# Acid Rain and Related Programs

## 2009 Emission, Compliance, and Market Analyses

The Acid Rain Program (ARP), established under Title IV of the 1990 Clean Air Act (CAA) Amendments, requires major emission reductions of sulfur dioxide ($SO_2$) and nitrogen oxides ($NO_x$), the primary precursors of acid rain, from the electric power industry. The $SO_2$ program sets a permanent cap on the total amount of $SO_2$ that may be emitted by electric generating units (EGUs) in the contiguous United States. The program is phased in, with the final 2010 $SO_2$ cap set at 8.95 million tons, a level of about one-half of the emissions from the power sector in 1980. $NO_x$ reductions under the ARP are achieved through a program that applies to a subset of coal-fired EGUs and is closer to a traditional, rate-based regulatory system. Since the program began in 1995, the ARP has achieved significant emission reductions. As Figure 1 shows, these reductions have occurred as electricity generation has increased overall.

### At a Glance: ARP Results in 2009

**$SO_2$ Emissions:** 5.7 million tons

**$SO_2$ Compliance:** 100%

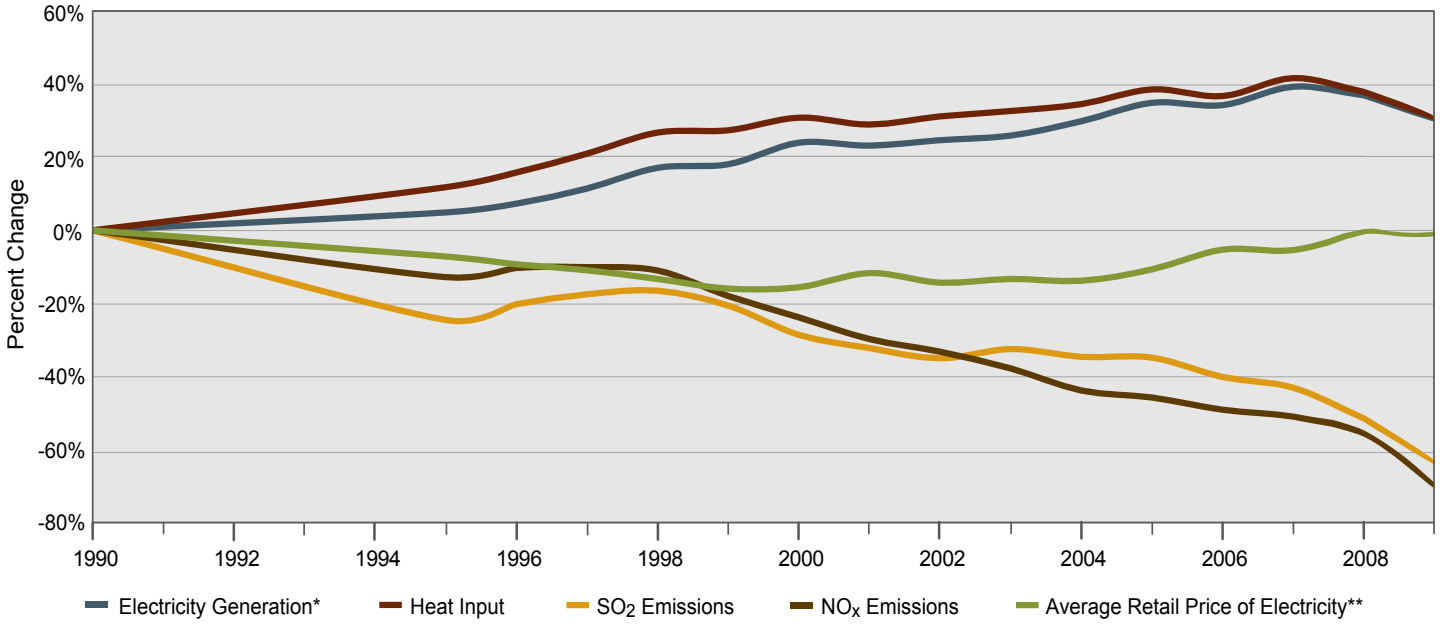
**$SO_2$ Allowances:** Banked allowances increased by nearly 4 million from 2008 levels.

**$SO_2$ Allowance Prices:** In 2009 allowance prices fell from $187 per ton to $61 per ton.

**$NO_x$ Emissions:** 2.0 million tons

**$NO_x$ Compliance:** 100%

**Figure 1: Trends in Electricity Generation, Fossil Energy Use, Prices, and Emissions from the Electric Power Industry, 1990-2009**

