Acid Rain and Related Programs: 2009 Highlights

15 Years of Results

1995 to 2009

United States Environmental Protection Agency

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 oxide (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, and includes provisions for trading and banking emission allowances. 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.

The 2009 compliance year marked the fifteenth anniversary of the ARP and fifteen years of compliance emissions monitoring data. The program's success has demonstrated that market-based trading systems can cost-effectively reduce pollution and address environmental damage. The ARP's example led the way for programs like the NO_x Budget Program (NBP) and the Clean Air Interstate Rule (CAIR).

From August to October 2010, the U.S. Environmental Protection Agency (EPA) released three reports detailing progress under the ARP. These reports can be accessed at <www.epa.gov/airmarkets/progress/ARP09.html>. This report highlights the key results from the previous reports and discusses the effects of CAIR.

For more information on the ARP, please visit: <www.epa.gov/airmarkets/progsregs/arp/index.html>. Detailed emission results and other facility and allowance data are also publicly available on EPA's Data and Maps website at <camddataandmaps.epa.gov/gdm>. To view emission and other facility information in an interactive file format using Google Earth or a similar three-dimensional platform, go to <www.epa.gov/airmarkets/progress/interactivemapping.html>. Additionally, updated quarterly SO_2 emission data for ARP coal-fired power plants can be found at <www.epa.gov/airmarkets/quarterlytracking.html>. For general information on cap and trade programs, please visit: <www.epa.gov/captrade/>.

Dedicated to Brian McLean, PhD., on his retirement after 41 years of distinguished public service. Among his many contributions to improving public health and the environment, Mr. McLean led EPA's efforts to design and implement the acid rain cap and trade program — recognized nationally and internationally as a model for innovative and effective environmental protection. The 15 years of progress accomplished by the Acid Rain Program and documented in this report are due in large measure to the vision, leadership, hard work and keen practicality of Mr. McLean.

Key Components of the ARP SO_2 Trading Program

Phases and Reductions: Title IV of the 1990 CAA Amendments set a goal of reducing annual SO_2 emissions by 10 million tons from all sources (8.4 million tons from power plants) below 1980 levels. To achieve these reductions, the law required a two-phase tightening of the restrictions placed on fossil fuel-fired power plants. Phase I began in 1995 and Phase II began in the year 2000.

Allowance Allocation: The EPA allocates allowances to affected utility units based on their historic fuel consumption and a specific emissions rate. Each allowance permits a unit to emit 1 ton of SO_2 during or after a specified year.

Annual Reconciliation: For each ton of SO_2 emitted in a given year, one allowance is retired, that is, it can no longer be used. Allowances may be bought, sold, or banked. At the end of each year, sources are granted a 60-day grace period to ensure that they have sufficient allowances to match their SO_2 emissions during the previous year. If they need to, they may buy allowances during the grace period. Sources may sell allowances that exceed their emissions or bank them for use in future years.

Allowance Trading: SO_2 allowance trading minimizes compliance costs, and since unused allowances can be sold to other program participants, the system encourages units to reduce emissions beyond required levels.

Flexible Compliance: Each source can choose the most efficient way to reduce its SO_2 emissions. Installing new control technology, switching to lower-sulfur fuel, or optimizing existing controls are all options.

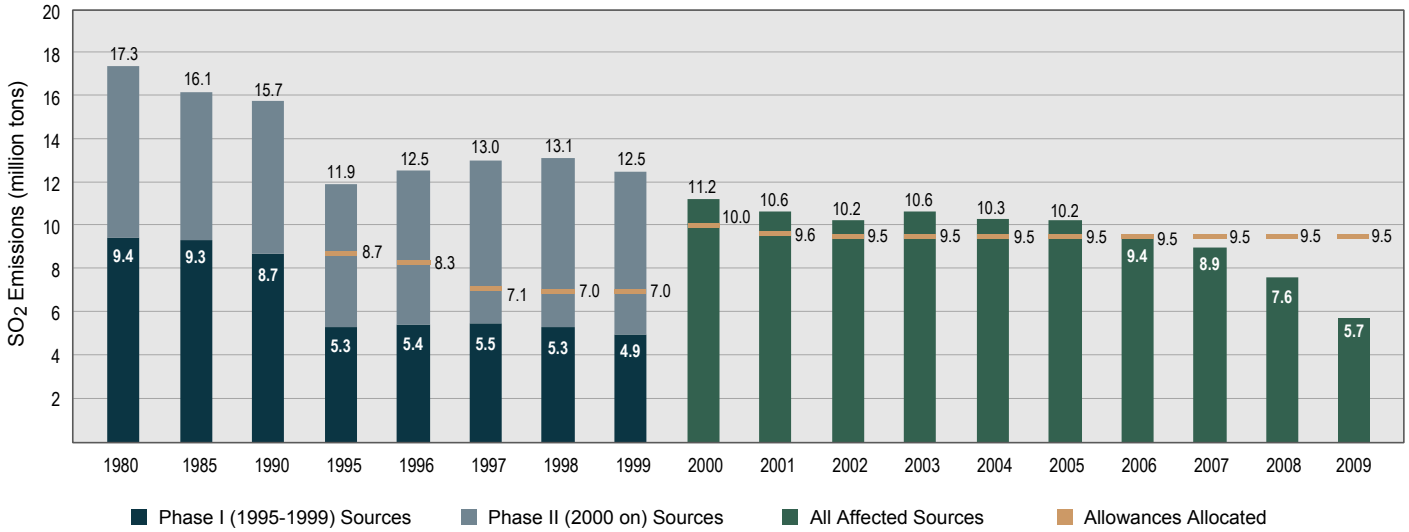
Stringent Monitoring: Each source must continuously measure and record its emissions of SO_2, NO_x, and CO_2, as well as heat input, volumetric flow, and opacity. Most emissions are measured using a continuous emission monitoring system (CEMS).

