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.

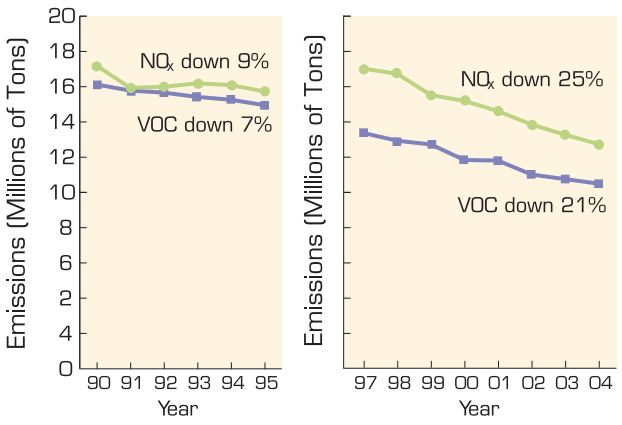
The second period reflects implementation of many control programs mandated by the 1990 Clean Air Act Amendments. The results of these programs are evident in emission trends from 1997 to 2004: NO_X emissions decreased by 25 percent and VOC emissions decreased by 21 percent.

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.

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

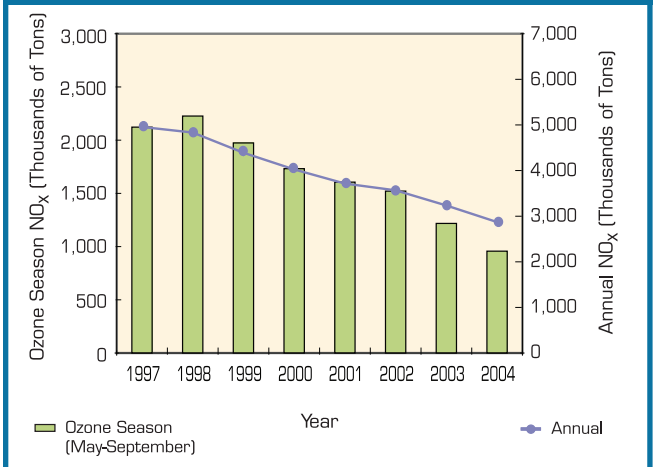


Source: EPA

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.**

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

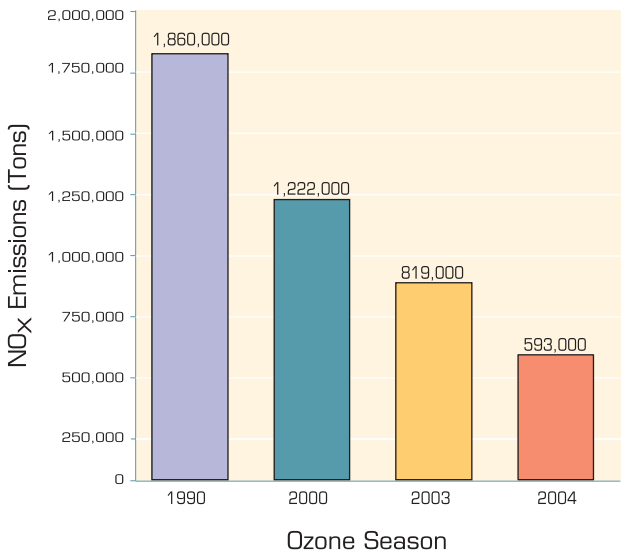
This section assesses progress under the NO_X Budget Trading Program (NBP) by comparing NO_X emission levels in 2004 (the second year of the NBP) to levels in 1990, 2000 (baseline years), and 2003. Therefore, these results include emissions from affected sources in states included in the NO_X SIP Call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