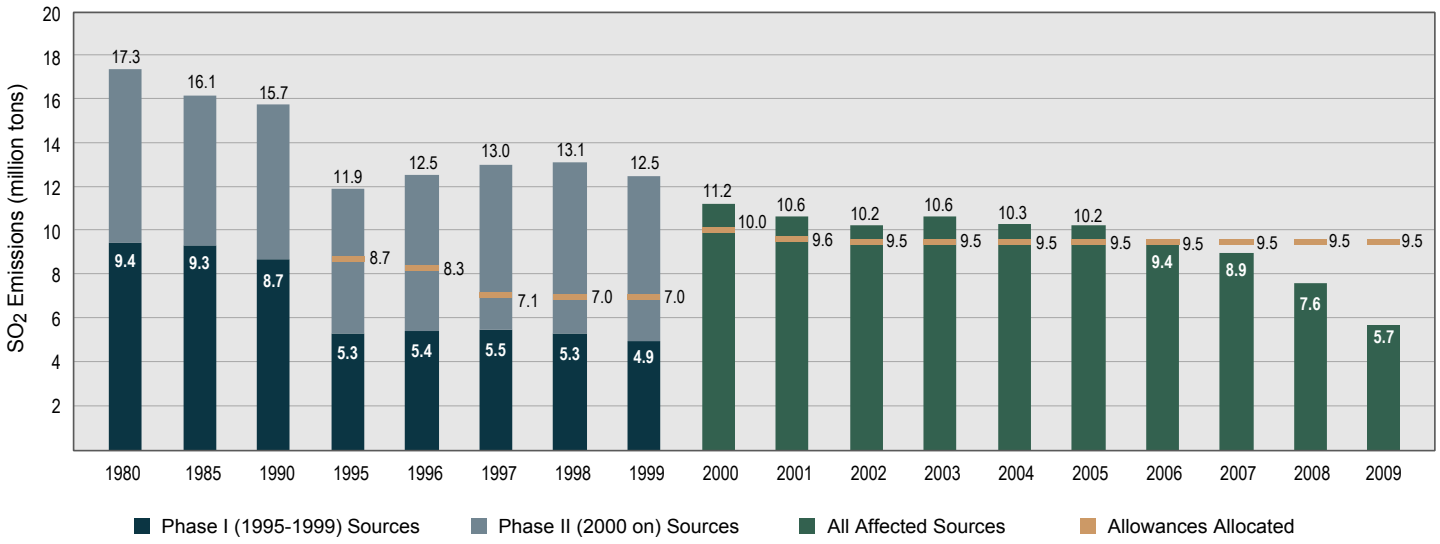



* Generation from fossil fuel-fired plants.

** Constant year 2000 dollars adjusted for inflation.

Source: Energy Information Administration (electricity generation, retail price); EPA (heat input and emissions, representing all affected ARP units), 2010. EIA data are preliminary.

**Figure 2: $SO_2$ Emissions from Acid Rain Program Sources, 1980 – 2009**




Source: EPA, 2010

EPA is releasing a series of reports summarizing progress under the ARP. A previous online report presented 2009 data on $SO_2$ and $NO_x$ emission reductions and compliance results under the ARP. This second report analyzes 2009 data on emission reductions, reviews compliance results, and summarizes market activity. A future report will compare changes in emissions to changes in acid deposition and surface water chemistry. For more information on the ARP, please visit <www.epa.gov/airmarkets/progsregs/arp/index.html>.

## $SO_2$

### $SO_2$ Emission Reductions

The $SO_2$ requirements under the ARP apply to EGUs, fossil fuel-fired combustors that serve a generator that provides electricity for sale, with an output greater than 25 megawatts. The vast majority of ARP $SO_2$ emissions result from coal-fired EGUs, although the program also applies to oil and gas units. As Figure 2 shows, ARP units have reduced annual $SO_2$ emissions by 67 percent compared with 1980 levels and 64 percent compared with 1990 levels. Sources emitted 5.7 million tons of $SO_2$ in 2009, well below the current annual emission cap of 9.5 million tons, and already below the statutory annual cap of 8.95 million tons set for compliance in 2010.

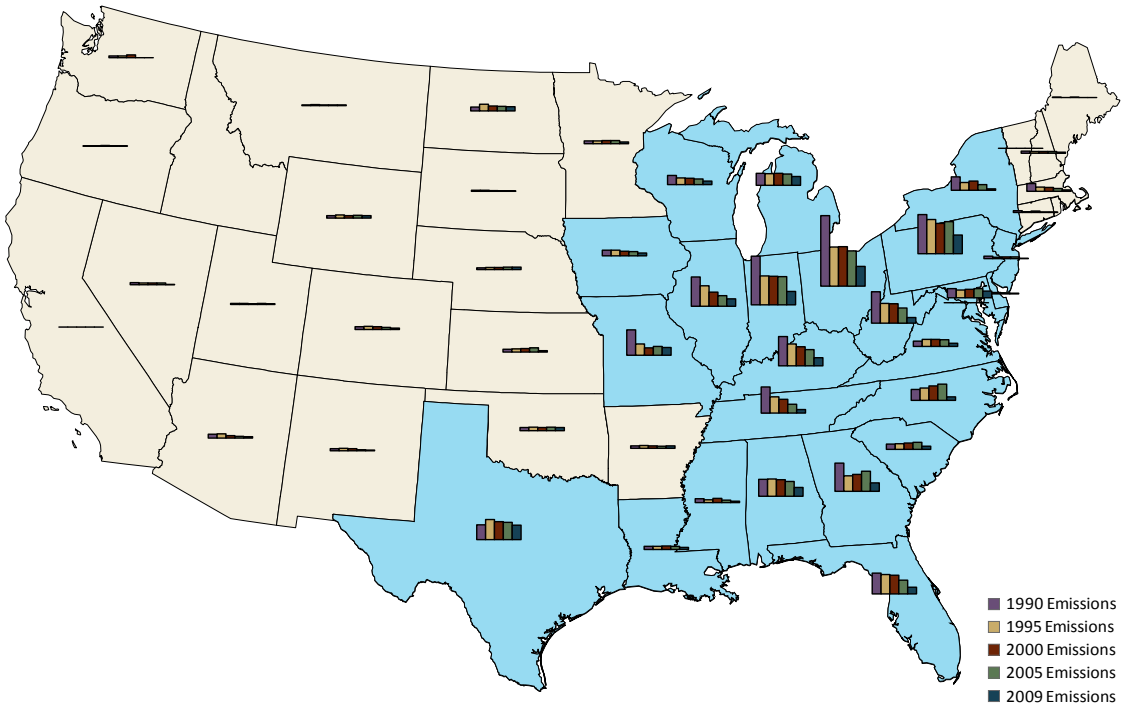
The states with the highest emitting sources in 1990 have generally seen the greatest $SO_2$ reductions under the ARP (see Figure 3). Most of these states are upwind of the areas the ARP was designed to protect, and reductions have resulted in important environmental and health benefits over a large region. In addition, from 2008 to 2009, reductions in $SO_2$ emissions from ARP units in 45 states totaled about 1.89 million tons, or about 25 percent for the year. Six states (Georgia, Indiana, North Carolina, Ohio, Pennsylvania, and West Virginia) accounted for most of the one-year reductions from 2008 to 2009, with reductions ranging from 108,758 to 258,296 tons of $SO_2$ in each of these states.

