
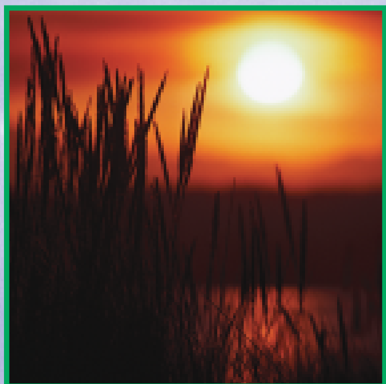
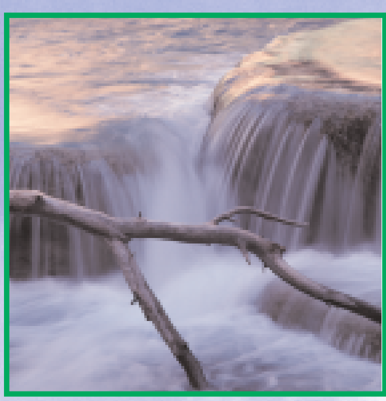


EPA

Acid Rain Program

2002 Progress Report

CLEAN AIR
MARKET PROGRAMS

November 2003

This 2002 Progress Report updates the key Acid Rain Program data reported in the 2001 Progress Report. This update includes:

- Emission levels
- Compliance with the SO_2 and NO_x components of the program
- SO_2 allowance market information
- Status and trends in acid deposition and related air quality

A Progress Report is published annually by EPA to update the public on compliance with the Acid Rain Program, the status of implementation, and our progress toward achieving our environmental goals. Detailed unit-level emissions data are available on EPA's Clean Air Markets website at http://www.epa.gov/airmarkets/2002emissions.pdf. A new query tool that provides easy access to a variety of EPA emissions data is available at http://cfpub.epa.gov/gdm. For more information on the Acid Rain Program, including information on SO_2 and NO_x emissions, acid deposition monitoring, and the environmental effects of acid deposition, please visit EPA's Clean Air Markets website at http://www.epa.gov/airmarkets.

EPA Acid Rain Program
2002 Progress Report
EPA-430-R-03-011

Clean Air Markets Division
Office of Air and Radiation
U.S. Environmental Protection Agency

November 2003

The Acid Rain Program: Overview

Acid deposition, more commonly known as acid rain, occurs when emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) react in the atmosphere (with water, oxygen, and oxidants) to form various acidic compounds. Prevailing winds transport the acidic compounds hundreds of miles, often across state and national borders. These acidic compounds then fall to earth in either a wet form (rain, snow, and fog) or a dry form (gases and particles). The acidic compounds (including small particles such as sulfates and nitrates) cause many serious health and environmental effects. These pollutants impair air quality and damage public health, acidify lakes and streams, harm sensitive forest and coastal ecosystems, degrade visibility, and accelerate the decay of building materials, paints, and cultural artifacts such as buildings, statues, and sculptures nationwide.

The pollutants that cause acid rain often cause human health and environmental impacts far away from where they are emitted. This long-range transport makes it critical to reduce emissions that occur over large geographic areas.

The Acid Rain Program was established under Title IV of the 1990 Clean Air Act amendments. The program requires major reductions of SO_2 and NO_x emissions, the pollutants that cause acid rain. Using a market-based "cap and trade" mechanism, the program sets a permanent cap on the total amount of SO_2 that may be emitted by electric power plants nationwide. The cap is set at about one-half of the amount of SO_2 these sources emitted in 1980, and the trading component allows flexibility for individual combustion units to select their own methods of compliance. The program also sets NO_x emission limitations for certain coal-fired electric utility boilers with the objective of achieving and maintaining a 2 million ton reduction from projected NO_x emission levels that would have been emitted in 2000 without implementation of Title IV. The Acid Rain Program is comprised of two phases: Phase I applied primarily to the largest coal-fired sources from 1995 through 1999 for SO_2 and from 1996 through 1999 for NO_x. Phase II for both pollutants began in 2000 and applies to thousands of combustion units generating electricity nationwide.

The Acid Rain Program's ultimate objective is to protect the environment and improve human health by reducing SO_2 and NO_x emissions from power generation sources. These emission reductions benefit the nation by:

- Improving air quality and protecting public health
- Restoring acidified lakes and streams so they can once again support fish and other aquatic life
- Improving visibility, especially at scenic vistas in National Parks
- Reducing damage to sensitive forests, such as those in the Appalachian Mountains and in certain high-elevation Western regions
- Reducing damage to nitrogen-sensitive coastal waters along the East and Gulf Coasts
- Protecting historic buildings and monuments from degradation

SO_2 Emission Reductions

There were 3,208 electric generating units[1] that were subject to the SO_2 provisions of the Acid Rain Program in 2002, the third year of Phase II. Acid Rain Program sources achieved a total reduction in SO_2 emissions of approximately 41% compared to 1980 levels (35% compared to 1990 levels). Compared to 2001 levels, these sources reduced their SO_2 emissions by almost 400,000 tons. **Figure 1** shows the trend in SO_2 emissions since 1980 for all affected sources.

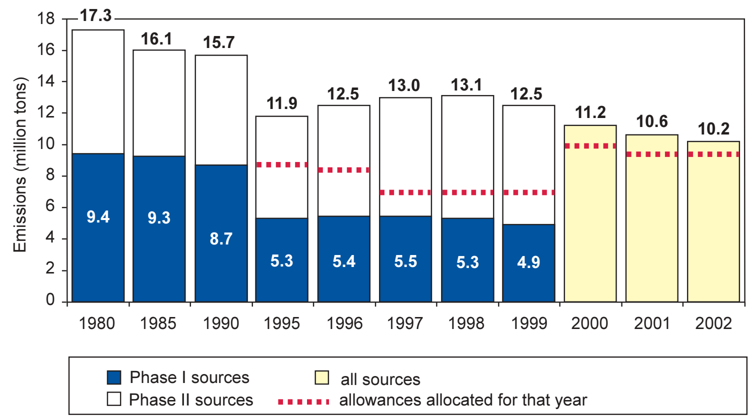

Figure 1. SO_2 Emissions from Acid Rain Sources, 1980 through 2002.
Source: EPA

The electric power generation industry is by far the largest single source of SO_2 emissions in the U.S., accounting for approximately 69% of total SO_2 emissions nation-wide (National Emission Inventory 2001 www.epa.gov/ttn/chief/trends/index.html). Emissions from each individual unit, as well as an additional 273 units which were retired or not yet operating, are listed in Appendix A of this Report, available on EPA's Clean Air Markets website at www.epa.gov/airmarkets/cmprpt/arp02/index.html.