Automatic Penalties and Enforcement: Any source that fails to hold enough allowances to match its SO_2 emissions for the previous year must pay to EPA an automatic penalty of $2,000 (inflation-adjusted to $3,517 for 2009) per ton of emissions in excess of allowances held. The source must also immediately surrender to EPA an amount (referred to as an "offset") of allowances, issued for the year the payment is due, equalling the tons of excess emissions.

Key Results of the SO_2 Trading Program

Affected Units: The SO_2 requirements under the ARP apply to EGUs, fossil fuel-fired combustors that serve a generator that provides electricity for sale. The vast majority of ARP SO_2 emissions result from coal-fired EGUs (close to 99 percent), although the program also applies to oil and gas units. There were 3,572 EGUs subject to the ARP's SO_2 requirements in 2009. These units were at 1,231 facilities and 417 of those facilities had coal-fired generating units.

Figure 1: SO_2 Emissions from Acid Rain Program Sources, 1980–2009



Note: ARP units have reduced annual SO_2 emissions by 67 percent compared with 1980 levels and 64 percent compared with 1990 levels.

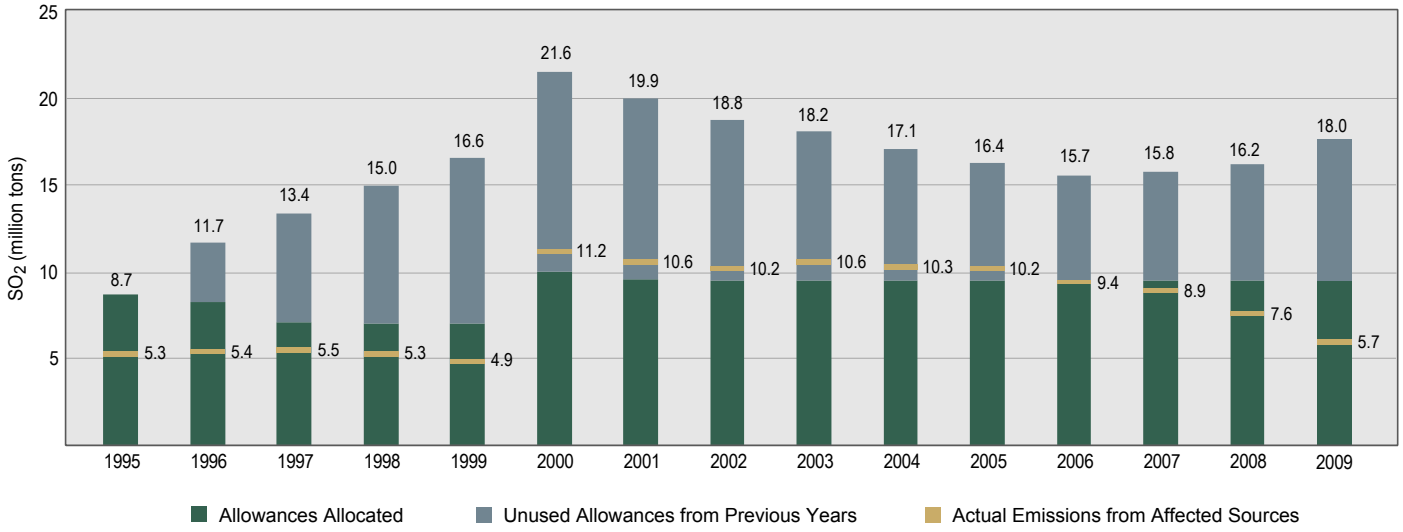
Source: EPA, 2010

SO_2 Emission Reductions: As Figure 1 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 (see Figure 2).