From 1990 to 2009, total annual $SO_2$ emissions in 41 states and the District of Columbia declined by approximately 10 million tons. In contrast, total annual $SO_2$ emissions in the remaining seven states increased by a total of 39,521 tons from 1990 to 2009. The seven states with the greatest reductions in annual emissions since 1990 include Ohio, which decreased emissions by over 1.5 million tons, Indiana, which reduced its emissions by over 1 million tons, and Illinois, Kentucky, Pennsylvania, Tennessee, and West Virginia, each of which reduced total emissions during this time by more than 500,000 tons. To view emission data in an interactive format using Google Earth or a similar three-dimensional platform, go to <www.epa.gov/airmarkets/progress/interactivemapping.html>.

### Why $SO_2$ Emissions Decreased in 2009

The 25 percent reduction in $SO_2$ emissions in 2009, the largest year-over-year emission drop in the program's history was caused in part by lower demand for power. Evidence of this is the 7.5 percent drop in heat input, a surrogate measure of electricity generation (see Table 1). Had the overall $SO_2$ emission rate (the amount of $SO_2$ emitted per unit of heat input, shown in Table 2) remained unchanged

### Figure 3: State-by-State $SO_2$ Emission Levels for Acid Rain Program Sources, 1990 – 2009




Note: States shaded in blue are in the CAIR Annual $NO_x$ and $SO_2$ programs.
Scale: Largest bar equals 2.2 million tons of $SO_2$ emissions in Ohio, 1990.
Source: EPA, 2010

from 2008 to 2009, the overall drop in demand would have resulted in a reduction of approximately 580,000 tons, only 30 percent of the actual reduction . The remaining 1.3 million tons of reduced $SO_2$ emissions can be explained by other factors such as the installation of $SO_2$ control technologies and fuel switching.

Thirty seven units installed $SO_2$ controls in 2009, reducing their collective $SO_2$ emission rate from 1.83 lb/mmBtu in January to 0.24 lb/mmBtu in December. The remaining sources in the ARP reported a steady annual $SO_2$ rate of 0.43 lb/mmBtu (see Figure 4). Had these newly-controlled units maintained their collective annual 2008 emission rate of 1.7 lb/mmBtu through 2009, their estimated emissions would have fallen by only 17 percent from 2008 due to reduced heat input. In actuality, the thirty seven units reduced their 2009 emissions by 50 percent by adding scrubbers, contributing over half a million tons in reductions to

### Table 1: $SO_2$, $NO_x$, and Heat Input Trends in Acid Rain Program Units, by Fuel Type

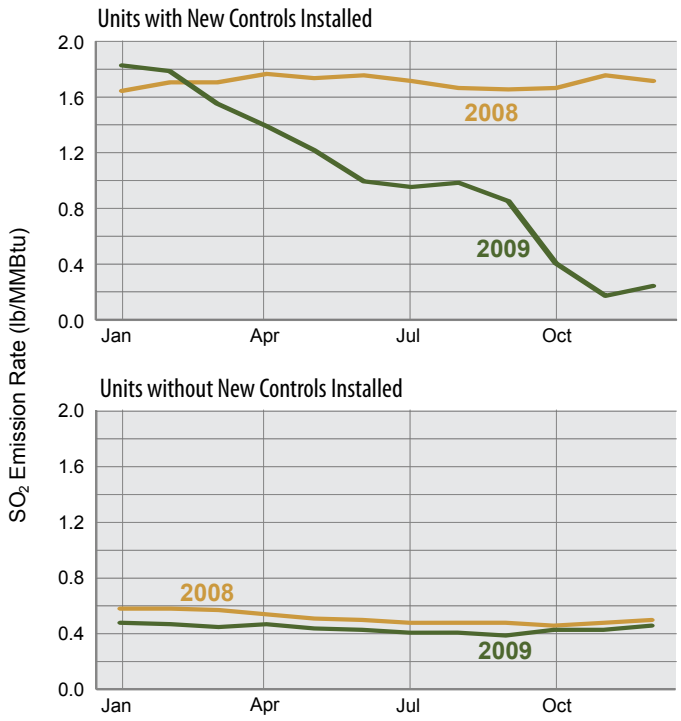
| | 2005 | | | 2006 | | | 2007 | | | 2008 | | | 2009 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fuel Type | $SO_2$ | $NO_x$ | HI | $SO_2$ | $NO_x$ | HI | $SO_2$ | $NO_x$ | HI | $SO_2$ | $NO_x$ | HI | $SO_2$ | $NO_x$ | HI |
| Coal | 9,835 | 3,356 | 20.77 | 9,243 | 3,208 | 20.44 | 8,767 | 3,069 | 20.75 | 7,517 | 2,817 | 20.25 | 5,656 | 1,824 | 18.03 |
| Gas | 34 | 142 | 5.35 | 7 | 131 | 5.7 | 10 | 141 | 6.33 | 7 | 129 | 6.21 | 5 | 125 | 6.51 |
| Oil | 350 | 129 | 0.99 | 135 | 63 | 0.58 | 149 | 68 | 0.61 | 84 | 46 | 0.48 | 55 | 32 | 0.37 |
| Other | 4 | 6 | 0.03 | 7 | 7 | 0.05 | 7 | 5 | 0.06 | 9 | 5 | 0.06 | 8 | 3 | 0.06 |
| Total | 10,223 | 3,633 | 27.14 | 9,393 | 3,409 | 26.77 | 8,934 | 3,284 | 27.74 | 7,616 | 2,997 | 27.01 | 5,724 | 1,984 | 24.97 |

