

## Clean Air Interstate Rule, Acid Rain Program, and Former NO<sub>x</sub> Budget Trading Program

# SO<sub>2</sub> and NO<sub>x</sub> Emissions, Compliance, and Market Analyses Report

### Program Basics

The Clean Air Interstate Rule (CAIR) and the Acid Rain Program (ARP) are both cap and trade programs designed to reduce emissions of sulfur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>) from power plants.

The ARP, established under Title IV of the 1990 Clean Air Act (CAA) Amendments, requires major emission reductions of SO<sub>2</sub> and NO<sub>x</sub>, the primary precursors of acid rain, from the power sector. The SO<sub>2</sub> program sets a permanent cap on the total amount of SO<sub>2</sub> that may be emitted by electric generating units (EGUs) in the contiguous United States. The program is phased in, with the final 2010 SO<sub>2</sub> cap set at 8.95 million tons, a level of about one-half of the emissions from the power sector in 1980. NO<sub>x</sub> 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. For more information on the ARP, please visit the ARP website at [epa.gov/airmarkets/progsregs/arp/index.html](http://epa.gov/airmarkets/progsregs/arp/index.html).

The NO<sub>x</sub> Budget Trading Program (NBP) operated from 2003 to 2008. The NBP was a cap and trade program that required NO<sub>x</sub> emission reductions from power plants and industrial units in the eastern U.S. during the summer months. For more information on the NBP, please visit the NO<sub>x</sub> Budget Trading Program/NO<sub>x</sub> SIP Call website at [epa.gov/airmarkets/progsregs/nox/sip.html](http://epa.gov/airmarkets/progsregs/nox/sip.html).

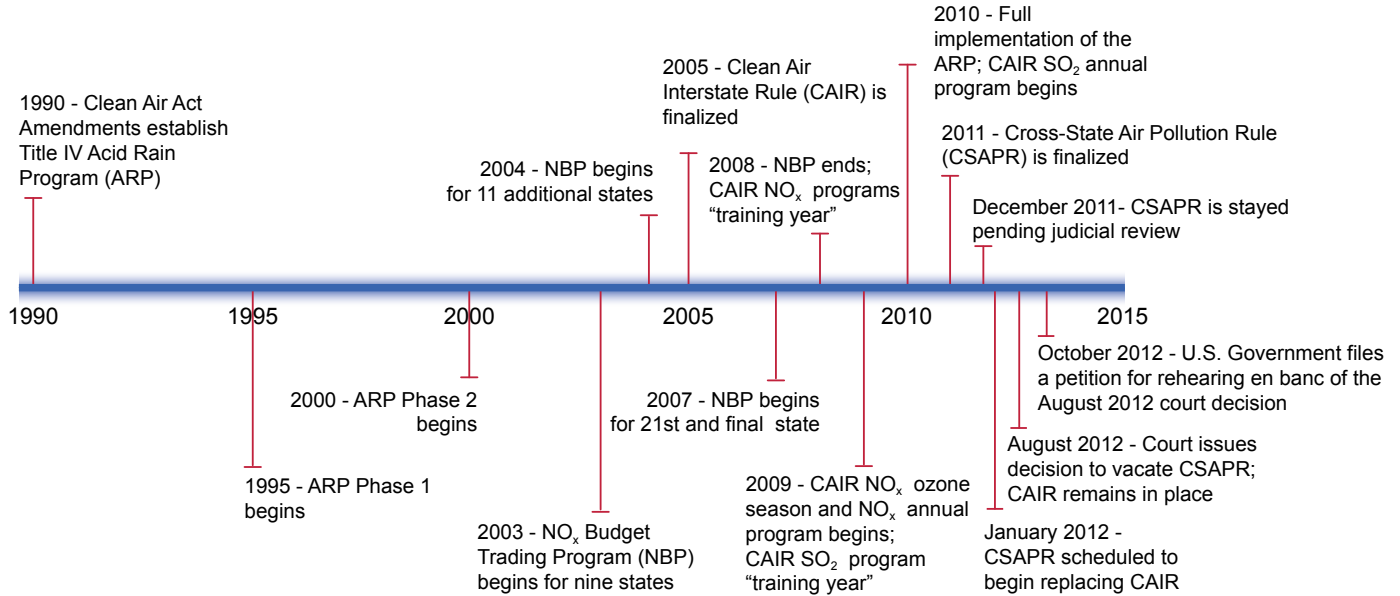
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S.J. Nelson and K. Strock, University of Maine

### 2011 ARP and CAIR at a Glance

- CAIR and ARP Annual SO<sub>2</sub> Emissions: 4.5 million tons (56 percent below 2005)
- CAIR Ozone Season NO<sub>x</sub> Emissions: 566 thousand tons (30 percent below 2005)
- CAIR and ARP Annual NO<sub>x</sub> Emissions: 2.0 million tons (46 percent below 2005)
- Near perfect compliance with the CAIR and ARP programs

CAIR addresses regional interstate transport of ozone and fine particle pollution. CAIR requires certain eastern states to limit annual emissions of NO<sub>x</sub> and SO<sub>2</sub>, which contribute to the formation of smog (ground-level ozone) and soot (fine particulate matter). It also requires certain states to limit ozone season NO<sub>x</sub> emissions, which contribute to the formation of smog during the summer ozone season (May through September). CAIR includes three separate cap and trade programs to achieve the required reductions: the CAIR NO<sub>x</sub> ozone season trading program, the CAIR NO<sub>x</sub> annual trading program, and the CAIR SO<sub>2</sub> annual trading program. The CAIR NO<sub>x</sub> ozone season and annual programs began in 2009, while the CAIR SO<sub>2</sub> annual program began in 2010. The reduction in ozone and fine particles (PM<sub>2.5</sub>) formation resulting from implementation of CAIR provides health benefits as well as improved visibility in national parks and improvements in freshwater aquatic ecosystems in the eastern U.S. For more information on CAIR, please visit the CAIR website at [epa.gov/airmarkets/progsregs/cair/](http://epa.gov/airmarkets/progsregs/cair/).