Compliance: All 3,572 units at ARP facilities complied in 2009 with the requirement to hold enough allowances to cover SO_2 emissions.

Allowances: EPA allocated 9.5 million SO_2 allowances under the ARP for 2009. When added to the 8.5 million unused allowances carried over (or banked) from prior years, there were a total of 18 million allowances available for use in 2009 (see Figure 2). 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 dropped to 8.95 million and remains statutorily fixed at that level.

Figure 2: SO_2 Emissions and the Allowance Bank, 1995–2009



Source: EPA, 2010

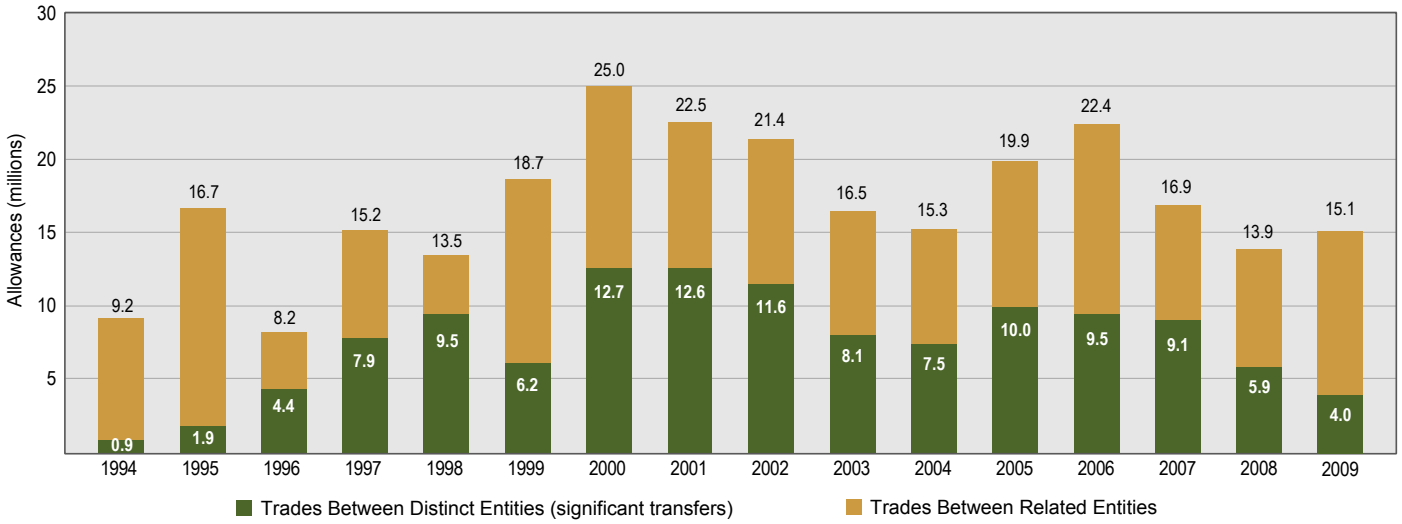
Allowance Market: In 2009, 2,716 private allowance transfers involving approximately 15.1 million allowances of past, current, and future vintages were recorded in EPA's Allowance Management System (see Table 1 for a summary of the SO_2 allowance market at the close of 2009). About 4 million allowances (26 percent) were transferred in economically significant transactions (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 3 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 1: 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 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

Figure 3: SO_2 Allowances Transferred under the ARP



Source: EPA, 2010

Key Results of the NO_x Program

Title IV requires NO_x emission reductions for certain coal-fired EGUs by limiting the NO_x emission rate (expressed in lb/mmBtu) to a value based on 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 2 million tons less than the projected level for the year 2000 without implementation of Title IV. EPA estimated this projected number to be 8.1 million tons.

NO_x Emission Reductions: Figure 4 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 NBP 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 also reduced their NO_x emission rate from 0.22 lb/MMBtu in 2008 to 0.16 lb/MMBtu in 2009. This large reduction in emissions is primarily attributable to compliance with the annual and ozone season CAIR NO_x programs beginning in 2009.

Compliance: In 2009, all 960 units that were subject to the ARP NO_x Program achieved compliance.