Notes: Emissions are in thousand tons, and heat input data are in quadrillion Btu (Quads). Totals may not reflect the sum of individual rows due to rounding. Fuel type represents primary fuel type; many electric generation units might combust more than one fuel.
EPA data in Table 1 and used elsewhere in this report are current as of June 9, 2010, and may differ from past or future reports as a result of resubmissions by sources and ongoing data quality assurance activities.

Source: EPA, 2010

The Clean Air Interstate Rule (CAIR) was designed to reduce the amount of ozone and fine particulate matter ($PM_{2.5}$) pollution that crosses state boundaries. To achieve these reductions CAIR uses three separate cap and trade programs to limit emissions of nitrogen oxides ($NO_x$) and sulfur dioxide ($SO_2$), which contribute to the formation of ozone and $PM_{2.5}$. The CAIR $NO_x$ ozone season program controls ozone formation under a summer-only $NO_x$ reduction program, while the CAIR $NO_x$ annual and CAIR $SO_2$ annual programs control the formation of $PM_{2.5}$ year round. The CAIR $NO_x$ ozone season and annual programs began in 2009, while required reductions under the CAIR $SO_2$ annual program began in 2010.

## Figure 4: Monthly $SO_2$ Emission Rates




Source: EPA, 2010

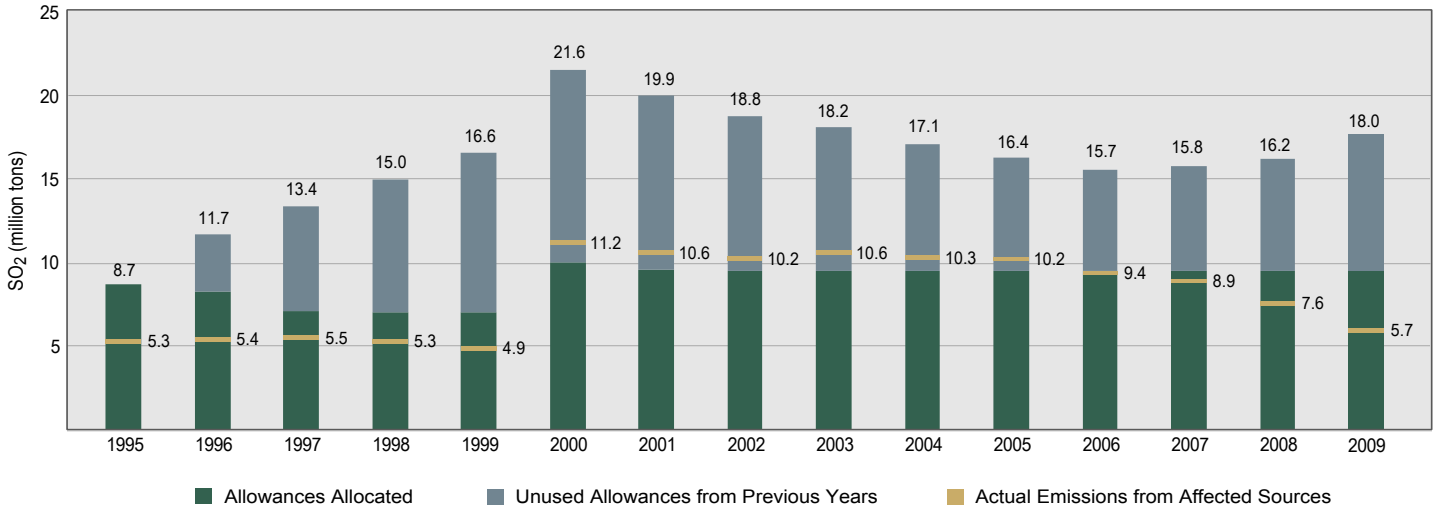
the total program-wide annual reduction of approximately 1.9 million tons. Because the new controls were installed at different times throughout 2009, the annual reduction reflects only partial operation, and the overall benefits of the new systems will be even greater in 2010. Thirty four of these units are in the Clean Air Interstate Rule (CAIR) $SO_2$ program, suggesting that the controls were installed to meet the emission reductions that will be required in 2010, the CAIR $SO_2$ program's first compliance year.