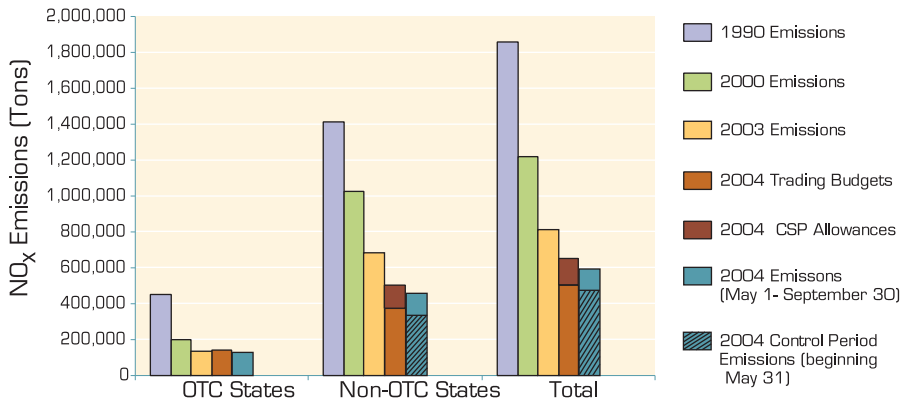
During the OTC NO_X Budget Program, emissions were less than allocated allowances in every year of the program (1999 to 2002). That trend has continued under the NBP in both 2003 and 2004. In 2004, ozone season NO_X emissions in the OTC states were approximately 132,000 tons, about 10 percent less than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

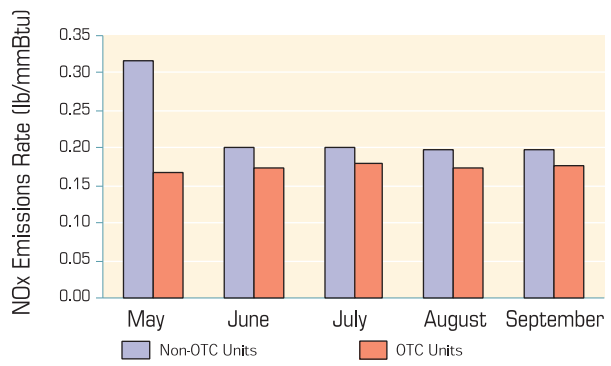


Source: EPA

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

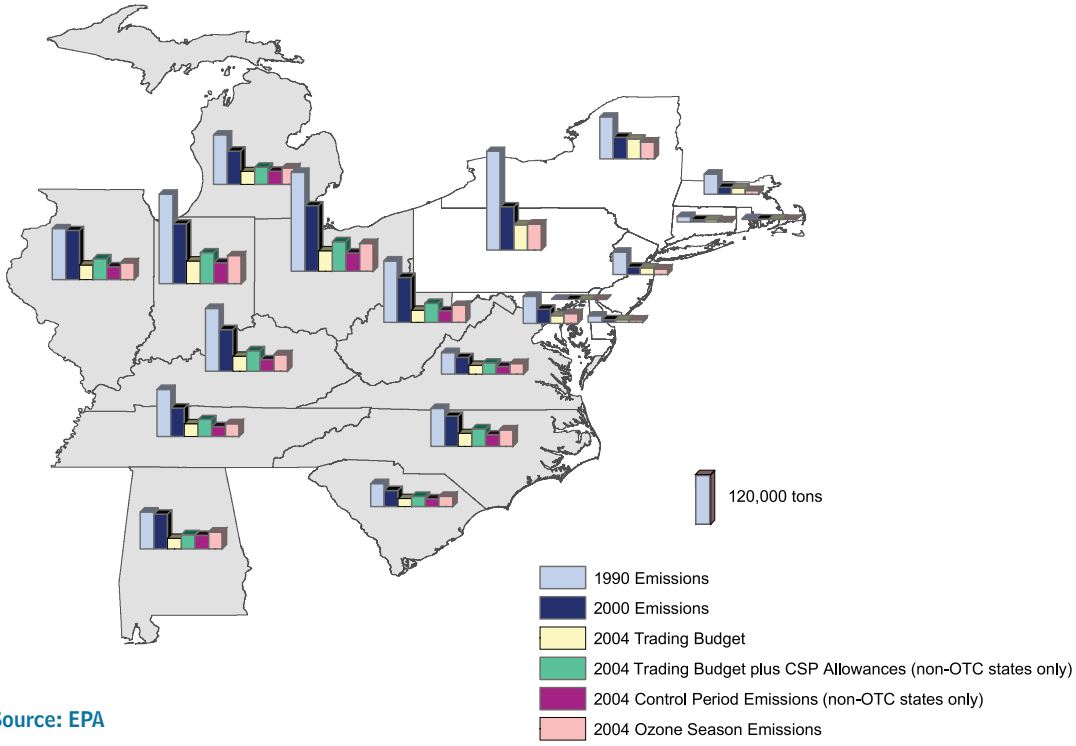
Two non-OTC states—Alabama and Michigan—had control period emissions that exceeded their trading budgets in 2004. However, all non-OTC states had 2004 control period emissions below their 2004 trading budgets when CSP allowances were included (see Figure 10).