**Figure 1: History of CAIR, ARP, CSAPR, and Former NBP**



Source: EPA, 2012

### CSAPR and Litigation

The Cross-State Air Pollution Rule (CSAPR) was promulgated to require 28 states in the eastern half of the U.S. to significantly improve air quality by reducing power plant emissions that cross state lines and contribute to ozone and fine particle pollution in other states. CSAPR includes three separate cap and trade programs to achieve these reductions: the CSAPR NO<sub>x</sub> ozone season trading program, the CSAPR NO<sub>x</sub> annual trading program, and the CSAPR SO<sub>2</sub> annual trading program. CSAPR was scheduled to replace CAIR starting on January 1, 2012. However, on

December 30, 2011, the U.S. Court of Appeals for the District of Columbia Circuit stayed CSAPR pending judicial review and on August 21, 2012 the court decided to vacate the rule. That judgment is not yet final and on October 5, 2012 the U.S. Government filed a petition for rehearing en banc, asking the full court to reconsider that decision. In the meantime, as the court stated in its opinion, CAIR remains in place and states and affected sources are expected to comply with the rule. For more information on CSAPR, please visit the CSAPR website at <epa.gov/crossstaterule/index.html>.

Figure 1 contains important milestones for CAIR, ARP, CSAPR, and the former NBP.

### Milestone Years for Measuring Progress under CAIR and ARP

- 1980: The Clean Air Act specified that annual SO<sub>2</sub> emissions be cut to 10 million tons below the 1980 level
- 1990: Baseline emission levels for the ARP
- 1995: First year of the ARP (Phase 1)
- 2000: Phase 2 of the ARP
- 2005: Baseline emission levels for CAIR
- 2008: Training year for CAIR NO<sub>x</sub> monitoring. Units participating in the two CAIR NO<sub>x</sub> trading programs were required to monitor and report their emissions, but were not required to hold allowances for compliance
- 2009: First year of CAIR NO<sub>x</sub> annual and CAIR NO<sub>x</sub> ozone season programs (Phase 1). Training year for CAIR SO<sub>2</sub> monitoring
- 2010: First year of CAIR SO<sub>2</sub> annual program (Phase 1)

### 2011 Progress Reports

Each year EPA releases reports summarizing progress under both CAIR and the ARP. In the 2011 reports, EPA combines data for both CAIR and the ARP into one report to more holistically show reductions in power sector emissions of SO<sub>2</sub> and NO<sub>x</sub> and the collective effect of these regional programs on human health and the environment. This report presents 2011 data on combined emission reductions and compliance results for CAIR and the ARP as well as some historic NBP emissions data, and analyzes emission reductions and market activity. A future report will evaluate changes in a variety of human health and environmental indicators.

## CAIR, ARP, and NBP Affected States and Units

### Affected States

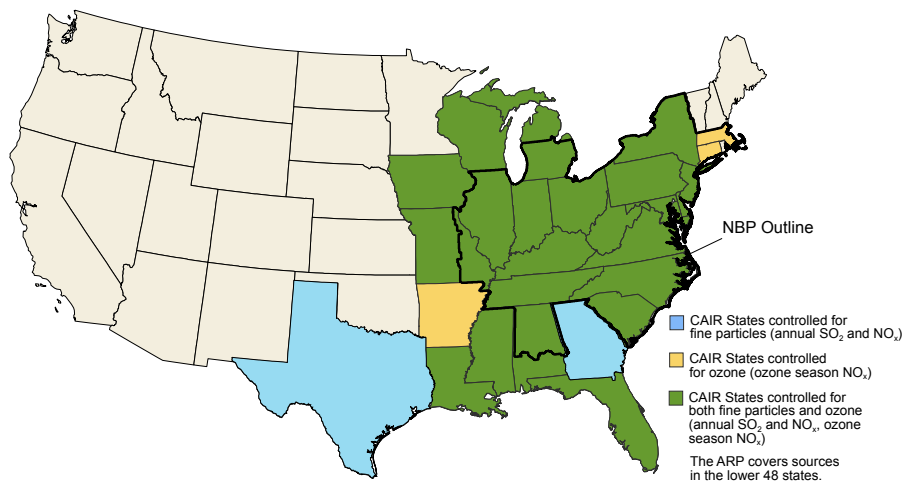
The ARP is a nationwide program affecting large fossil fuel-fired power plants across the country. CAIR covers 27 eastern states and the District of Columbia (D.C.) and requires reductions in annual emissions of SO<sub>2</sub> and NO<sub>x</sub> from 24 states and D.C. (to achieve improvements in fine particle pollution in downwind areas) and emission reductions of NO<sub>x</sub> during the ozone season from 25 states and D.C. (to achieve improvements in ozone pollution in downwind areas). The former NBP affected 20 eastern states and D.C. State coverage for CAIR, ARP, and NBP is shown in Figure 2.

### Affected Units

The CAIR SO<sub>2</sub> and NO<sub>x</sub> annual programs generally apply to large EGUs — boilers, turbines, and combined cycle units that primarily burn fossil fuels to generate electricity for sale. The CAIR NO<sub>x</sub> ozone season program includes EGUs as well as, in some states, large industrial units that produce electricity or steam primarily for internal use and that have been carried over from the NBP. Examples of these units are boilers and turbines at heavy manufacturing facilities such as paper mills, petroleum refineries, and iron and steel production facilities. These units also include some steam plants at institutional settings such as large universities or hospitals.

In 2011, there were 3,345 affected EGUs at 951 facilities in the CAIR SO<sub>2</sub> and NO<sub>x</sub> annual programs and 3,307 EGUs and industrial facility units at 949 facilities in the CAIR NO<sub>x</sub> ozone season program (see Table 1). The variation in the number of units covered under the programs is due to the difference in states that are included in each program (see Figure 2, above). EGUs in the CAIR programs cover a range of unit types, including units that operate year round to provide baseload power to the electric grid as well as units that provide power on peak demand days only and may not operate at all during some years.

**Figure 2: CAIR, ARP, and NBP States**



Source: EPA, 2012

The SO<sub>2</sub> requirements under the ARP apply to the 3,640 fossil fuel-fired combustion units at 1,245 facilities across the country that serve a large generator (greater than 25 megawatts) that provides electricity for sale. The vast majority of ARP SO<sub>2</sub> emissions result from coal-fired EGUs, although the program also applies to oil and gas units. Of the 3,345 units in the CAIR SO<sub>2</sub> program, 2,631 (79 percent) were also covered by the ARP in 2011. The other units are largely fossil fuel generation units that entered SO<sub>2</sub> control under the broader applicability requirements of CAIR.