Under the Acid Rain Program, allowances (i.e., authorizations to emit SO_2) allocated in a particular year to each unit are determined by several provisions of the Clean Air Act. For the year 2002, a total of 9.54 million allowances were allocated. Adding these allowances to the unused allowances carried over (or banked) from prior years, a total of 18.84 million allowances were available for use in 2002. Sources emitted 10.2 million tons in 2002, 650,000 tons more than the allowances granted in 2002 but far less than the total allowable level. For the third year in a row the number of allowances in the bank declined. As shown in **Figure 2**, the bank was reduced by 650,000 allowances in 2002. Over time the bank is expected to continue to be depleted as sources use banked allowances to continue to comply with the stringent Phase II requirements. **Figure 3** explains in more detail the origin of the allowances that were available for use in 2002.

In addition to the significant reductions from the electric power generation sector under the Acid Rain Program, reductions in SO_2 emissions from other sources, including smelters and sulfuric acid manufacturing plants, and use of cleaner fuels in residential and commercial burners, have also contributed to the 39% decline of SO_2 emissions from all sources since 1980 (National Emission Inventory www.epa.gov/ttn/chief/trends/index.html).

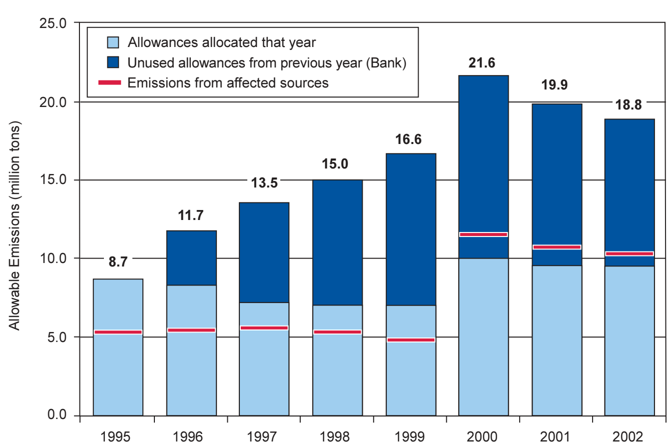

Figure 2. SO_2 Allowance Bank, 1995 through 2002.
Source: EPA

[1] In this report, the term "unit" means a fossil-fuel fired combustor that serves a generator that provides electricity for sale. The vast majority of SO_2 emissions affected by the program come from coal-fired generation units, but oil and natural gas units are also included in the program.

Type of Allowance Allocation	Number of Allowances	Explanation of Allowance Allocation Type
Initial Allocation	9,190,365[1]	Initial Allocation is the number of allowances granted to units based on the product of their historic utilization and emissions rates (performance standards) specified in the Clean Air Act and other provisions of the Act.
Allowances for Substitution Units	2,925	A lawsuit settlement allowed for a small amount of allowances to be allocated for Substitution Units in 2002 instead of an earlier year during Phase I.
Allowance Auctions	250,000	Allowance Auctions provide allowances to the market that were set aside in a Special Allowance Reserve when the initial allowance allocation was made.
Opt-in Allowances	99,188	Opt-in Allowances are provided to units entering the program voluntarily. There were 11 opt-in units in 2002.
Total 2002 Allocation	**9,542,478**	
Banked Allowances	9,300,138	Banked Allowances are those held over from 1995 through 2001, which can be used for compliance in 2002 or any future year.
Total 2002 Allowable	**18,842,616**	

[1] Note: The total year 2002 initial allocation was 9,191,897. 1,532 allowances were deducted as offsets for year 2001 reconciliation, and for other reasons, such as surrenders due to enforcement actions prior to the 2002 reconciliation.

Figure 3. Origin of 2002 Allowable SO_2 Emission Levels. Source: EPA

NO_x Emission Reductions

Title IV of the 1990 Clean Air Act amendments authorizes NO_x emission reduction requirements only for coal-fired Acid Rain Program affected units and they are to be set as annual emission-rate limitations for different types of utility boilers. The performance objective for the NO_x program component has been to achieve and maintain a 2 million ton reduction from these sources relative to the NO_x emission levels projected to occur in 2000 absent the Acid Rain Program. (This objective is consistent with guidelines in the statute and legislative history on the total NO_x emissions reduction intended by Congress under Title IV.[2]) The goal was achieved in 2000: total NO_x mass emissions for coal-fired electric utility units affected by the NO_x program component had been reduced to 4.5 million tons (2.9 million tons below program projections, or 2.2 million below an early forecast). Total NO_x mass emissions for all Acid Rain Program affected units were 3 million tons below the projected level without implementation of Title IV (**see Figure 4**). Emissions from those sources in 2002 were even less – 2.2 million tons (or 33%) below 1990 emissions levels, due to some degree to added state controls primarily in the Northeast

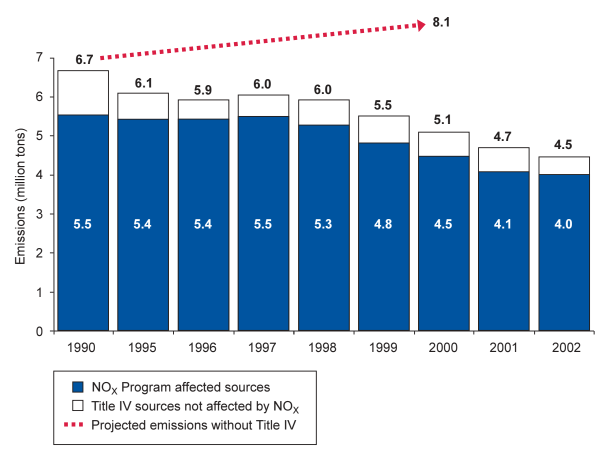

Figure 4. NO_x Emissions from Acid Rain Sources, 1990 through 2002. Source: EPA

[2] See discussion and emission reduction projections in preamble to the final Phase II Acid Rain NO_x Emission Reduction Rule (61 FR 67120, December 19, 1996) and supporting Regulatory Impact Analysis (Docket A-95-28, V-B-1, October 24, 1996).