## Table 2: $SO_2$ and $NO_x$ Emission Rates by Fuel Type

| Fuel Type | 2005 | | 2006 | | 2007 | | 2008 | | 2009 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $SO_2$ | $NO_x$ | $SO_2$ | $NO_x$ | $SO_2$ | $NO_x$ | $SO_2$ | $NO_x$ | $SO_2$ | $NO_x$ |
| Coal | 0.95 | 0.32 | 0.90 | 0.31 | 0.84 | 0.30 | 0.74 | 0.28 | 0.63 | 0.20 |
| Gas | 0.01 | 0.05 | <0.01 | 0.05 | <0.01 | 0.04 | <0.01 | 0.04 | <0.01 | 0.04 |
| Oil | 0.70 | 0.26 | 0.47 | 0.22 | 0.49 | 0.22 | 0.35 | 0.19 | 0.30 | 0.17 |
| Other | 0.27 | 0.42 | 0.29 | 0.29 | 0.26 | 0.20 | 0.28 | 0.16 | 0.27 | 0.11 |
| Total | 0.75 | 0.27 | 0.70 | 0.25 | 0.64 | 0.24 | 0.56 | 0.22 | 0.46 | 0.16 |

Source: EPA, 2010

## Figure 5: $SO_2$ Emissions and the Allowance Bank, 1995-2009




Source: EPA, 2010

### $SO_2$ Program Compliance

All 3,572 units at ARP facilities complied in 2009 with the requirement to hold enough allowances to cover $SO_2$ emissions. EPA allocated 9.5 million $SO_2$ allowances under the ARP for 2009. In addition to the 8.5 million unused allowances carried over (or banked) from prior years, there were 18 million allowances available for use in 2009 (see Figure 5). ARP sources emitted approximately 5.7 million tons of $SO_2$ in 2009, less than the allowances allocated for the year, and far less than the total allowances available. As a result, between 2008 and 2009 the bank increased by nearly four million allowances to 12.3 million allowances, a 45 percent increase. In 2010, the total number of Title IV allowances allocated annually will drop to 8.95 million and remain statutorily fixed at that level.

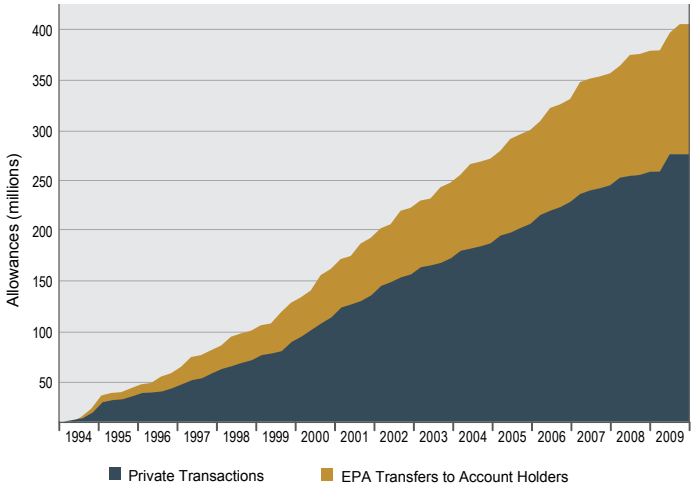
### 2009 $SO_2$ Allowance Market

Figure 6 shows the cumulative volume of $SO_2$ allowances transferred under the ARP. The figure differentiates between allowances transferred in private transactions and those annually allocated and transferred to source accounts by EPA.

Private transactions are indicative of both market interest and use of allowances as a compliance strategy. Approximately 67 percent of the nearly 406 million allowances transferred since 1994 have been traded in private transactions. Beginning in December 2001, parties had access to a system developed by EPA to allow online allowance transfers. By 2008, account holders were registering over 99 percent of all private allowance transfers through EPA's online transfer system. Allowance transfers are posted and updated daily on <www.epa.gov/airmarkets>.

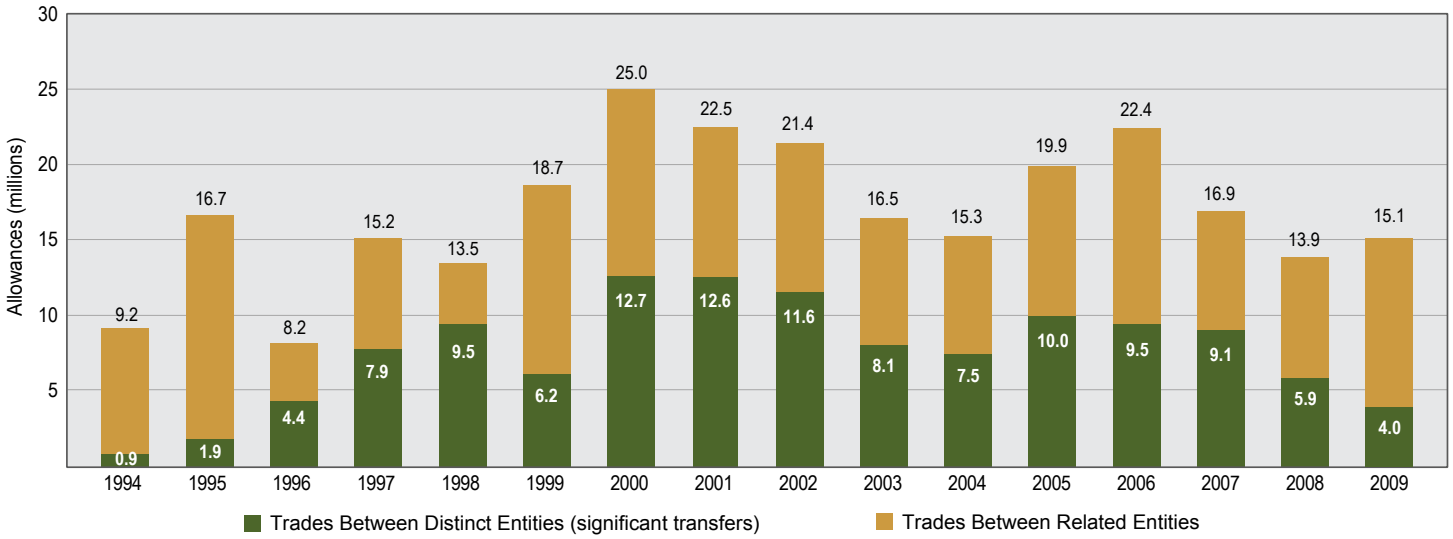
In 2009, 2,716 private allowance transfers involving approximately 15.1 million allowances of past, current, and future vintages were recorded in EPA's Allowance Management System. About 4 million allowances (26 percent) were transferred in economically significant transactions