**Table 1: Affected Units in CAIR and ARP, 2011**

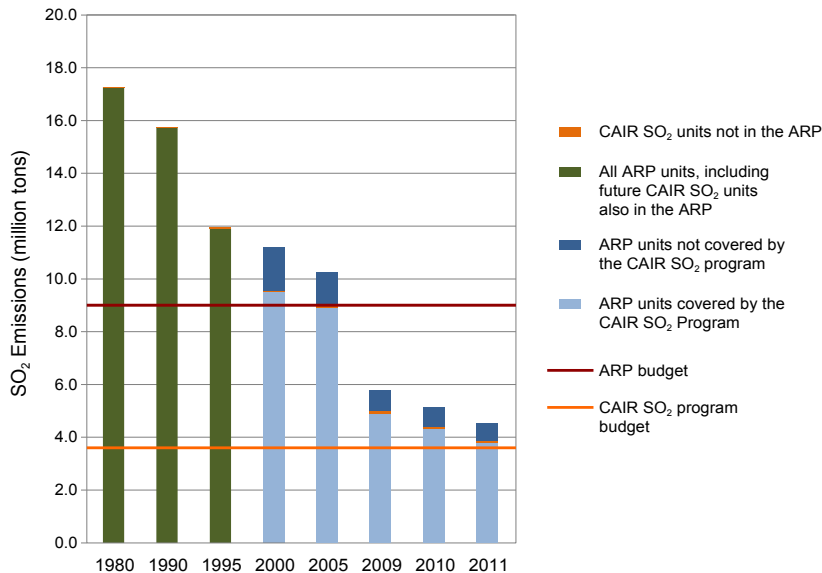
Fuel	ARP SO <sub>2</sub> Program	ARP NO <sub>x</sub> Program	CAIR NO <sub>x</sub> Ozone Season Program	CAIR NO <sub>x</sub> and SO <sub>2</sub> Annual Programs
Coal EGUs	1,028	918	845	895
Gas EGUs	2,381	8	1,685	1,969
Oil EGUs	200	0	543	451
Industrial Units	4	0	203	0
Unclassified EGUs	9	0	2	4
Other Fuel EGUs	18	4	29	26
<b>Total Units</b>	<b>3,640</b>	<b>930</b>	<b>3,307</b>	<b>3,345</b>

Notes:

- “Unclassified” units have not submitted a fuel type in their monitoring plan and did not report emissions.
- “Other” fuel refers to units that burn waste, wood, petroleum coke, tire-derived fuel, etc.

Source: EPA, 2012

**Figure 3: SO<sub>2</sub> Emissions from CAIR SO<sub>2</sub> Annual Program and ARP Sources, 1980–2011**



Note: For CAIR units not in the ARP, the 2009 annual SO<sub>2</sub> emissions were applied retroactively for each pre-CAIR year following the year in which the unit began operating. Source: EPA, 2012

The ARP also requires NO<sub>x</sub> emission reductions for older, large coal-fired EGUs by limiting their NO<sub>x</sub> emission rate (expressed in lb/mmBtu). The goal of the NO<sub>x</sub> program is to limit NO<sub>x</sub> emission levels from affected coal-fired boilers so that their emissions are at least two million tons less than the projected level for the year 2000 without implementation of Title IV. In 2011, 930 units at 375 facilities were subject to the ARP NO<sub>x</sub> program.

### Emission Reductions

#### Overall Trends

Table 2 on page 5 shows a large reduction in annual SO<sub>2</sub> and NO<sub>x</sub> emissions from CAIR and ARP sources between 2005 and 2011. Tons of SO<sub>2</sub> emitted fell 56 percent from the 2005 level, and annual NO<sub>x</sub> emissions dropped 46 percent. During this same period, ozone season NO<sub>x</sub> emissions from CAIR sources alone decreased by approximately 30 percent. These reductions occurred while electricity demand (measured as heat input) remained relatively stable, indicating that the reduction in emissions was not driven by decreased electric generation. Instead, there was a significant drop in emission rate for sources in all three programs: 54 percent for SO<sub>2</sub> sources, 43 percent for annual NO<sub>x</sub> sources, and 26 percent for ozone season NO<sub>x</sub> sources. A drop in emission rate represents an overall increase in the environmental efficiency of these sources as power genera-

tors installed controls, ran their NO<sub>x</sub> controls year round, switched to different fuels, or otherwise cut their SO<sub>2</sub> and NO<sub>x</sub> emissions while meeting relatively steady demand for power. Most of the reductions since 2005 are from early reduction incentives and stricter emission limits under CAIR.

Between 2010 and 2011, CAIR and ARP sources continued to reduce their SO<sub>2</sub> emissions and emission rate. Annual NO<sub>x</sub> emissions from CAIR and ARP sources also fell. CAIR sources' ozone season NO<sub>x</sub> emissions fell slightly (five percent), and facilities were all below both the CAIR NO<sub>x</sub> ozone season and CAIR NO<sub>x</sub> annual budgets for the year.

Visit EPA's Quarterly Emissions Tracking site at <[epa.gov/airmarkets/quarterlytracking.html](http://epa.gov/airmarkets/quarterlytracking.html)> for the most up-to-date emissions and control data for sources in CAIR and the ARP.

### SO<sub>2</sub> Emission Reductions

Figure 3 shows that the CAIR SO<sub>2</sub> program continues and complements the ARP's history of SO<sub>2</sub> emission reductions. In 2011, the second year of operation of the CAIR SO<sub>2</sub> trading program, sources in both the CAIR SO<sub>2</sub> annual program and the ARP together reduced SO<sub>2</sub> emissions by over 11 million tons (71 percent) from 1990 levels (before implementation of the ARP), 6.7 million tons (60 percent) from 2000 levels (ARP Phase 2), and 5.8 million tons (56 percent) from 2005 levels (before implementation of CAIR). All ARP and CAIR sources together emitted a total of 4.54 million tons of SO<sub>2</sub> in 2011, well below the ARP's statutory annual cap of 8.95 million tons.

Annual SO<sub>2</sub> emissions from sources in the CAIR SO<sub>2</sub> program alone fell from 9 million tons in 2005 to 3.9 million tons in 2011, a 57 percent reduction. Between 2010 and 2011, SO<sub>2</sub> emissions fell 543,000 tons (12 percent). However, the 2011 emissions total is higher than the CAIR SO<sub>2</sub> program's state budget total of 3.6 million tons, indicating that affected sources used banked allowances carried over from the ARP for compliance with CAIR (see Table 3 on page 10).

ARP units alone emitted 4.50 million tons of SO<sub>2</sub> in 2011, meaning that ARP sources reduced emissions by 11.2 million tons (71 percent) from 1990 levels and 12.8 million tons (73 percent) from 1980 levels.