Total Allowances Held in Accounts as of 3/1/2003 (1995 through 2002 Vintages)[1]	18,847,494
Unit Accounts	14,080,907
General Accounts[2]	4,766,587
Allowances Deducted for Emissions (1995 through 2002)[3]	10,193,684
2003 Penalty Allowances Deducted	33
Banked Allowances	8,653,843
Unit Accounts	3,887,256
General Accounts[3]	4,766,587

[1]The number of allowances held in the Allowance Tracking System (ATS) accounts equals the number of 2002 allowances allocated (see Figure 3) plus the number of banked allowances. March 1, 2003 represents the Allowance Transfer Deadline, the point in time at which unit accounts are frozen and after which no transfers of 1995 through 2002 allowances will be recorded. The freeze on these accounts is removed when annual reconciliation is complete.

[2]Includes 40 allowances deducted from Opt-in sources for reduced utilization.

[3]General accounts can be established in the ATS by any utility, individual or other organization.

Figure 5. SO_2 Allowance Reconciliation Summary, 2002. Source: EPA

These reductions have been achieved while the amount of fuel burned to produce electricity, as measured by heat input, increased 30% since 1990. Without further reductions in emissions rates or institution of a cap on NO_x emissions, however, NO_x emissions from power plants may rise with increased use of fossil fuels in some areas of the country.

NO_x emissions come from a wide variety of sources including those affected by the Acid Rain Program. NO_x emissions from electric power generation account for approximately 22% of NO_x emissions from all sources. NO_x emissions from transportation sources are 55% of all NO_x emissions. Nationally, total NO_x emissions have decreased 12% from 1990 through 2001. NO_x emissions from transportation sources decreased 14%, but NO_x emissions from heavy duty vehicles increased by 10%. The emission decreases from electric power generation and other fuel combustion sources are due in part to a variety of federal and state emission reduction programs (including the Acid Rain Program, the Ozone Transport Commission NO_x Budget Trading Program, and anticipation of the NO_x SIP call) and federal enforcement actions (National Emissions Inventory, www.epa.gov/ttn/chief/trends/index.html).

SO_2 Program Compliance

As in previous years, compliance with the Acid Rain Program continues to be extraordinarily high – nearly 100%. A total of 10.19 million allowances were deducted from sources' accounts in 2002 to cover emissions. A single unit was short a total of 33 allowances to cover its emissions for the 2002 compliance year. Thirty-three year 2003 allowances were taken from this unit as "offsets" and are included in the total number of used allowances for 2002. In addition to the offsets, the operator of this unit was assessed an automatic monetary penalty totaling over $90,000.[3] **Figure 5** displays these allowance deductions, as well as the remaining bank of 1995 through 2002 allowances.

Under the Acid Rain Program, units are required to measure and record emissions using Continuous Emissions Monitoring Systems (CEMS) or an approved alternative measurement method.

One important measure of accuracy of a CEMS is the relative accuracy test audit, and all units continued to operate with high levels of accuracy in 2002. Additionally, the percent monitor data availability (PMA) exceeded 99% for coal-fired units and approximately 98% for oil and gas-fired units. PMA is a method to determine CEMS reliability – both accuracy and reliability measures ensure that the actual amount of emissions is being captured. And in 2002, for the third consecutive year, 100% of affected sources were reporting hourly emissions electronically.

New in 2003, the Acid Rain Program is employing an electronic audit capability. Since the program's inception in 1995, the emissions data – continuously reported by sources, verified and recorded by EPA, and posted for public consumption on the Internet – has been among the most complete and accurate data ever collected by EPA. New audit capabilities include

[3] A source that does not hold enough allowances in its unit account to cover its annual SO_2 emissions has "excess emissions" and must pay a $2,000 per ton automatic penalty in 1990 dollars. The $2,000 per ton penalty is adjusted annually for inflation, so the year 2002 penalty was $2,849 per ton.

Compliance Option	Number of Units
Standard Emission Limitation	150
Early Election	273
Emissions Averaging	631
Alternative Emission Limitation	26
Total	**1,080**[1]

[1]The total does not equal 1,048 because 25 units have both early election and emissions averaging compliance plans, and 7 units have both AEL and emissions averaging compliance plans.

Figure 6. Compliance Actions in the NO_x Program, 2002.
Source: EPA

software that performs hourly checks to catch errors, miscalculations, and oversights in monitoring and reporting systems, thereby helping to ensure the completeness, high quality, and integrity of the emissions data. The electronic audit highlights a greater number of potential 'red flags' that require additional verification – some units may need to surrender additional allowances for periods when monitors were not providing fully-validated data. These conservative 'missing data' procedures help ensure that emissions are never understated. The result is an improved body of information about emissions.

To date, 80% of the total cumulative SO_2 emissions data for Acid Rain units was electronically audited. This audit included comprehensive checks for relative accuracy, linearity, and bias adjustment.

NO_x Program Compliance

In 2002, 1,048 of all Acid Rain Program units were required to meet NO_x emissions limitations. Of these coal-fired units, 1,047 NO_x units met their NO_x emissions limits through compliance with their respective NO_x compliance plans. Only one unit failed to meet its NO_x emissions limit in 2002. That unit had excess NO_x emissions of 47 tons and was assessed a monetary penalty of $134,000 (47 tons x $2,849 per ton penalty). Detailed compliance information by unit can be found in Appendices B1 and B2. These appendices are available on EPA's Clean Air Markets website at www.epa.gov/airmarkets/cmprpt/arp02/index. **Figure 6** summarizes the compliance options chosen for NO_x-affected units in 2002. Averaging was the most widely chosen compliance option; 55 averaging plans involving 631 units were in place in 2002.

SO_2 Allowance Market

The flexibility provided by the Acid Rain Program enabled the 3,208 units subject to the SO_2 requirements in 2002 to pursue a variety of compliance options. Sources have met their SO_2 reduction obligations by options including installing scrubbers, switching fuels, changing practices or procedures to improve energy efficiency, and buying allowances. The presence of the allowance market has given some sources the incentive to reduce their SO_2 emissions below the level of their allowance allocation in order to bank their allowances for use in future years or to sell them to other sources. Other sources have been able to postpone or reduce expenditures for control by purchasing allowances from sources that controlled below their allowance allocation level. The flexibility in compliance options is possible because strict monitoring requirements for all affected units ensure one allowance is surrendered for every ton of SO_2 emitted. The program's flexibility significantly reduces the cost of achieving these emissions reductions as compared to the cost of a technological mandate or fixed emission rate.