Overall Progress Lowering Emissions

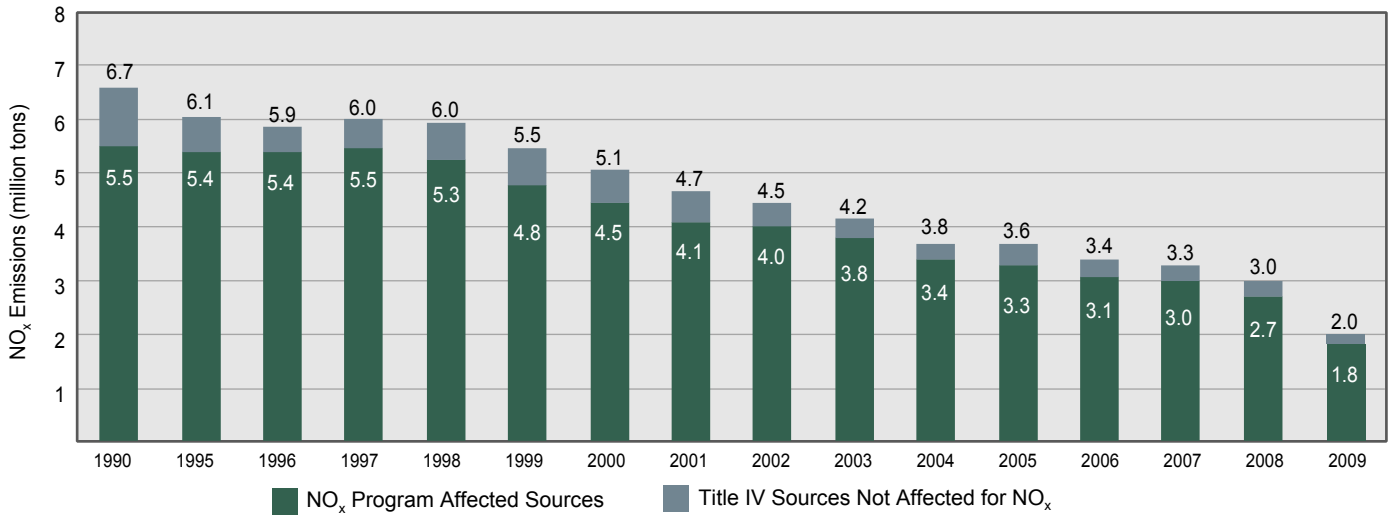
Figures 1 and 4 provide a sense of the emission reductions of SO_2 and NO_x that have resulted from the electric power industry from the ARP and related programs over time. Another useful measure is the improvement of the emissions rates of the fossil generation fleet over time. Table 2 provides this 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 2: SO_2 and NO_x Emission Rates (lb/MMBtu), 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

Figure 4: NO_x Emission Trends for All Acid Rain Program Units, 1990–2009



Source: EPA, 2010

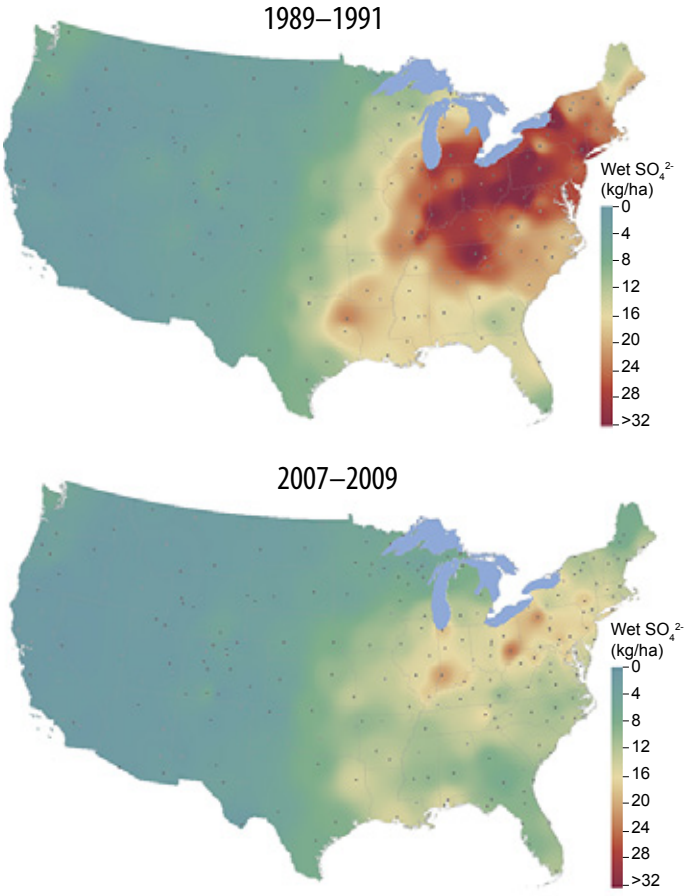
Environmental Results

SO_2 Air Quality: Data collected from monitoring networks show that the decline in SO_2 emissions from the power industry has improved air quality. The national composite average of SO_2 annual mean ambient concentrations decreased 76 percent between 1980 and 2009. The largest single-year reduction (20 percent) occurred in the first year of the ARP, between 1994 and 1995. The second largest single-year reduction (16 percent) occurred most recently between 2008 and 2009.