**Table 2: Comparison of Emissions, Emission Rates, and Heat Input for CAIR and ARP Sources, 2000–2011**

**CAIR and ARP Annual SO<sub>2</sub> Trends**

Primary Fuel	SO <sub>2</sub> Emissions (thousand tons)					SO <sub>2</sub> Rate (lb/mmBtu)					Heat Input (billion mmBtu)				
	2000	2005	2009	2010	2011	2000	2005	2009	2010	2011	2000	2005	2009	2010	2011
Coal	10,708	9,835	5,653	5,090	4,508	1.04	0.95	0.63	0.53	0.50	20.67	20.77	18.02	19.30	18.18
Gas	28	36	6	7	5	0.02	0.01	0.00	0.00	0.00	3.71	5.35	6.51	7.19	7.37
Oil	464	347	54	44	14	0.76	0.71	0.29	0.21	0.08	1.22	0.98	0.37	0.41	0.33
Other	1	4	8	26	17	0.23	0.27	0.27	0.53	0.28	0.01	0.03	0.06	0.10	0.12
<b>Total</b>	<b>11,201</b>	<b>10,223</b>	<b>5,722</b>	<b>5,168</b>	<b>4,544</b>	<b>0.88</b>	<b>0.75</b>	<b>0.46</b>	<b>0.38</b>	<b>0.35</b>	<b>25.61</b>	<b>27.13</b>	<b>24.95</b>	<b>27.00</b>	<b>26.00</b>

**CAIR and ARP Annual NO<sub>x</sub> Trends**

Primary Fuel	NO <sub>x</sub> Emissions (thousand tons)					NO <sub>x</sub> Rate (lb/mmBtu)					Heat Input (billion mmBtu)				
	2000	2005	2009	2010	2011	2000	2005	2009	2010	2011	2000	2005	2009	2010	2011
Coal	4,587	3,356	1,847	1,923	1,806	0.44	0.32	0.20	0.20	0.20	20.67	20.77	18.27	19.30	18.19
Gas	321	142	133	140	140	0.17	0.05	0.04	0.04	0.04	3.71	5.35	6.71	7.19	7.37
Oil	195	129	34	34	23	0.32	0.26	0.18	0.17	0.14	1.22	0.98	0.38	0.41	0.33
Other	2	6	5	7	8	0.26	0.42	0.12	0.13	0.13	0.01	0.03	0.09	0.10	0.12
<b>Total</b>	<b>5,104</b>	<b>3,633</b>	<b>2,020</b>	<b>2,103</b>	<b>1,976</b>	<b>0.40</b>	<b>0.27</b>	<b>0.16</b>	<b>0.16</b>	<b>0.15</b>	<b>25.61</b>	<b>27.13</b>	<b>25.45</b>	<b>27.00</b>	<b>26.00</b>

**CAIR Ozone Season NO<sub>x</sub> Trends**

Primary Fuel	NO <sub>x</sub> Emissions (thousand tons)					NO <sub>x</sub> Rate (lb/mmBtu)					Heat Input (billion mmBtu)				
	2000	2005	2009	2010	2011	2000	2005	2009	2010	2011	2000	2005	2009	2010	2011
Coal	1,398	695	442	527	511	0.45	0.22	0.17	0.18	0.18	6.19	6.31	5.21	5.85	5.58
Gas	62	43	33	42	39	0.15	0.06	0.04	0.04	0.04	0.84	1.47	1.53	1.97	2.01
Oil	83	72	19	22	14	0.29	0.27	0.18	0.16	0.13	0.57	0.53	0.21	0.27	0.20
Other	1	2	2	2	3	0.15	0.17	0.14	0.12	0.11	0.02	0.02	0.02	0.04	0.05
<b>Total</b>	<b>1,545</b>	<b>812</b>	<b>495</b>	<b>594</b>	<b>566</b>	<b>0.41</b>	<b>0.20</b>	<b>0.14</b>	<b>0.15</b>	<b>0.14</b>	<b>7.62</b>	<b>8.33</b>	<b>6.98</b>	<b>8.13</b>	<b>7.84</b>

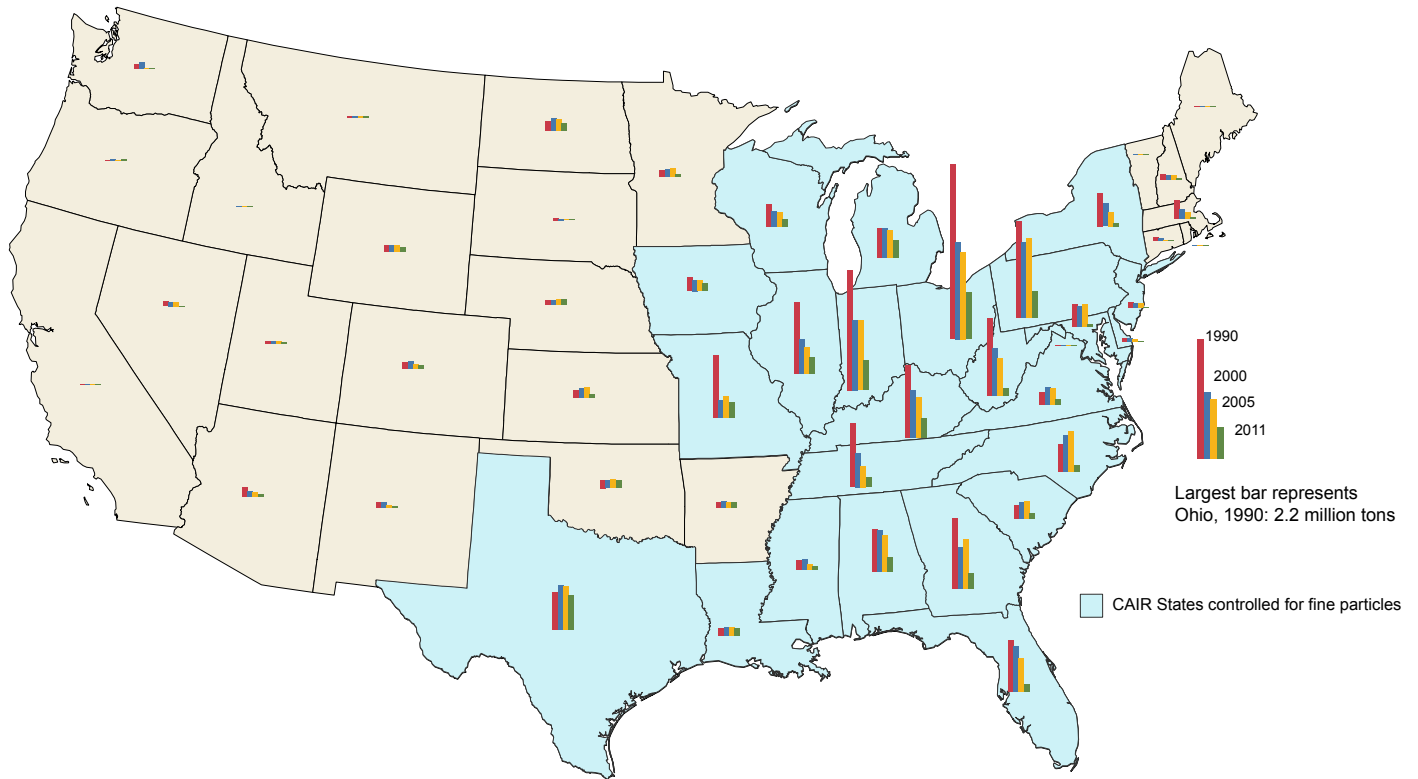
Notes:

- The data shown here for the annual programs reflect totals for those facilities required to comply with each program in each respective year. This means that CAIR NO<sub>x</sub> annual program facilities are not included in the annual NO<sub>x</sub> data for 2000 and 2005, and CAIR SO<sub>2</sub> annual program facilities are not included in the annual SO<sub>2</sub> data for 2000, 2005, or 2009.
- The CAIR ozone season NO<sub>x</sub> table includes emissions and heat input data for 2000 and 2005 that were reported under other programs. For facilities that were not covered by another program and did not report 2005 emissions, their reported emissions for 2008 were substituted.
- 2009 was a monitoring and reporting training year for facilities covered by the CAIR SO<sub>2</sub> annual program.
- Fuel type represents primary fuel type; units might combust more than one fuel.
- Totals may not reflect the sum of individual rows due to rounding.
- Each year's total emission rate does not equal the arithmetic mean of the four fuel-specific rates, as each facility influences the annual emission rate in proportion to its heat input.
- EPA data in these tables and used elsewhere in this report are current as of June 2012, and may differ from past or future reports as a result of resubmissions by sources and ongoing data quality assurance activities.

Source: EPA, 2012



**Figure 4: State-by-State Annual SO<sub>2</sub> Emission Levels for CAIR and ARP Sources, 1990–2011**



Note: a detailed interactive version of this map is available online at <[epa.gov/airmarkets/progress/ARPCAIR11\\_01.html](http://epa.gov/airmarkets/progress/ARPCAIR11_01.html)>  
Source: EPA, 2012

The states with the highest emitting sources in 1990 have generally seen the greatest SO<sub>2</sub> reductions under the ARP, and this trend continues under CAIR (see Figure 4). Most of these states are upwind of the areas the ARP and CAIR were designed to protect, and reductions have resulted in important environmental and health benefits over a large region.

From 1990 to 2011, annual SO<sub>2</sub> emissions in the nationwide ARP and the regional CAIR SO<sub>2</sub> program dropped in 42 states and D.C. by a total of approximately 11 million tons. In contrast, annual SO<sub>2</sub> emissions increased by a total of only 33,300 tons in six states (Arkansas, Idaho, Nebraska, Oregon, Rhode Island, Vermont) from 1990 to 2011.

In 2011, the total SO<sub>2</sub> emissions from participating sources were about 252,000 tons above the regional CAIR emission budget. Nine states had emissions below their allowance budgets, collectively by about 555,000 tons. Another 15 states and Washington, D.C. exceeded their 2011 budgets by a total of about 807,000 tons, indicating that, on an aggregate basis, sources within those states covered a portion of their emissions with allowances banked from earlier years, transferred from an out-of-state account, or purchased from the market.

#### **Newly Installed Control Devices**

Fifteen ARP units installed SO<sub>2</sub> controls in 2011. Twelve of these units were analyzed and shown to have reduced their collective SO<sub>2</sub> emission

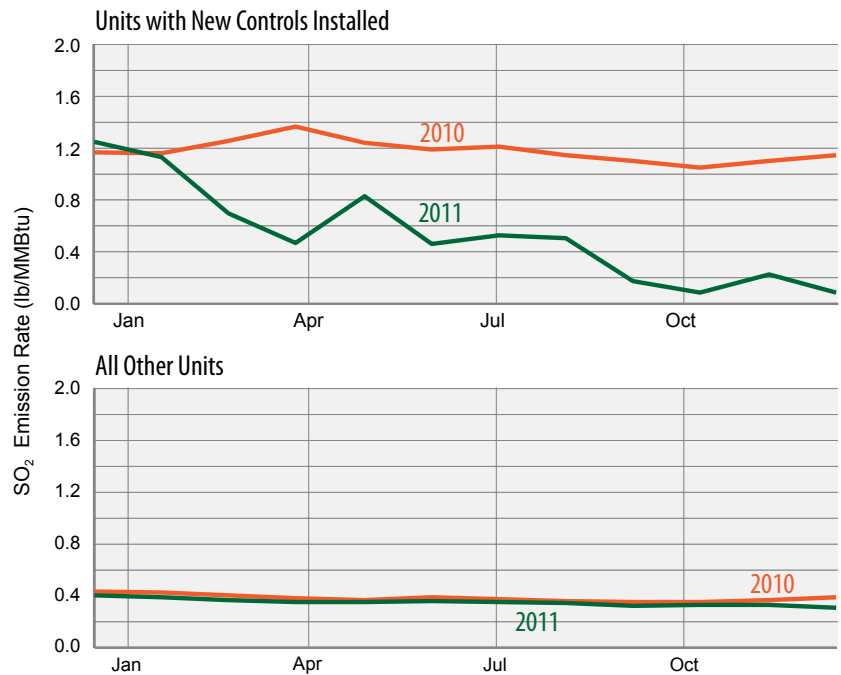
rate from 1.25 lb/mmBtu in January to 0.08 lb/mmBtu in December. The remaining sources in the ARP reported a steady annual SO<sub>2</sub> rate around 0.34 lb/mmBtu (see Figure 5). Had these twelve newly-controlled units maintained their collective annual 2010 emission rate of 1.18 lb/mmBtu through 2011, their estimated emissions would have remained around 146,000 thousand tons. In actuality, the twelve units emitted 50 percent less SO<sub>2</sub> in 2011 than in 2010 by adding scrubbers, contributing about eleven percent of the total ARP-wide reduction of 617,000 tons between 2010 and 2011. Because the new controls were installed at different times throughout 2011, the annual reduction reflects only partial operation, and the overall benefits of the new systems could be even greater in 2012.

### NO<sub>x</sub> Emission Reductions

#### Ozone Season NO<sub>x</sub> Reductions

Figure 6 shows ozone season NO<sub>x</sub> emissions from 1990 to the present for CAIR and NBP sources. In 2011, the third year of the CAIR NO<sub>x</sub> ozone season program, sources from both CAIR and the former NBP, together with a small number of sources that were previously in the NBP but did not enter CAIR, reduced their overall NO<sub>x</sub> emissions from 819,000 tons in 2005 (before implementation of CAIR) to 572,000 tons in 2011, a decrease of 30 percent. NO<sub>x</sub> emissions were 1.5 million tons lower (73 percent) than in 1990 and 887,000 tons lower (61 percent) than in 2000 (before implementation of the NBP).