The marginal cost of compliance – the cost of reducing the next ton of SO_2 emitted from the power sector – is reflected in the price of an allowance. Emission reductions continue to cost less than anticipated when the Clean Air Act Amendments were enacted and this is reflected in the price of allowances.

Allowance prices for 2002 continued the downward trend that started in the second half of 2001. Prices hovered in the $170/ton range early in 2002 and decreased slightly during the summer months, ending the year in the $130/ton range. Prices stabilized at historical averages in 2002 after the more stringent limits in Phase II resulted in higher average prices in 2001 (**See Figure 7**). Some market observers believe lower-than-expected allowance prices during the first several years of the program were due primarily to lower than expected compliance costs and larger than expected emissions reductions, which increased the supply of allowances and put downward pressure on prices.

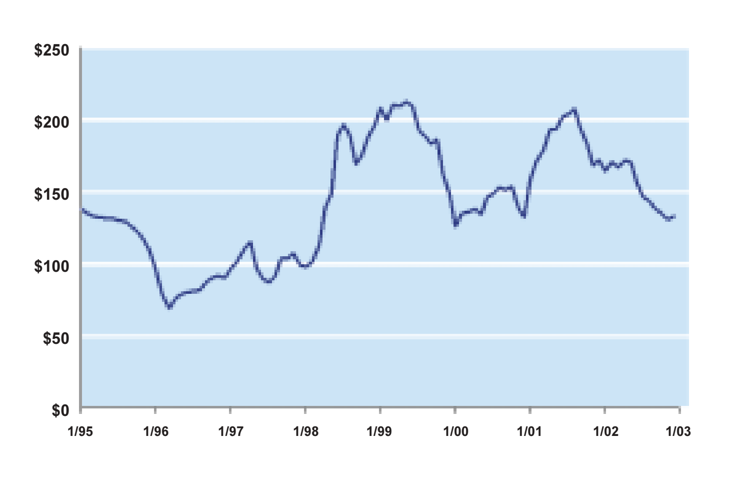

Figure 7. SO_2 Allowance Price Index. Source: Monthly Price Reports from Cantor Fitzgerald Environmental Brokerage Services

In 2002, over 5,700 allowance transfers affecting roughly 21.4 million allowances (of past, current, and future vintages) were recorded in the Allowance Transfer System, the accounting system developed by EPA to track holdings of allowances. Of the allowances transferred, 11.6 million, or 54%, were transferred in economically significant transactions (i.e., between economically unrelated parties). The majority of the allowances transferred in economically significant transactions were acquired by power companies. **Figure 8** shows the volume of SO_2 allowances transferred under the Acid Rain Program since official recording of transfers began in 1994. **Figure 9** shows the cumulative trading volume of SO_2 allowances transferred under the Acid Rain Program. Almost 224 million allowances have been traded since 1994, with 70% of those trades submitted by authorized account representatives for private accounts. In December 2001, parties began to use the On-line Allowance Tracking System (OATS) developed by EPA to allow transfers to occur online. During 2002, OATS recorded 4,654 transfers electronically over the Internet.

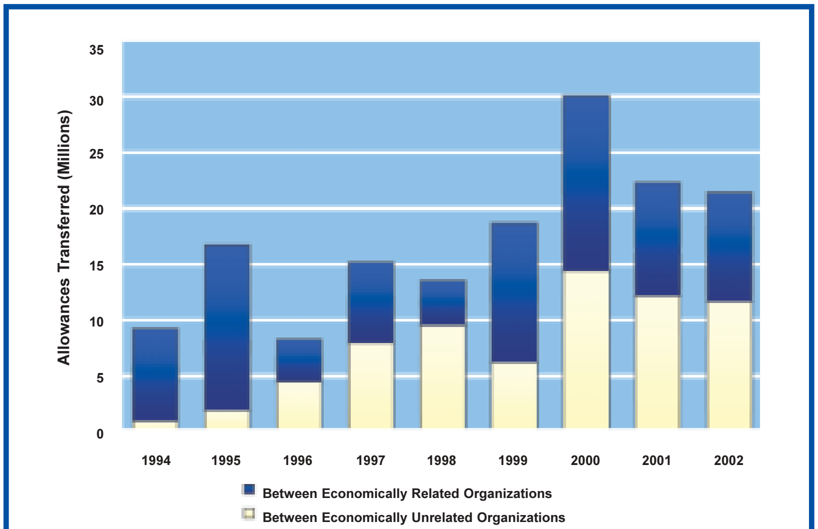

Figure 8. SO_2 Allowances Transferred under the Acid Rain Program. Source: EPA

All official allowance transactions, as well as data on account balances and ownership, are posted and updated daily on the Clean Air Markets Division's website (www.epa.gov/airmarkets) in order to better inform trading participants of the status of the market. Cumulative market statistics and analysis are also available.

NO_x Emissions Limits

Instead of using a cap with allowance trading to achieve NO_x emissions reductions, the Acid Rain Program establishes NO_x emission limitations (lb/mmBtu NO_x) for coal-fired electric generation units.

The Acid Rain Program NO_x regulation (40 CFR part 76), establishes NO_x limits for Group 1 boilers (dry bottom wall-fired and tangentially-fired boilers), as well as Group 2 boilers (cell burners, cyclones, vertically-fired, and wet bottom boilers). **Figure 10** shows the number of NO_x affected units by boiler type and the emissions limit for each boiler type.

The owners and operators of the 1,048 units subject to NO_x emissions limitations in 2002 were required to choose at least one NO_x compliance plan (described below) to indicate how each unit will comply with its NO_x limit:

- Standard Limitation. A unit with a standard limit simply meets the applicable individual NO_x limit prescribed for its boiler type under 40 CFR 76.5, 76.6, or 76.7.
- Early Election. Under this compliance option, a Phase II Group 1 NO_x affected unit met a less stringent Phase I NO_x limit beginning in 1997, three years before it would normally be subject to an Acid Rain NO_x limit. In return for accepting a NO_x limit three years earlier than would normally be required, an

early election unit does not become subject to the more stringent Phase II NO_x limit until 2008.

- Emissions Averaging. A company can meet its NO_x emissions reduction requirements by choosing to make a group of NO_x affected boilers subject to a group NO_x limit, rather than meeting individual NO_x limits for each unit. The group limit is established at the end of each calendar year, and the group rate for the units must be less than or equal to the Btu-weighted rate at which the units would have been limited had each been subject to an individual NO_x limit.