Acid Deposition Improvements: Monitoring data show significant improvements in the primary acid deposition indicators:

- **Wet Sulfate Deposition:** Between the 1989 to 1991 and 2007 to 2009 observation periods, regional decreases in wet deposition of sulfate averaged 43 percent for the eastern United States (see Figure 5).
- **Nitrogen Deposition:** Inorganic nitrogen in wet deposition decreased in the Mid-Atlantic and Northeast, but to a lesser extent than sulfur (see Figure 6). Wet nitrogen deposition is influenced by sources outside the ARP.

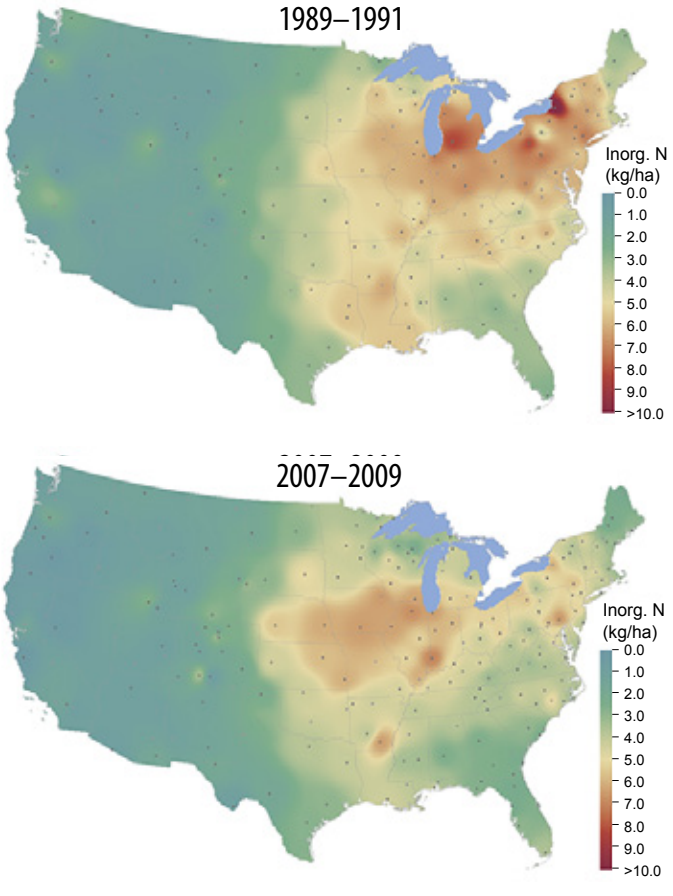
Figure 5: Annual Mean Wet Sulfate Deposition



Note: Areas of red indicate higher deposition levels and areas of green indicate lower deposition levels.

Source: NADP, 2010

Figure 6: Annual Mean Wet Inorganic Nitrogen Deposition



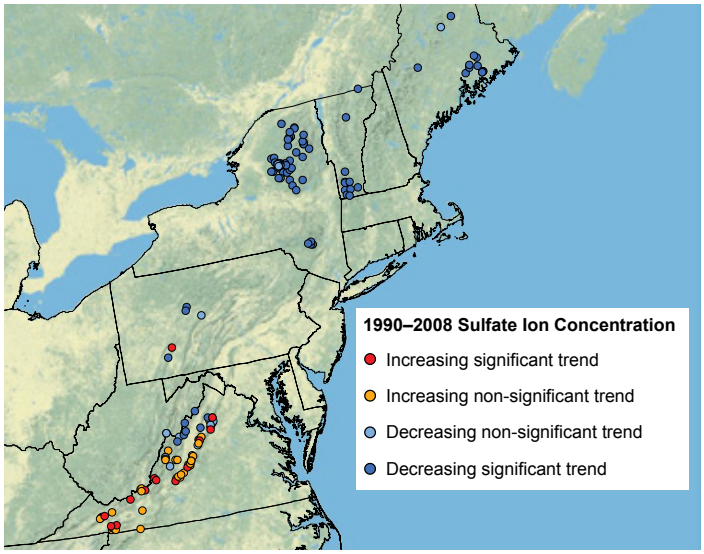
Note: Areas of red indicate higher deposition levels and areas of green indicate lower deposition levels.