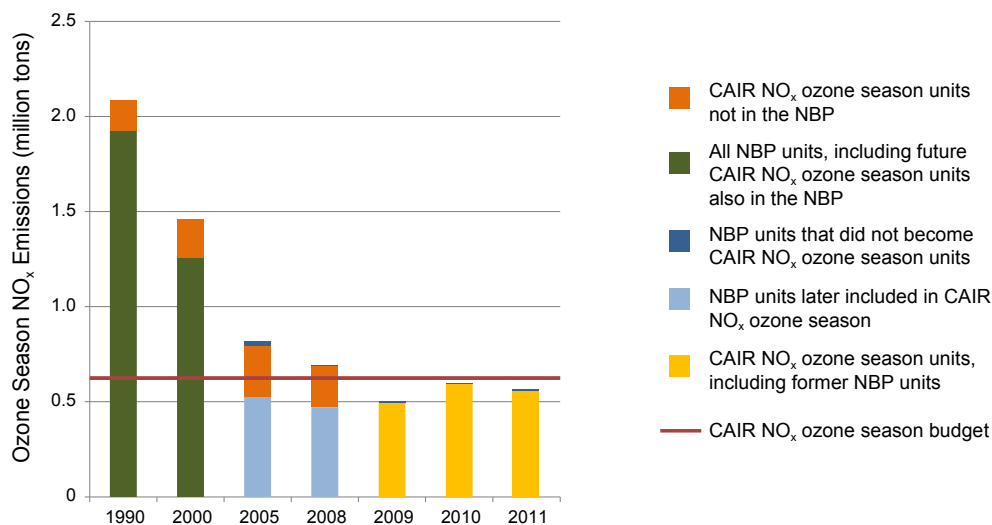
**Figure 5: Monthly SO<sub>2</sub> Emission Rates, 2011**



Note: a total of 15 ARP units added controls in 2011. Three are excluded from this chart due to the use of substitute data during the transition period.  
Source: EPA, 2012

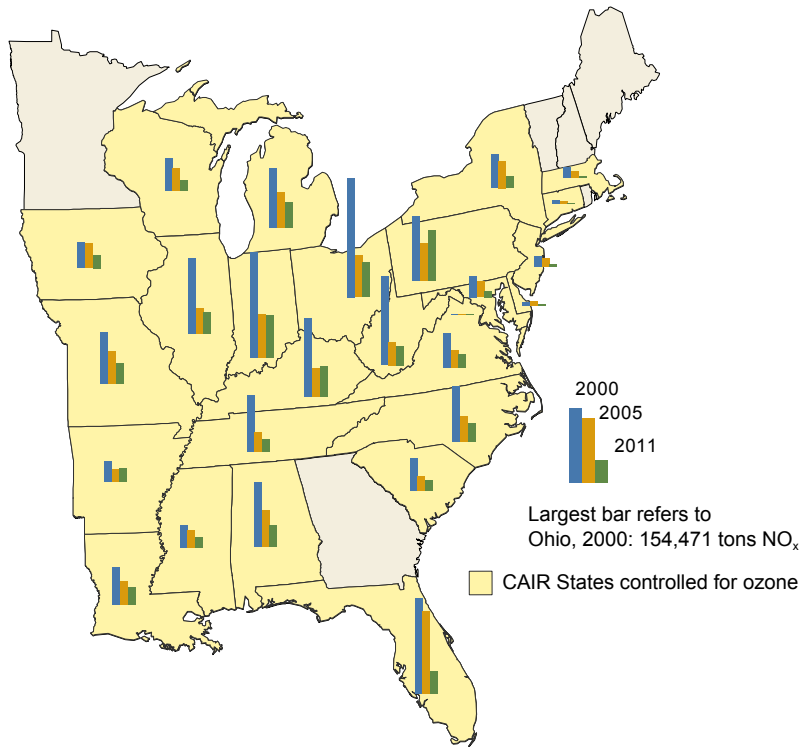
Between 2005 and 2011, ozone season NO<sub>x</sub> emissions from sources in the CAIR program alone have fallen 246,000 tons, a decrease of 30 percent. From 2010 to 2011, ozone season NO<sub>x</sub> emissions from sources in the CAIR NO<sub>x</sub> ozone season program decreased by 28,000 tons (five percent), reversing a one-year increase in emissions from 2009 to 2010. Ozone season NO<sub>x</sub> emissions

**Figure 6: Ozone Season NO<sub>x</sub> Emissions from CAIR and NBP Sources, 1990–2011**



Note: For CAIR units not in the NBP, the 2008 NO<sub>x</sub> emissions were applied retroactively to 1990 and 2000 if the unit operated in the previous year's ozone season.  
Source: EPA, 2012

**Figure 7: State-by-State Ozone Season NO<sub>x</sub> Emission Levels from CAIR Sources, 2000–2011**

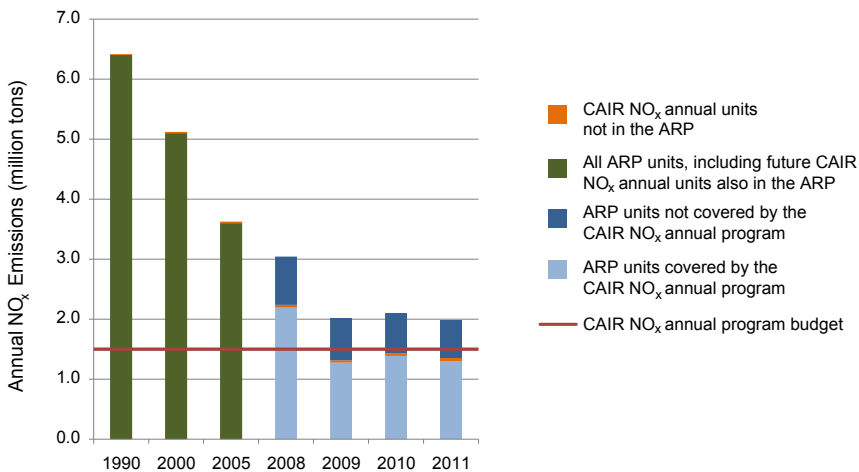


**Notes:**

- The 2000 and 2005 ozone season values reflect data that were reported under other programs (ARP and NBP). For facilities that were not covered by another program and did not report 2000 or 2005 emissions, their reported emissions for the earliest subsequent year (usually the 2008 training year) were substituted.
- A detailed interactive version of this map is available online at <epa.gov/airmarkets/progress/ARPCAIR11\_01.html>

Source: EPA, 2012

**Figure 8: Annual NO<sub>x</sub> Emissions from CAIR and ARP Sources, 1990–2011**



Note: For CAIR units not in the ARP in 1990, 2000, and 2005, the 2008 annual NO<sub>x</sub> emissions were applied retroactively for each pre-CAIR year following the year in which the unit began operating.

