or coal reburn; and optimizing existing low NO_x burners and modifying boiler characteristics, such as air-to-fuel ratio. In addition, sources noted the co-benefits from blending or switching to sub-bituminous coals.

Section 5 — Future NO_x Reductions and Ozone Improvements: Transition to the Clean Air Interstate Rule

Building upon the nitrogen oxides (NO_x) emission reductions of the NO_x Budget Trading Program (NBP) and the Acid Rain Program, the Clean Air Interstate Rule (CAIR), issued March 10, 2005, will permanently lower power industry emissions of sulfur dioxide (SO_2) and NO_x in the eastern United States, achieving significant reductions of these pollutants. In addition to addressing ozone attainment, CAIR assists states in attaining the PM 2.5 National Ambient Air Quality Standards (NAAQS) by reducing transported precursors, SO_2 and NO_x. CAIR accomplishes this by creating three separate programs: an ozone season NO_x program and annual NO_x and SO_2 programs. Each of the three programs uses a two-phased approach, with declining emission caps in each phase based on highly cost-effective controls on power plants. The first phase will begin in 2009 for the NO_x ozone season and annual programs and 2010 for the SO_2 annual program. The second phase for all three programs will begin in 2015. Similar to the NO_x SIP Call, CAIR gives states the flexibility to reduce emissions using a strategy that best suits their circumstances and provides an EPA-administered, regional cap and trade program as one option. States are now choosing the strategy that best enables them to achieve these mandated reductions and plans are due to be submitted to EPA for approval by the fall of 2006.

Figure 22: Transition from the NO_x Budget Trading Program to the Clean Air Interstate Rule



Note: The affected portions of Missouri and Georgia are required to comply with the NO_x SIP Call as of May 1, 2007. However, EPA has stayed 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.

Source: EPA

How CAIR Affects NO_x Budget Trading Program States

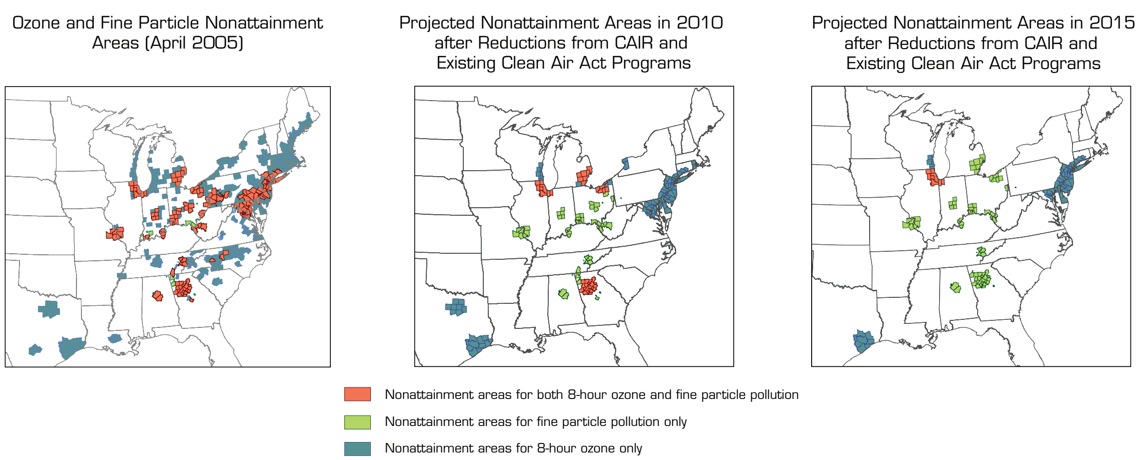
In 2009, NBP states affected under CAIR will transition to the CAIR annual and/or ozone season programs. All NBP states, with the exception of Rhode Island, are included in the CAIR NO_x ozone season program (see Figure 22). States can meet their NBP obligations using the CAIR NO_x ozone season program and, as a result, CAIR allows states to include all of their NBP sources in the CAIR NO_x ozone season program. EPA also will allow Rhode Island to opt into the CAIR NO_x ozone season program so that it can continue to participate in an interstate trading program. The 2009 CAIR NO_x ozone season emission caps for electric generating units are at least as stringent as the NBP, and in some states are tighter. If a state includes industrial units, the trading budget for those units remains the same as the NBP. CAIR also allows sources to bank and use pre-2009 NBP allowances for the CAIR NO_x ozone season program compliance on a 1:1 basis, thereby giving sources the incentive to begin reducing their emissions now. Progressive flow control will be eliminated as of 2009 with the start of the CAIR program.

CAIR Benefits

In 2004, EPA officially designated 103 areas in the eastern United States as 8-hour ozone "nonattainment areas". Based on 2003 to 2005 air monitoring data, nearly 70 percent of them (68 areas home to about 20 million people) now have air quality that is better than the level of the standard. In 2005, however, there were still 31 areas (home to about 80 million people) that are not meeting the 8-hour ozone standard. CAIR will help bring the remaining 31 areas in this part of the eastern United States into attainment with the ozone standard.

EPA projects that in 2015, CAIR, the NBP, and other programs in the CAIR region will reduce power industry ozone season NO_x emissions by about 40 percent and annual NO_x emissions by

Figure 23: Ozone and Particle Pollution in the Future



Note: Projections concerning future levels of air pollution in specific geographic locations were estimated using the best scientific models available. They are estimations, however, and should be characterized as such in any description. 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.

Source: EPA

about 55 percent from 2005 levels. EPA also projects that CAIR and existing federal and state programs will reduce the number of 8-hour ozone nonattainment areas in the East to six by 2015 (see Figure 23). The phase in of clean diesel engines and low sulfur fuel requirements will further reduce ozone and fine particle pollution throughout the United States. Additionally, states are working to identify and implement local controls to move these remaining six areas into attainment.

By 2015, the air quality improvements under CAIR are projected to result in:

- $85 to $100 billion in annual health benefits, annually preventing 17,000 premature deaths, millions of lost work and school days, and tens of thousands of non-fatal heart attacks and hospital admissions.
- Nearly $2 billion in annual visibility benefits in southeastern national parks, such as Great Smoky and Shenandoah.
- Significant regional reductions in sulfur and nitrogen deposition, reducing the number of acidic lakes and streams in the eastern United States.

For more information, visit <www.epa.gov/CAIR>.

Online Resources

General Information:

- Office of Air and Radiation: www.epa.gov/oar
  - Office of Atmospheric Programs: www.epa.gov/air/oap.html
  - Office of Air Quality Planning and Standards: www.epa.gov/oar/oaqps
- Mobile Sources: www.epa.gov/otaq
- Cap and Trade and Related Programs: www.epa.gov/airmarkt
- Air Trends: www.epa.gov/airtrends

NO_x Control Programs:

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

Ozone Information:

- General Information: http://www.epa.gov/air/urbanair/ozone
- USDA Forest Service, Forest Health Monitoring Program http://fhm.fs.fed.us/pubs

Emission Data and Monitoring Information:

- National Emissions Inventory (NEI): www.epa.gov/ttn/chief/net
- Clean Air Markets Data and Maps: http://cfpub.epa.gov/gdm

Ozone Monitoring Networks and Data:

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

Other Emission and Air Quality Resources:

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

EPA

United States
Environmental Protection Agency
Office of Air and Radiation
Office of Atmospheric Programs
Clean Air Markets Division (6204J)
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