Source: NADP, 2010

Surface Water Quality Improvements: Acid rain resulting from SO_2 and NO_x emissions is one of many large-scale anthropogenic impacts that negatively affect the health of lakes and streams in the United States. Surface water chemistry provides direct indicators of the potential effects of acidic deposition on the overall health of aquatic ecosystems. Long-term surface water monitoring networks provide information on the chemistry of lakes and streams and on how water bodies are responding to changes in emissions. Since the implementation of the ARP, scientists have measured changes in some lakes and streams in the eastern United States and found signs of recovery in many, but not all, of those areas.

- **Sulfate Concentrations:** Measurements of sulfate ion concentrations in surface waters provide important information on the level of acidification of a water body. Decreasing sulfate concentrations in surface water signify a trend toward recovery from acidification. Figure 7 shows that sulfate concentrations are declining at most sites in the Northeast (New England, Adirondacks, Catskills/Northern Appalachian Plateau). However, in the Central Appalachians, sulfate concentrations in some streams (21 percent) are increasing. This region has highly weathered soils that can store large amounts of deposited sulfate. As long-term sulfate deposition exhausts the soil's ability to store sulfate, a decreasing proportion of the deposited sulfate is retained in the soil and an increasing proportion is exported to surface waters. Thus sulfate concentrations in surface waters, mainly streams in this region, are increasing despite reduced sulfate deposition.

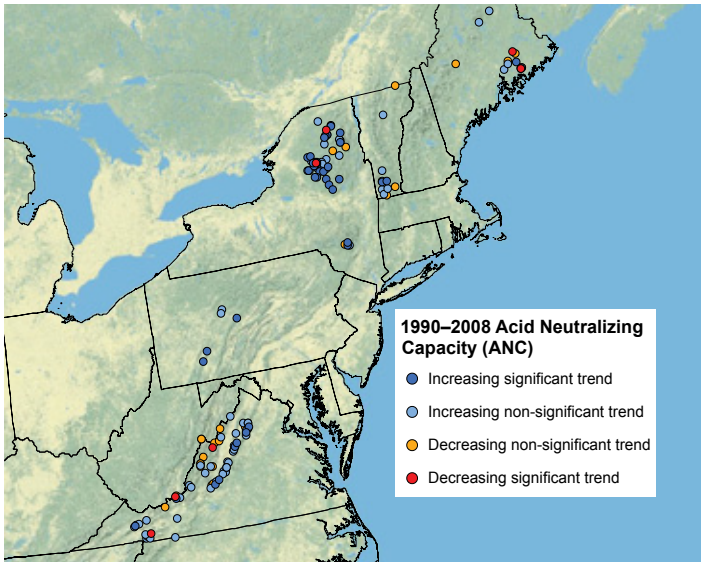
Figure 7: Trends in Lake and Stream Water Chemistry at LTM Sites, 1990–2008 — Sulfate Ion Concentration (µeq/L/yr)



Source: EPA, 2010

- **Acid Neutralization Capacity (ANC):** ANC is a measure of the sensitivity of a water body to acidification. Movement toward recovery of an acidified aquatic ecosystem is indicated by an increase in ANC. Figure 8 shows that ANC, as measured in surface waters, is increasing in many of the sites in the Adirondack and Catskills/Northern Appalachian Plateau regions, which in part can be attributed to declining sulfate deposition. The site trends also indicate variation within each region. Only 12 percent of sites in New England and the Central Appalachians have improving ANC trends, but overall, only seven sites in all regions have a significant downward trend in ANC.

Figure 8: Trends in Lake and Stream Water Chemistry at LTM Sites, 1990–2008 — ANC Levels (µeq/L/yr)



Source: EPA, 2010

Clean Air Interstate Rule (CAIR)

CAIR was issued on March 10, 2005, in order to build on the emission reductions under the NBP and the ARP. The rule was designed to permanently lower emissions of SO_2 and NO_x in the eastern United States. CAIR, as promulgated, was designed to help states address ozone nonattainment and attain the National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$ by reducing transported precursors, SO_2 and NO_x. CAIR was also expected to improve visibility in Class 1 areas, including national parks, monuments, and wilderness areas. To achieve these emission reductions, it created three separate compliance programs: an annual NO_x program, an ozone season NO_x program, and an annual SO_2 program. As Figure 9 shows, the two annual programs affect the same set of states.

Each of the three programs uses a two-phased approach, with declining emission caps in each phase. The first phase began in 2009 for the NO_x annual and NO_x ozone season programs, and started in 2010 for the SO_2 annual program. The rule also establishes a second phase for all three programs beginning in 2015.