Source: EPA, 2012

totaled 566,000 tons in 2011, nine percent below the regional emission budget of 624,698 tons.

In addition to the CAIR NO<sub>x</sub> ozone season program and the former NBP, current regional and state NO<sub>x</sub> emission control programs have also contributed significantly to the ozone season NO<sub>x</sub> reductions achieved by sources in 2011.

Between 2005 and 2011, ozone season NO<sub>x</sub> emissions from CAIR and former NBP sources fell in every state participating in the CAIR NO<sub>x</sub> ozone season program except Pennsylvania, Arkansas, and Kentucky (see Figure 7), where emissions increased by a total of 22,000 tons. In the 2011 ozone season, the total emissions from participating sources were about 59,000 tons below the regional emission budget. Seventeen states had emissions below their allowance budgets, collectively by about 108,000 tons. Another eight states and Washington, D.C. exceeded their 2011 budgets by a total of about 49,500 tons, indicating that, on an aggregate basis, sources within those states covered a portion of their emissions with allowances banked from earlier years, transferred from an out-of-state account, or purchased from the market.

*Annual NO<sub>x</sub> Reductions*

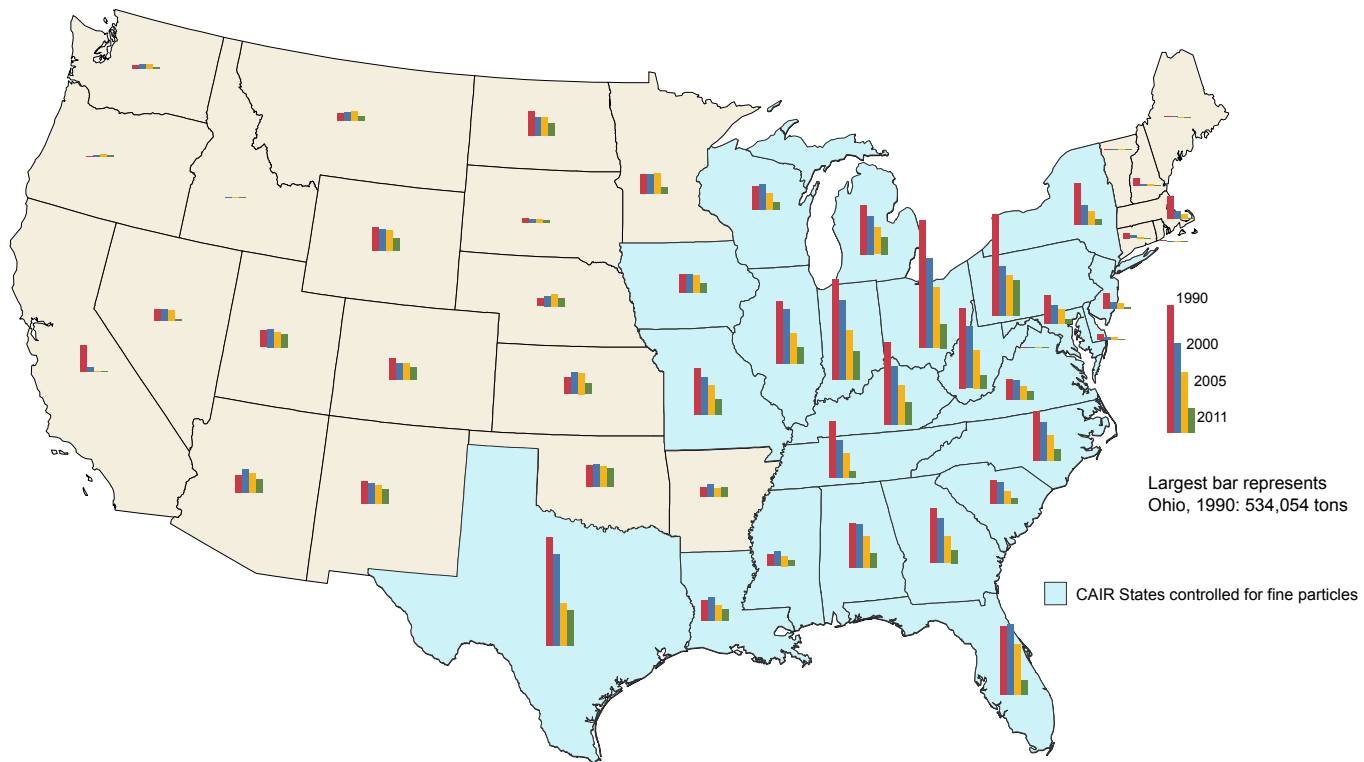
Figure 8 shows that from 1990 to 2011, annual NO<sub>x</sub> emissions from CAIR and ARP units together dropped by about 4.4 million tons to 2 million tons, a decrease of 60 percent. In 2011, the third year of the CAIR NO<sub>x</sub> annual program, NO<sub>x</sub> emissions from all ARP and CAIR units were 1.7 million tons lower (46 percent) than in 2005 and 3.2 million tons lower (62 percent) than in 2000.

Emissions from CAIR NO<sub>x</sub> annual program sources alone were 1.35 million tons in 2011, 146,000 tons (10 percent) below the 2011 CAIR NO<sub>x</sub> annual program’s regional budget of 1.5 million tons. Annual NO<sub>x</sub> emissions were 1.3 million tons lower (49 percent) than in 2005, and 74,000 tons lower (5 percent) than in 2010.

All ARP sources emitted 1.9 million tons of NO<sub>x</sub> in 2011. This level is over 6 million tons less than



**Figure 9: State-by-State Annual NO<sub>x</sub> Emission Levels for CAIR and ARP Sources, 1990–2011**



Note: a detailed interactive version of this map is available online at [epa.gov/airmarkets/progress/ARPCAIR11\\_01.html](http://epa.gov/airmarkets/progress/ARPCAIR11_01.html)  
 Source: EPA, 2012

the projected level in 2000 without the ARP, and over three times the Title IV NO<sub>x</sub> emission reduction objective.