**Figure 6: Cumulative $SO_2$ Allowances Transferred under the ARP (through 2009)**




Source: EPA, 2010

**Figure 7: $SO_2$ Allowances Transferred under the ARP**




Source: EPA, 2010

(i.e., between economically unrelated parties). Transfers between economically unrelated parties are "arm's length" transactions and are considered a better indicator of an active, functioning market than are transactions among the various facility and general accounts associated with a given company. In the majority of all private transfers, allowances were acquired by power companies. Figure 7 shows the annual volume of $SO_2$ allowances transferred under the ARP (excluding allocations, retirements, and other transfers by EPA) since official recording of transfers began in 1994.

**Table 3: $SO_2$ Allowance Market in Brief (close of 2009)**

| | |
|---|---|
| Total Value of the $SO_2$ Allowance Market | $1.1 billion |
| Year-End Price | $61 per ton |
| Total Allowance Volume (Allowable Emissions) | 18,017,192 |
| 2009 Private Transactions | 2,716 transactions moving 15.1 million allowances<br>26 percent of allowances transferred between economically unrelated parties |

Note: Total value of allowance market is a snapshot based on the average nominal price as of December 2009 ($61/ton) and total allowance volume available for 2009 compliance.
Source: EPA, 2010 and CantorCO2e Market Price Index, 2010

Over the first decade of the ARP, allowance prices were stable and significantly lower than projected. When CAIR was proposed in late 2003, allowance prices were influenced by the more stringent CAIR $SO_2$ cap and the new compliance deadlines. The Acid Rain $SO_2$ market essentially had become the CAIR $SO_2$ market.

During 2009, the $SO_2$ allowance market experienced a 67 percent price decline; the monthly average price fell from $187 per ton in January to $61 per ton in December. That decline has continued in 2010, with the monthly average price falling to $40 per ton by May. See Table 3 for a summary of the 2009 $SO_2$ allowance market.

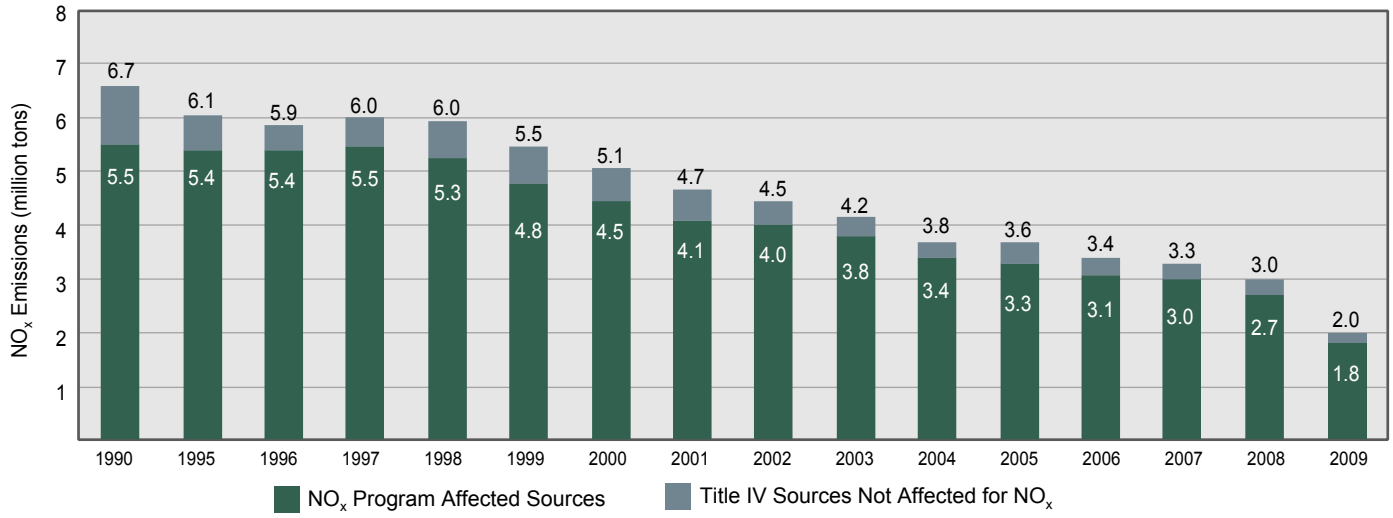
## $NO_x$

### $NO_x$ Emission Reductions

Title IV requires $NO_x$ emission reductions for certain coal-fired EGUs by limiting the $NO_x$ emission rate (expressed in lb/mmBtu). Congress applied these rate-based emission limits according to a unit's boiler type. The goal of the $NO_x$ program is to limit $NO_x$ emission levels from the affected coal-fired boilers so that their emissions are at least two million tons less than the projected level for 2000 without implementation of Title IV.