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:

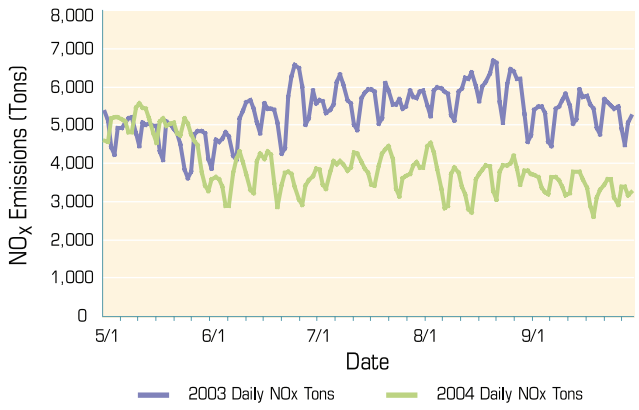
- **The Non-OTC states are shaded.**
- **In 2004, the control period for non-OTC States was from May 31 through September 30.**

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.

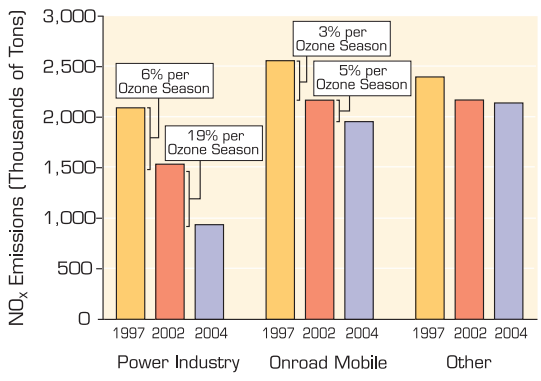
Similarly, VOC emissions dropped somewhat between 1997 and 2002, but there were few additional reductions after 2002 (Figure 13). VOC emissions from onroad mobile sources, for example, dropped an average of 5 percent per ozone season for both time periods.

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.

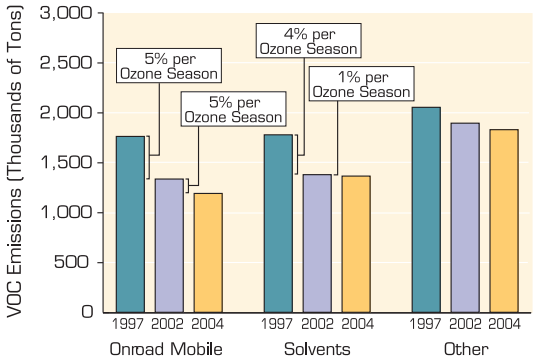
Figure 12: Ozone Season NO_X Emissions in the Eastern United States by Category, 1997, 2002, 2004



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



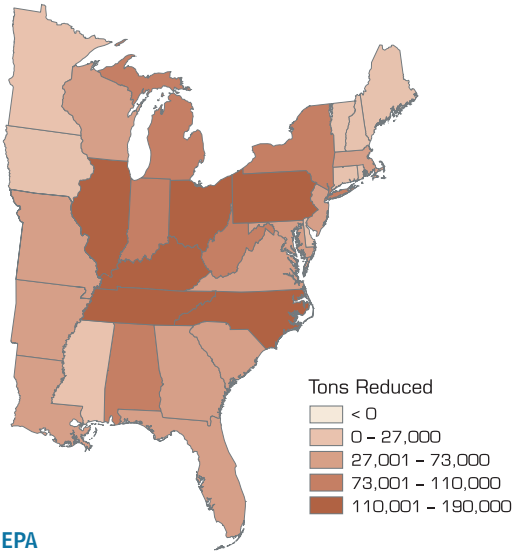
Source: EPA

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.