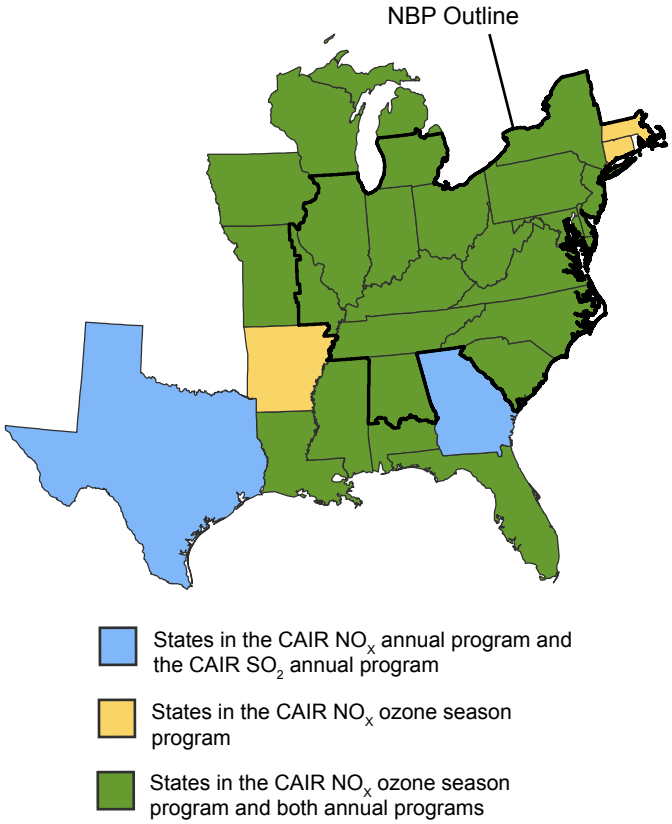
Monitoring and reporting according to EPA's regulations began in 2008 for the NO_x programs and in 2009 for the SO_2 program.

Litigation and CAIR Replacement Rule

On July 11, 2008, the U.S. Court of Appeals for the D.C. Circuit issued a ruling vacating CAIR in its entirety. EPA and other parties requested a rehearing, and on December 23, 2008, the Court revised its decision and remanded CAIR to EPA without vacatur. This ruling leaves CAIR and the CAIR Federal Implementation Plans (FIPs)—including the CAIR trading programs—in place until EPA issues new rules to replace CAIR.

EPA is committed to issuing rules to replace CAIR that will help states address the interstate air emissions transport problem in a timely way and that fully comply with the requirements of the CAA and the opinions of the D.C. Circuit. EPA has developed a proposed Transport Rule that is intended to replace CAIR in 2012. The proposed rule was signed in July 2010.

Figure 9: The CAIR Program Region



Note: In a November 2009 rule, EPA stayed the effectiveness of CAIR for Minnesota, which had previously been among the states controlled for fine particles.
Source: EPA, 2010

Current CAIR Implementation

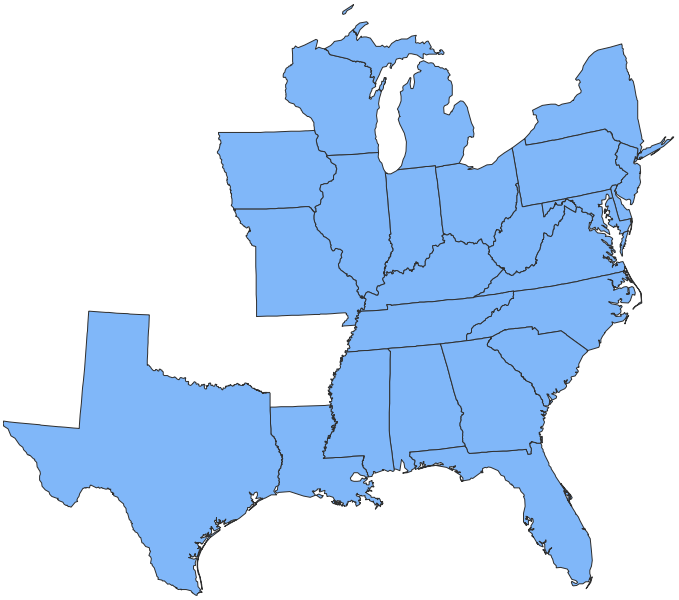
The CAIR NO_x ozone season and CAIR NO_x annual program requirements to hold allowances equivalent to ozone season and annual emissions started in 2009. For results of the first year of these programs please visit <www.epa.gov/airmarkets/progress/CAIR_09/CAIR09.html>.