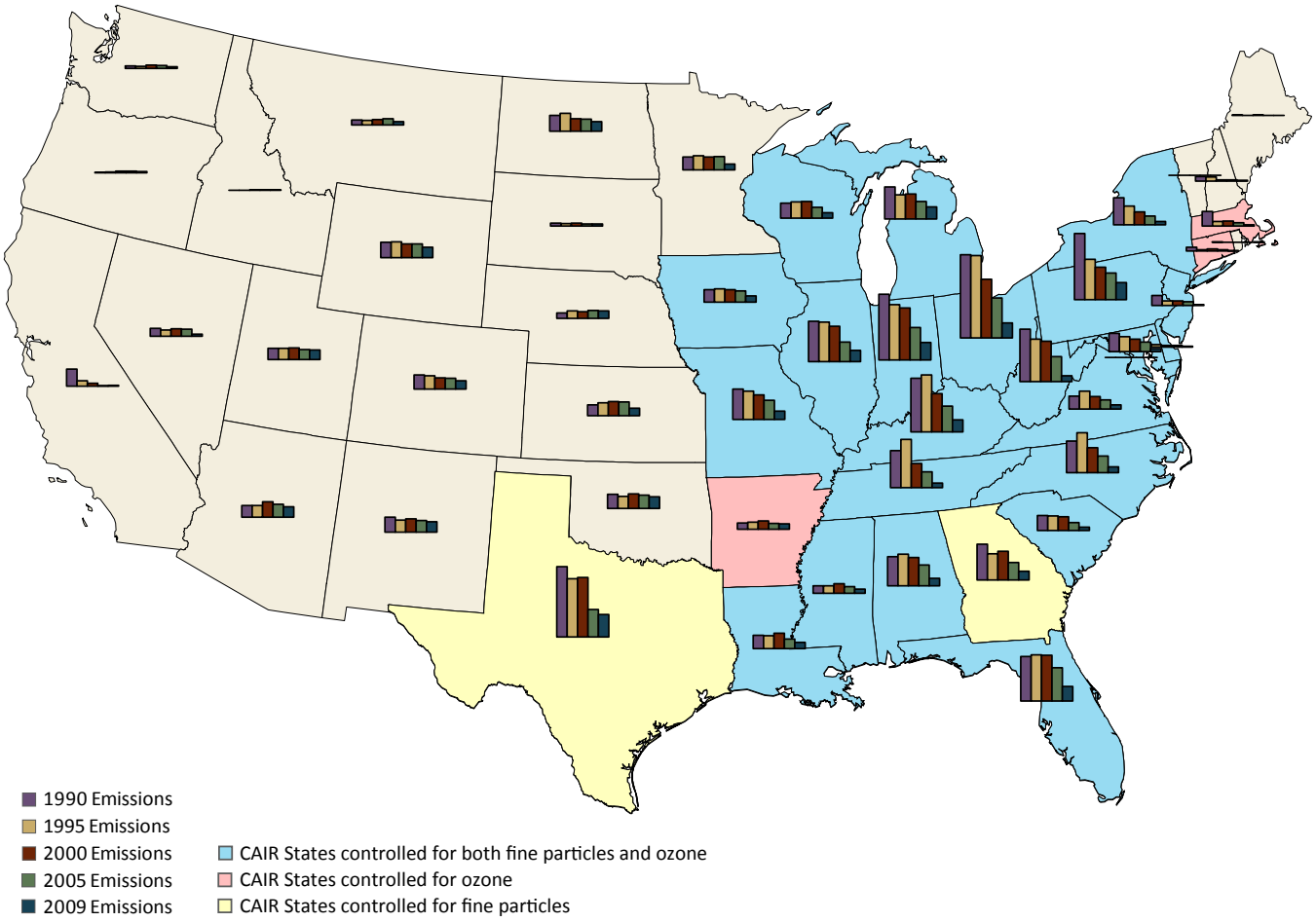
Figure 8 shows that $NO_x$ emissions from all ARP sources were 2.0 million tons in 2009. This level is 6.1 million tons less than the projected level in 2000 without the ARP, or more than triple the Title IV $NO_x$ emission reduction objective. Although the ARP was responsible for a large portion of these annual $NO_x$ reductions, other programs — such as CAIR, the $NO_x$ Budget Program under EPA's $NO_x$ State Implementation Plan (SIP) Call, the Ozone Transport Commission (OTC), and other regional and state $NO_x$ emission control programs — contributed significantly to the $NO_x$ reductions achieved by sources in 2009. The significant drop from 2008 to 2009 is the largest single year decline in the history of the program. Lower demand for electricity contributed to reduced $NO_x$ emissions, but ARP sources reduced their NOx emission rate from 0.22 lb/mmBtu in 2008 to 0.16 lb/mmBtu in 2009. This large reduction in

**Figure 8: $NO_x$ Emission Trends for All Acid Rain Program Units, 1990-2009**




Source: EPA, 2010

**Figure 9: State-by-State $NO_x$ Emission Levels for All Acid Rain Program Sources, 1990-2009**




Scale: Largest bar equals 500,000 tons of $NO_x$ emissions in Ohio, 1990.
Source: EPA, 2010

emissions is primarily attributable to compliance with the annual and ozone season CAIR $NO_x$ programs beginning in 2009.

From 1995 to 2009, annual $NO_x$ emissions from ARP units dropped by about 4.1 million tons, a net decrease of 67 percent. Forty-four states and the District of Columbia reduced $NO_x$ emissions between 1995 and 2009, while the remaining six states accounted for only 5,542 tons of increased $NO_x$ emissions during this period (see Figure 9).