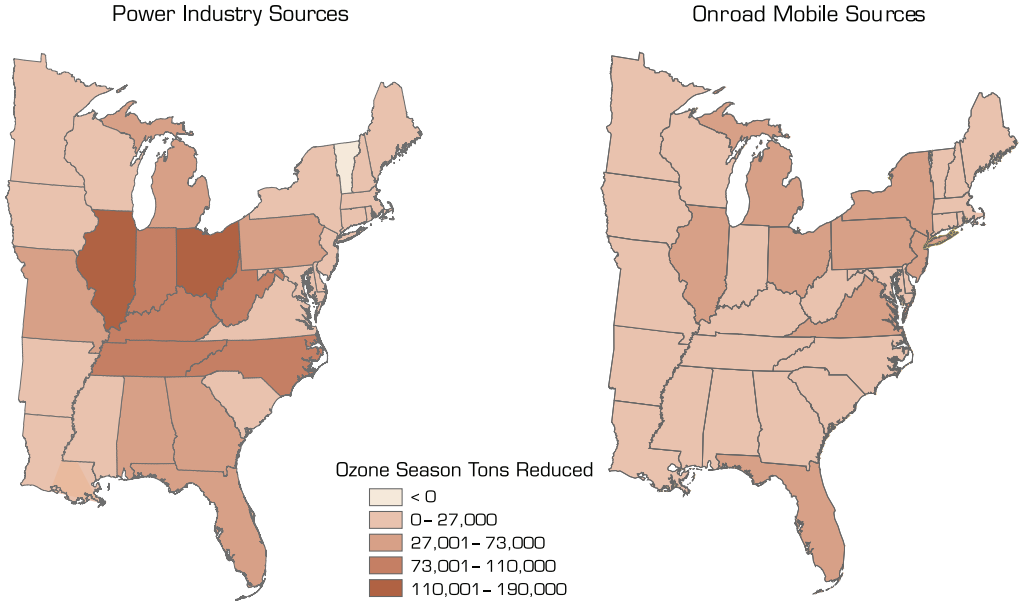
Figure 14: Ozone Season NO_X Emissions Reduced, 1997 vs. 2004



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



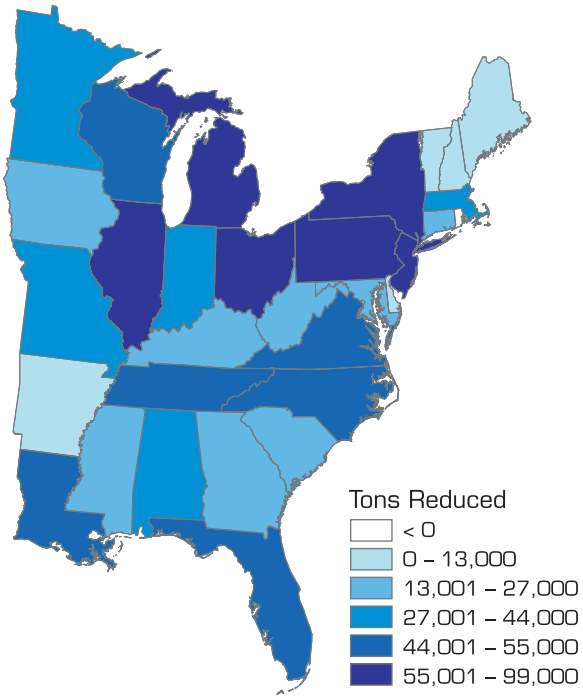
Source: EPA

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.