- Alternative Emission Limitation (AEL). A utility can petition for a less stringent AEL if it properly installs and operates the NO_x emissions reduction technology prescribed for that boiler, but is unable to meet its standard limit. EPA determines whether an AEL is warranted based on analyses of emissions data and information about the NO_x control equipment.

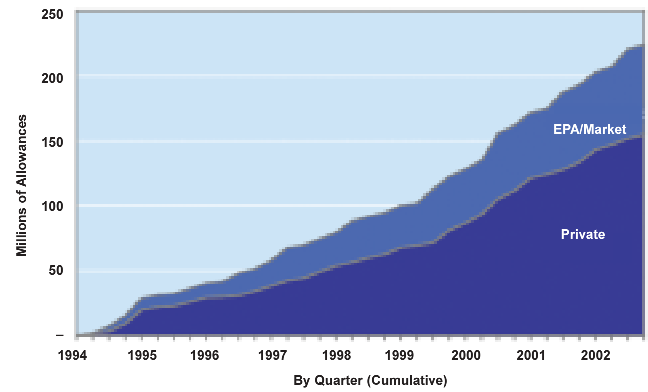

Figure 9. Cumulative SO_2 Allowances Transferred through the End of 2002.

Private Transfers: these transfers were submitted by authorized account representatives for private accounts. (EPA does not attempt to determine what constitutes an actual trade where money is exchanged).

EPA/Market Transfers: most of these transfers involved movement of allowances from EPA accounts to market accounts (e.g., auctions, Phase I extension allowances, substitution allowances, etc.)

Status and Trends in Acid Deposition and Related Air Quality

The emission reductions achieved under the Acid Rain Program have led to important environmental and public health benefits. These include improvements in air quality with significant benefits to human health, reductions in acid deposition, the beginnings of recovery from acidification in fresh water lakes and streams, improvements in visibility, and reduced risk to forests, coastal waters, and materials and structures.

To evaluate the impact of emissions reductions on the environment, scientists and policymakers use data collected from long-term national monitoring networks such as the Clean Air Status and Trends Network (CASTNET) and the National Atmospheric Deposition Program (NADP). Deposition and air quality monitoring data from these and other air quality monitoring networks can be accessed on or through the CASTNET website at http://www.epa.gov/castnet.

Data collected from these networks show that the decline in SO_2 emissions from the power industry has decreased acidic deposition and improved air quality. The decline in NO_x emissions has not been as large and the environmental improvements are not as widespread.

Coal-Fired Boiler Type	Standard Emission Limit (lb/mmBtu)	Number of Units
Phase I Group 1 Tangentially-fired	0.45	135
Phase I Group 1 Dry Bottom Wall-fired	0.50	130
Phase II Group 1 Tangentially-fired	0.40	306
Phase II Group 1 Dry Bottom Wall-fired	0.46	312
Cell Burners	0.68	37
Cyclones > 155 MW	0.86	56
Wet Bottom > 65 MW	0.84	31
Vertically-fired	0.80	41
Total		**1,048**

Figure 10. Number of NO_x Affected Units by Boiler Type. Source: EPA

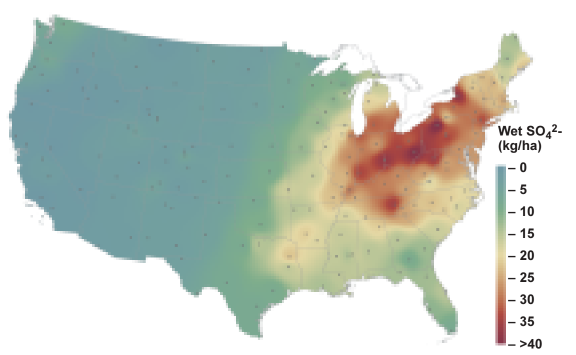

Figure 11. Mean Wet Sulfate Deposition 1989 through 1991. Source: National Atmospheric Deposition Program

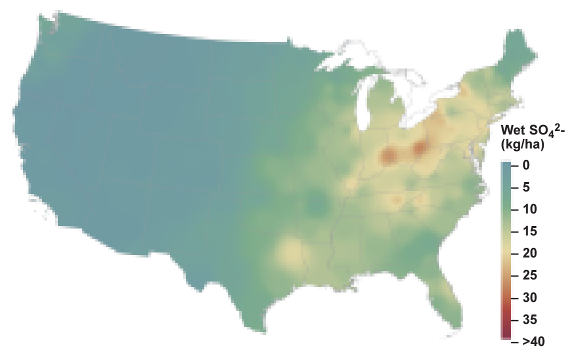

Figure 12. Mean Wet Sulfate Deposition 2000 through 2002. Source: National Atmospheric Deposition Program

Note: Points on map represent location of monitoring sites

This 2002 Progress Report highlights changes in deposition and certain air quality parameters. As data become available, new information on ecosystems and human health impacts will be included in subsequent progress reports.

- SO_2 concentrations in the atmosphere have decreased since 1990. In 2002, concentrations in the Northeast and Mid-Atlantic were 6-12 micrograms per cubic meter (µg/m^3), as much as 8 µg/m^3 lower than in 1990.
- Sulfate concentrations in the atmosphere have decreased since 1990 as well. In 2002, concentrations in most of the East were 3-5 µg/m^3, as much as 4 µg/m^3 lower than in 1990.
- Wet sulfate deposition has decreased significantly since 1990. In 2002, deposition in most of the Northeast and Midwest was 10-20 kilograms per hectare per year (kg/ha/yr), as much as 12 kg/ha/yr lower than it was in 1990.
- Wet nitrate deposition has decreased regionally although nitrate concentrations in precipitation have remained unchanged or increased in some areas.

Scientists have documented that both wet and dry sulfur deposition (and the actual acidity of rain) have declined with reductions of SO_2 emissions over a large portion of the eastern U.S. following implementation of Title IV. A strong, near linear correlation, between large scale SO_2 emissions reductions and large reductions in sulfate concentrations in precipitation has been noted for the Northeast, one of the areas most affected by acid deposition.