### Seasonal $NO_x$ Control Programs

States subject to EPA's 1998 $NO_x$ SIP Call have significantly reduced ozone season $NO_x$ emissions since the baseline years 1990 and 2000. All of these states have achieved reductions since 1990 as a result of programs implemented under the 1990 CAA Amendments, with many of them reducing their emissions by more than half in this period. A significant percentage of decreases in $NO_x$ emissions has occurred since 2000. This has been largely a result of reductions under ozone season $NO_x$ trading programs implemented by the OTC, from 1999-2002, under the $NO_x$ SIP Call, from 2003-2008, and under CAIR in 2009. For reports about these programs, see EPA's Clean Air Markets Progress Reports page at <www.epa.gov/airmarkets/progress/progress-reports.html>.

### $NO_x$ Compliance

The ARP $NO_x$ Program does not impose a cap on $NO_x$ emissions and does not rely on allowance trading. The program allows affected sources to comply either by meeting a unit-specific emission rate or by including two or more units in an emission rate averaging plan. These options provide affected sources with the flexibility to meet the $NO_x$ emission reduction requirements in a cost-effective manner. In 2009, all 960 units that were subject to the ARP $NO_x$ Program achieved compliance.

### Sources Achieved 100 Percent $NO_X$ Compliance in 2009, Using a Variety of $NO_X$ Compliance Plan Options

**Standard Limitation.** A unit with a standard limit meets the applicable individual $NO_X$ limit prescribed for its boiler type under 40 CFR Parts 76.5, 76.6, or 76.7 (297 units used this option in 2009).

**Emissions Averaging.** Many companies meet their $NO_X$ emission reduction requirements by choosing to become subject to a group $NO_X$ limit, rather than by meeting individual $NO_X$ limits for each unit. The group limit is established at the end of each calendar year. The group rate must be less than or equal to the Btu-weighted group rate units would have had if each had emitted at their standard limit rate (660 units used this option in 2009).

**Alternative Emission Limit (AEL).** A utility can petition for a less stringent AEL if it properly installs and operates the $NO_X$ emission 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 emission data and information about the $NO_X$ control equipment (three units used this option in 2009).

**Note:** Unit counts do not include those with a retired unit exemption.

## Emission Monitoring and Reporting

The ARP requires regulated sources to measure, record, and report emissions using continuous emission monitoring systems (CEMS) or an approved alternative measurement method. The vast majority of emissions are monitored with CEMS, while the alternatives provide an efficient means of monitoring emissions from the large universe of units with lower overall mass emissions. Table 4 shows the number of units with and without $SO_2$ CEMS for various fuel types, as well as the amount of $SO_2$ emissions monitored using CEMS. Although only 31 percent of units use CEMS, over 99 percent of all $SO_2$ emissions from ARP sources are monitored in this fashion.

CEMS and approved alternatives are a cornerstone of the ARP's accountability and transparency. Since the program's inception in 1995, affected sources have met stringent quality assurance and control requirements for monitoring found in 40 CFR Part 75. These provisions apply as well to sources participating in the CAIR trading programs. Since 1999, affected sources have reported hourly emission data in quarterly electronic reports to EPA. Using automated software audits, EPA rigorously checks the completeness, quality, and integrity of these data. All emission data are available to the public on the Data and Maps website maintained by EPA's Clean Air Markets Division (CAMD) at

**Table 4: Units and $SO_2$ Emissions Covered by Monitoring Method for the Acid Rain Program in 2009**

| | | Number of Units | Percentage of Units | Percentage of $SO_2$ Emissions |
|---|---|---|---|---|
| Coal | CEMS | 1,044 | 29.4 | 98.80 |
| Gas | CEMS | 14 | 0.4 | 0.03 |
| | Non-CEMS | 2,277 | 64.1 | 0.06 |
| Oil | CEMS | 43 | 1.2 | 0.16 |
| | Non-CEMS | 158 | 4.5 | 0.80 |
| Other | CEMS | 13 | 0.4 | 0.15 |
| | Non-CEMS | 1 | < 0.1 | < 0.01 |

Note: The table excludes affected units that did not operate in 2009. "Other fuel units" include units that in 2009 combusted primarily wood, waste, or other nonfossil fuel.
Source: EPA, 2010

<camddataandmaps.epa.gov/gdm/>. The site also provides access to other data associated with emission trading programs, including reports, queries, maps, charts, and file downloads covering source information, emissions, allowances, program compliance, and air quality.

### ECMPS

Sources use the Emissions Collection and Monitoring Plan System (ECMPS) to evaluate and report their quarterly emissions data, along with monitoring plans and quality assurance data, to EPA. ECMPS is a desktop tool provided by EPA to the regulated community; authorized users are able to use tools and procedures in ECMPS to quality assure their data prior to submission. The data validation checks in ECMPS are easily expanded, and assist EPA in implementing improved auditing as sources comply with new CAMD programs.

## Overall Progress Lowering Emissions

Figures 1, 2, 3, and 8 provide a sense of the emission reductions of $SO_2$ and $NO_X$ that have resulted from the electric power industry under the Acid Rain Program and related programs over time. Another useful measure is the improvement in emission rates of the fossil generation fleet over time. Table 5 provides this information for $SO_2$ and $NO_X$ from 1990 through 2009. For this time period, the $SO_2$ rate has dropped 71 percent and the $NO_X$ rate has dropped 77 percent.

**Table 5: $SO_2$ and $NO_X$ Emission Rates, 1990 – 2009**

| | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|
| $SO_2$ | 1.60 | 1.09 | 0.88 | 0.75 | 0.70 | 0.64 | 0.56 | 0.46 |
| $NO_X$ | 0.68 | 0.56 | 0.40 | 0.27 | 0.26 | 0.24 | 0.22 | 0.16 |

Source: EPA, 2010