The CAIR SO_2 program requirements for continuous monitoring and reporting started January 1, 2009 in the participating eastern states (see Figure 10). ARP sources that are already complying with Part 75 monitoring and reporting provisions essentially do not have to do anything additional to comply with CAIR SO_2 monitoring requirements. Sources not subject to the ARP but subject to CAIR began complying with Part 75 monitoring and reporting in 2010. The requirement to hold allowances in the CAIR SO_2 program began on January 1, 2010.

Of the 3,321 units in the CAIR SO_2 program, 2,595 (78 percent) were also covered by the ARP in 2009. The other units are largely fossil generation units that entered SO_2 control under the broader applicability requirements of CAIR. All the CAIR SO_2 program facilities participated in a monitoring and reporting training year in 2009. In 2010, the first year of operation of the CAIR SO_2 trading program, facilities were obligated to hold SO_2 allowances. Since SO_2 allowances from the ARP are used in CAIR, there has been an incentive from 2005 to 2009 for units to lower SO_2 emissions in order to have allowances under CAIR. Except for a small number of facilities with pending applicability questions, all participating units reported data in 2009. Their total SO_2 emissions were 5.0 million tons.

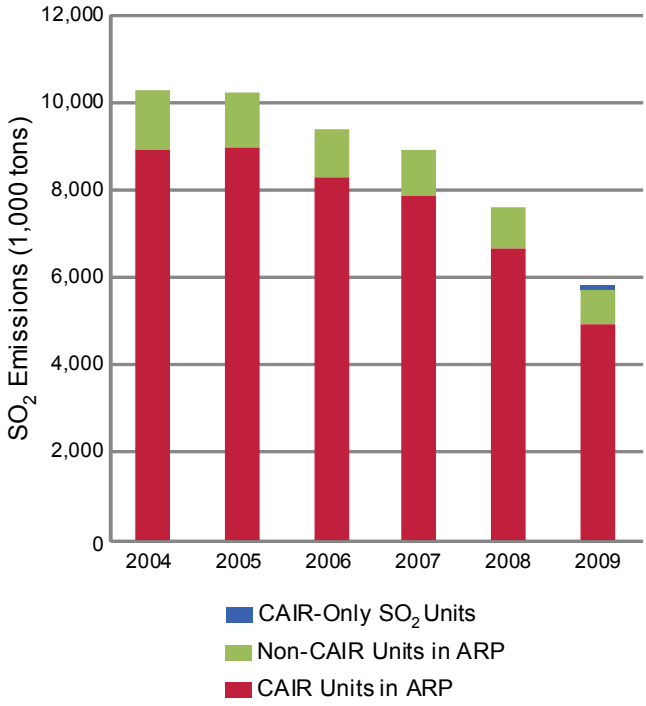
Figure 11 shows that most of the SO_2 emissions under the ARP are also subject to CAIR, and that the CAIR SO_2 program continues and complements the ARP's history of SO_2 emission reductions.

Figure 10: The CAIR SO_2 Region



Source: EPA, 2010

Figure 11: SO_2 Emissions from Sources in the ARP and in the CAIR Annual SO_2 Program Region, 2004–2009



Source: EPA, 2010

Online Information, Data, and Resources

The availability and transparency of data, from emission measurement to allowance trading to deposition monitoring, is a cornerstone of effective cap and trade programs. Clean Air Markets Division (CAMD), in the Office of Air and Radiation's Office of Atmospheric Programs, develops and manages programs for collecting these data and assessing the effectiveness of cap and trade programs, including the ARP.

The CAMD website provides a public resource for general information on how market-based programs work and what they have accomplished, along with the processes, information, and tools necessary to participate in any of these market-based programs. For information about EPA's air emission trading programs, see <www.epa.gov/airmarkets>. For information about the ARP, see <www.epa.gov/airmarkets/progsregs/arp/index.html>.

In a recent effort to increase data transparency, EPA began posting updates of quarterly SO_2 and NO_x emissions data from coal-fired power plants controlled under the ARP and other programs to make it easy for the public to track changes in emissions from these sources (available at: <www.epa.gov/airmarkets/quarterlytracking.html> and shown in Figure 12). The data presented on the quarterly emissions tracking website compare emissions, emission rates, and heat input from power plant units in the ARP. These files graphically and spatially compare quarterly emission data from the most recent completed quarter with data for the same quarter from 2008. A key feature on the quarterly tracking website is the use of interactive motion charts to show, historically, how coal-fired power plants have responded to the ARP.

To utilize other interactive data tools, visit the website at <epa.gov/airmarkets/progress/interactivemapping.html>.

Figure 12: Quarterly Emissions Tracking Website

Source: EPA, 2010

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EPA-430-R-10-014

December 2010

www.epa.gov/airmarkets