Some of the greatest reductions in wet sulfate deposition occurred in the Mid-Appalachian region, including Maryland, New York, West Virginia, Virginia, and most of Pennsylvania (**see Figures 11 and 12**). Wet sulfate deposition decreased more than 8 kg/ha from rates observed throughout the early 1990s in much of the Ohio River Valley and Northeastern U.S. Other less dramatic reductions were observed across much of New England, portions of the Southern Appalachian Mountains and in the Midwest, most notably Indiana and Illinois.

Figures 11 and 12 show the mean wet sulfate deposition in the continental U.S. between 1989 through 1991 and 2000 through 2002. The highest rates of sulfur deposition have been observed in the areas containing the highest SO_2 emissions – the Midwest and the East. Most areas in the East have had reductions in sulfate deposition since 1989 through 1991.

A main reason for reduced concentrations of sulfate in precipitation in the Northeast is a reduction in the long-range transport of sulfate from emission sources located in the Ohio River Valley. The reductions in sulfate documented in the Northeast, particularly across New England and portions of New York State, were also affected by SO_2 emission reductions in eastern Canada. Concurrent with these sulfate reductions were similar reductions in precipitation acidity, expressed as hydrogen ion (H+) in concentrations (NADP).

For ambient sulfate concentrations, both the size of the affected region and magnitude of the highest concentrations were dramatically reduced following implementation of Title IV. Sulfate concentrations decreased up to 3 µg/m^3 in the eastern U.S. from the levels of 5-8 µg/m^3

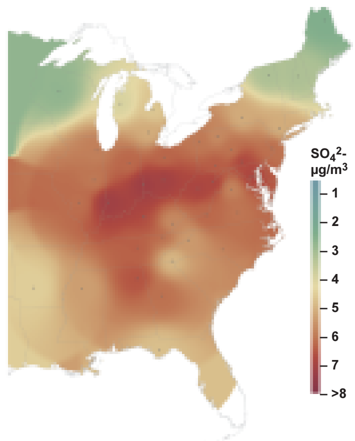

Figure 13. Mean Sulfate Concentration 1989 through 1991. Source: CASTNET

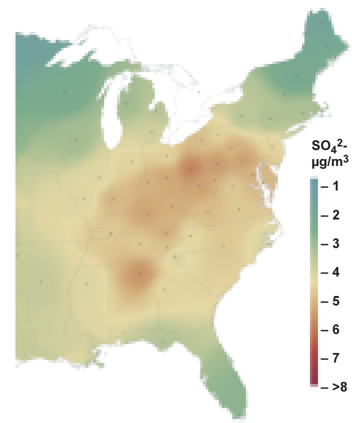

Figure 14. Mean Sulfate Concentration 2000 through 2002. Source: CASTNET

observed in the early 1990s (**see Figures 13 and 14.**). The largest decreases were observed along the Ohio River Valley.

Analyses of regional monitoring data from CASTNET show the geographic pattern of SO_2 and airborne sulfate in the eastern U.S. Three-year mean annual concentrations of SO_2 and sulfate from a set of 34 CASTNET long-term monitoring sites were compared from 1989 through 1991 and 2000 through 2002. In 1989 through 1991, prior to implementation of Phase I of Title IV, the highest ambient concentrations of SO_2 in the East were observed in western Pennsylvania, and along the Ohio River Valley. The highest ambient sulfate concentrations, greater than 7 µg/m^3, were observed in this area and in northern Alabama. Most of the eastern U.S. experienced annual ambient sulfate concentrations greater than 5 µg/m^3.

During the late 1990s, following implementation of Phase I of the Acid Rain Program, dramatic regional improvements in SO_2 and sulfate ambient concentrations were observed at CASTNET sites throughout the eastern U.S.

Ambient concentrations of SO_2 in 2000 through 2002 decreased up to 8 µg/m^3 in the Northeast and Mid-Atlantic regions compared to concentrations of 10-20 µg/m^3 observed in the early 1990s **(see Figures 15 and 16)**. The largest decreases in ambient SO_2 concentrations were noted in high emissions and concentration areas (e.g., vicinity of Chicago and throughout Indiana, Ohio, Pennsylvania, Kentucky, and West Virginia). The highest SO_2 concentrations observed in the rural parts of the United States are now concentrated in eastern Ohio and southwestern Pennsylvania.

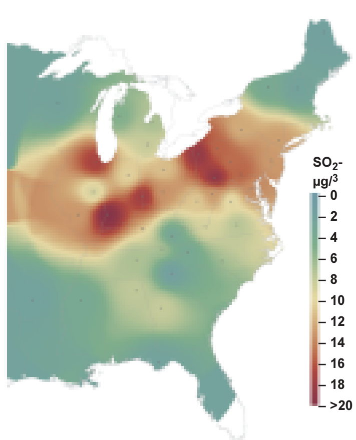

Figure 15. Mean Sulfur Dioxide Concentration 1989 through 1991. Source: CASTNET

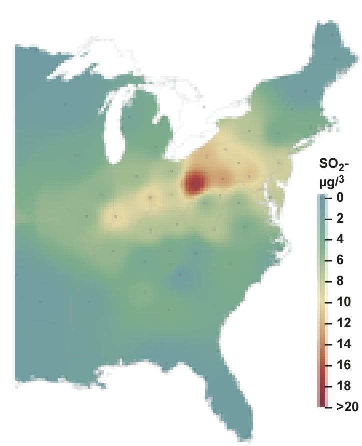

Figure 16. Mean Sulfur Dioxide Concentration 2000 through 2002. Source: CASTNET

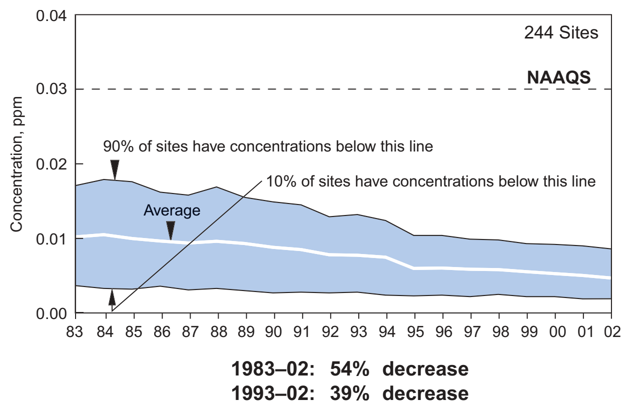

Fig. 17. SO_2 Annual Arithmetic Average 1983 through 2002.
Source: Latest Findings on National Air Quality 2002 Status and Trends, EPA

Nationally, average SO_2 ambient concentrations have decreased 54% from 1983 through 2002 and 39% over the more recent 10-year period 1993 through 2002 (see **Figure 17** regarding National Ambient Air Quality Standard). Reductions in SO_2 concentrations since 1990 are due, in large part, to controls implemented under EPA's Acid Rain Program.

Figures 18 and 19 show mean wet nitrate deposition in the continental U.S. between 1989 through 1991 and 2000 through 2002. Large reductions in wet nitrate deposition were observed in the northeastern U.S. and Michigan. **Figures 20 and 21** show mean wet nitrate concentrations in the continental U.S. between 1989 through 1991 and 2000 through 2002. Wet nitrate concentrations across the U.S. have generally remained the same, or increased in some regions. Unlike sulfate concentrations, sharp declines

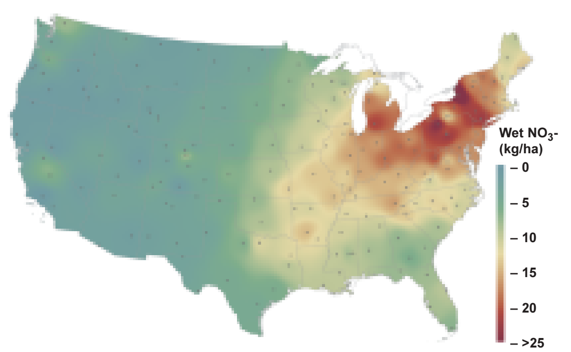

Fig. 18. Mean Wet Nitrate Deposition 1989 through 1991. Source: National Atmospheric Deposition Program

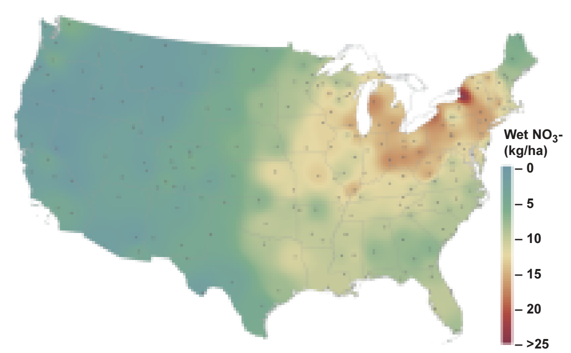

Fig. 19. Mean Wet Nitrate Deposition 2000 through 2002. Source: National Atmospheric Deposition Program

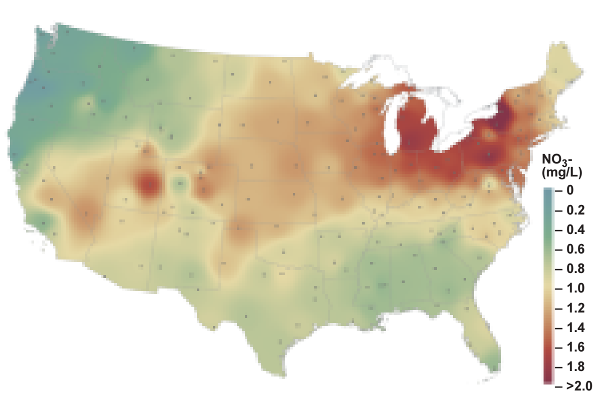

Fig. 20. Mean Wet Nitrate Concentrations 1989 through 1991. Source: National Atmospheric Deposition Program

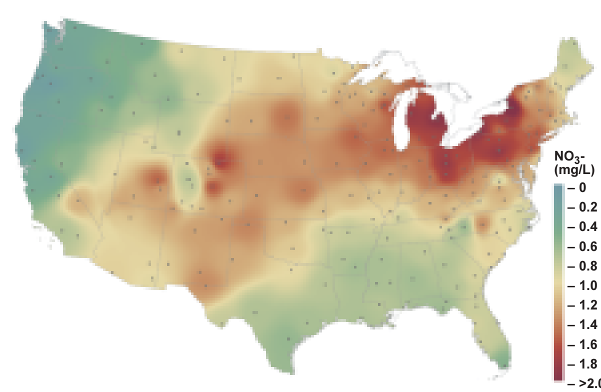

Fig. 21. Mean Wet Nitrate Concentrations 2000 through 2002. Source: National Atmospheric Deposition Program

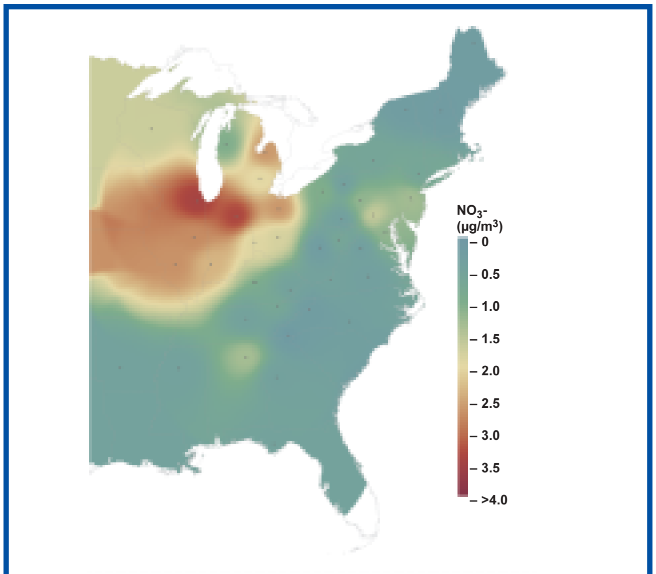

Fig. 22. Mean Ambient Nitrate Concentrations 1989 through 1991. Source: CASTNET

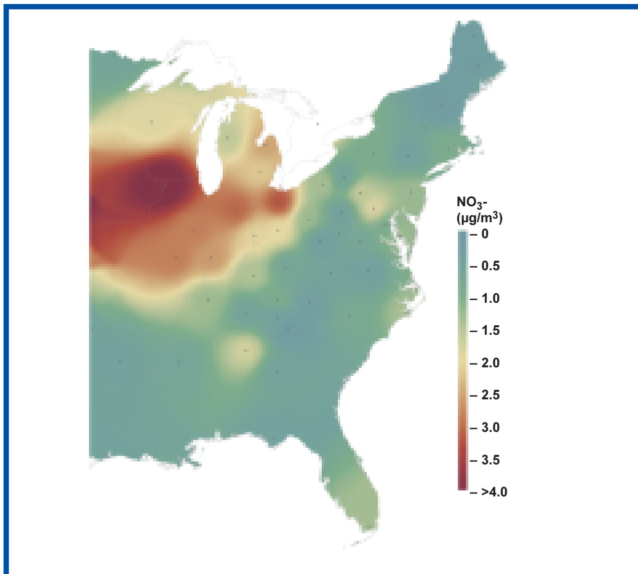

Fig. 23. Mean Ambient Nitrate Concentrations 2000 through 2002. Source: CASTNET

in wet nitrate concentrations have not been observed in the Northeast, even though wet nitrate deposition does appear to be substantially lower there. The decreases in wet nitrate deposition observed in 2000 through 2002 appear related to lower precipitation levels over those same years. In addition, there are no observable broad-scale reductions in total nitrogen deposition (wet + dry) in the U.S. 1989 through 2002.* The highest levels of total nitrogen deposition were recorded in the Midwest and Eastern U.S. 2000 through 2002, although several monitoring stations in the west observed high levels of total nitrogen deposition. In the west, southern California in particular, dry deposition makes up a greater percentage of the total.

Acid rain sources account for only 22% of nationwide NO_x emissions, so emissions trends in other source categories, especially agriculture and mobile sources, also affect air concentrations and deposition of nitrogen. Because NO_x emissions from the power sector are not capped throughout the country annually these emissions may grow as demand for electricity continues to increase. However, an environmental signal is expected over the next decade due to the implementation of the OTC NO_x Budget Trading program, NO_x SIP call and several state programs such as Texas, North Carolina and several mobile source NO_x controls. Continued monitoring of nitrogen deposition and air quality will be particularly important to track and assess the magnitude of the signal.

Figures 22 and 23 show mean ambient nitrate concentrations in the eastern half of the U.S. in 1989 through 1991 and 2000 through 2002, respectively. Data from CASTNET suggest ambient nitrate concentrations have remained unchanged and have even increased in some regions, with the highest ambient nitrate concentrations in 2000 through 2002 greater than 4 $\mu g/m^3$ recorded in the upper Midwest.

* Based on data compiled annually by National Atmospheric Deposition Program/National Trends Network (NADP/NTN) http://nadp.sws.uiuc.edu and Clean Air Status and Trends Network (CASTNET) www.epa.gov/castnet

Did you know?

Environmental contamination from mercury and acidification are linked. While many questions remain about how mercury moves from atmospheric deposition through the environment into fish, for several years scientists have recognized one thing: often, mercury levels in fish correlate with the presence of sulfate in the ecosystem. The species of mercury that forms in the environment and bio-accumulates in fish – methylmercury – causes neurological and other problems in humans who consume those fish. Sulfate is an indicator of acid deposition, one of the main ions whose presence in lakes and streams indicates that those waters are suffering from acidification.

The amount of methylmercury in fish appears to depend in most environments on two primary things: the amount of mercury entering the ecosystem and the rate of the processes that transform it into methylmercury. Mercury contamination and sulfur are linked in both these aspects. Coal-fired power plants are a primary atmospheric source of both sulfur dioxide (the main precursor to sulfate) and mercury emissions, and sulfate-reducing bacteria are responsible for much of the mercury methylation that happens in the ecosystem. Therefore, the effects of mercury deposition are often closely tied to the effects of acid deposition. While there is still much more that scientists need to understand about how these pollutants interact, our current understanding offers hints of the complex and interdependent behavior of these pollutants.

Summary

In 2002, the third year of Phase II, the Acid Rain Program continued to be successful in substantially reducing emissions of SO_2 and NO_x from electric power plants.

Sources continue to close in on the goal of reducing power plant SO_2 emissions by 50% from 1980 levels to a cap level of 8.95 million tons. Sources have also exceeded the goal of a two million-ton reduction in NO_x emissions from projected 2000 levels by over one million tons.

Sources in both the cap and trade program for SO_2 and the more conventional NO_x program have demonstrated a high level of compliance with both the emissions monitoring and emission reduction requirements. These efforts have achieved measurable results. The flexibility for sources inherent in the cap and trade approach has significantly reduced compliance costs.

In 2002, the Acid Rain Program achieved:

- **Dramatic Emission Reductions:** In 2002, SO_2 emissions from power plants were 9% lower than the year 2000 and 41% lower than 1980. NO_x emissions from power plants also continued a downward trend, posting a 13% reduction from 2000 and a 33% decline from 1990 emissions levels.

  – In 2002, the more than 3,000 units in the Acid Rain Program emitted 10.2 million tons of SO_2, down from 15.7 million tons in 1990. Emissions of SO_2 in 2002 were almost 400,000 tons less than they had been in 2001. As in 2001, sources drew down the bank of unused allowances in 2002, resulting in emission levels greater than the allowances allocated in 2002, but still lower than emissions during any previous year.

  – NO_x emissions from all acid rain units have decreased steadily from 6 million tons in 1997 to 4.5 million tons in 2002. The subset of more than 1,000 units affected by the Acid Rain NO_x Program emitted 4.0 million tons in 2002, approximately 1.5 million tons (29%) less than they did in 1990.

- **Significant Air Quality Improvements:** Air quality has notably improved, reducing human exposure to pollutants such as SO_2 and fine particles that are associated with chronic bronchitis, asthma attacks, hospitalizations for cardiac and respiratory diseases, and premature death.

  – Acid deposition (especially sulfate concentrations in wet and dry deposition) has been substantially reduced, allowing lakes and streams in the Northeast to begin recovering from decades of acid rain.

  – Although NO_x emissions have been reduced under the Acid Rain Program, there are no clear long-term trends in nitrogen deposition.

- **Better Information, Compliance and Flexibility:** The Acid Rain Program's rigorous emissions monitoring and reporting requirements and new audit capability ensure complete accountability, resulting in a robust, transparent emissions inventory. The program has an extraordinary compliance level of nearly 100%.

- **Cost-Effectiveness:** The cost of compliance is substantially lower than estimated in 1990. Achievement of the required SO_2 emission reductions when the program is fully implemented in 2010 is now projected to cost just one quarter ($1 to $2 billion per year) of original EPA estimates.

For more information on the EPA Acid Rain Program, visit EPA's Clean Air Markets website at http://www.epa.gov/airmarkets.

For additional detailed emissions data see http://www.epa.gov/airmarkets/emissions/index.

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