Although the ARP and CAIR NO<sub>x</sub> programs were responsible for a large portion of these annual NO<sub>x</sub> reductions, other programs — such as regional and state NO<sub>x</sub> emission control programs — also contributed significantly to the annual NO<sub>x</sub> reductions achieved by sources in 2011.

From 1990 to 2011, all states participating in the CAIR NO<sub>x</sub> annual program decreased their emissions, as indicated in Figure 9. Comparing 2005 to 2011, all states in the CAIR region emitted less NO<sub>x</sub> except Arkansas, which increased its NO<sub>x</sub> emissions by 3,000 tons. The total NO<sub>x</sub> emissions from participating sources in 2011 were about 55,000 tons below the regional emission budget of 1,490,264 tons. Twelve states and D.C. exceeded their 2011 budgets by a total of about 174,000 tons, indicating that, on an aggregate basis, sources within those states covered a portion of their emissions with allowances banked from earlier years, transferred from an out-of-state account, or purchased from the market. Sixteen states had emissions below their 2011 allowance budgets, collectively by about 275,000 tons.

## CAIR and ARP Program Compliance

### SO<sub>2</sub> Programs

Because SO<sub>2</sub> allowances from the ARP are used by sources to comply with the CAIR SO<sub>2</sub> annual program, compliance results for both programs are displayed together in this report. Table 3 shows how ARP allowances are used for compliance under both programs. All ARP and CAIR SO<sub>2</sub> facilities were in compliance with both programs in 2011 and held enough allowances to cover their SO<sub>2</sub> emissions.

2011 was the second year for compliance with the CAIR SO<sub>2</sub> program. Under this program, allowances are used to cover emissions based on the vintage year of the allowances, with pre-2010 vintage allowances used at 1 allowance for 1 ton of SO<sub>2</sub> emissions, and 2010 and 2011 vintage allowances used at 2 allowances for 1 ton. For facilities covered

by both CAIR and the ARP, reconciliation is a two-step process. First, ARP deductions are made. Then, any additional deductions to comply with the CAIR SO<sub>2</sub> program are made. The additional deductions under CAIR could be to cover the 2 for 1 use of 2010 and 2011 allowances or to cover emissions for units that are subject to CAIR, but not the ARP.

In 2011, over 24 million SO<sub>2</sub> allowances were available for compliance under both programs (9 million vintage 2011 and over 15 million banked from prior years). Just over 4.5 million allowances were deducted for ARP compliance and an additional 2 million allowances were deducted to complete reconciliation for CAIR. After reconciliation for both programs, over 17.7 million ARP SO<sub>2</sub> allowances were banked and carried forward to the 2012 compliance year.

Compliance Results	CAIR and ARP SO <sub>2</sub> Programs	
As of June 21, 2012, the reported 2011 SO <sub>2</sub> emissions by CAIR and ARP sources totaled 4,544,208 tons. Because of variation in rounding conventions, changes due to resubmissions by sources, and allowance compliance issues at certain units, this number is lower than the sums of emissions used for reconciliation purposes shown in Table 3. Therefore, the allowance totals deducted for actual emissions in Table 3 differ from the number of emissions shown elsewhere in this report.	Reported emissions (tons)	4,544,208
	Compliance issues, rounding, and report resubmission adjustments (tons)	-44,480
	Emissions not covered by allowances (tons)	0
	Additional vintage 2010 and 2011 allowances deducted for CAIR	+2,052,711
	Total allowances deducted for emissions (includes some 2 for 1 CAIR deductions)	6,552,439

**Table 3: CAIR and ARP SO<sub>2</sub> Allowance Reconciliation Summary, 2011**

<b>Total Allowances Held (1995–2011 Vintage)</b>	<b>24,275,585</b>	Held by Affected Facility Accounts	17,042,402
		Held by Other Accounts (General and Non-Affected Facilities)	7,233,183
Allowances Deducted for Acid Rain Compliance*	-4,507,630		
Penalty Allowance Deductions (2012 Vintage)	0		
<b>Banked Allowances (after ARP Compliance)</b>	<b>19,767,955</b>	Held by Affected Facility Accounts	12,534,772
		Held by Other Accounts (General and Non-Affected Facilities)	7,233,183
Acid Rain Program Allowances Deducted for CAIR SO <sub>2</sub> Compliance	-2,052,711		
<b>Banked Allowances (After ARP and CAIR SO<sub>2</sub> Compliance)</b>	<b>17,715,244</b>	Held by Affected Facility Accounts	10,482,061
		Held by Other Accounts (General and Non-Affected Facilities)	7,233,183

\*Includes 7,902 allowances deducted from opt-ins for reduced utilization.

Source: EPA, 2012

## NO<sub>x</sub> Programs

### CAIR NO<sub>x</sub> Compliance Results

Tables 4 and 5 show how NO<sub>x</sub> allowances were used in 2011. All covered facilities were in compliance with the CAIR NO<sub>x</sub> ozone season programs in 2011 and held enough allowances to cover their NO<sub>x</sub> emissions. Only one facility did not hold enough allowances to cover its 2011 emissions for the CAIR NO<sub>x</sub> annual program. That facility automatically surrendered a 3-for-1 penalty deduction.

### Compliance Results

As of June 21, 2012, the reported 2011 ozone season NO<sub>x</sub> emissions by CAIR sources totaled 566,049 tons, and annual emissions totaled 1,354,114 tons. Because of variation in rounding conventions, changes due to resubmissions by sources, and allowance compliance issues at certain units, these numbers are different from the sums of emissions used for reconciliation purposes shown in Table 4 (ozone season reconciliation) and Table 5 (annual reconciliation). Therefore, the allowance totals deducted for actual emissions in Tables 4 and 5 differ from the number of emissions shown elsewhere in this report.

### CAIR NO<sub>x</sub> Ozone Season

Reported emissions (tons)	566,049
Compliance issues, rounding, and report resubmission adjustments (tons)	+188
Emissions not covered by allowances (tons)	0
Total allowances deducted for emissions	566,237

### CAIR NO<sub>x</sub> Annual Program

Reported emissions (tons)	1,354,114
Compliance issues, rounding, and report resubmission adjustments (tons)	-1,708
Emissions not covered by allowances (tons)	-3
Total allowances deducted for emissions	1,352,403

### ARP NO<sub>x</sub> Compliance Results

The ARP NO<sub>x</sub> Program does not impose a cap on NO<sub>x</sub> 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<sub>x</sub> emission reduction requirements in a cost-effective manner. Of the 930 units that were subject to the ARP NO<sub>x</sub> Program in 2011, one facility faces a monetary penalty for noncompliance with the ARP NO<sub>x</sub> program.

**Table 4: CAIR NO<sub>x</sub> Ozone Season Allowance Reconciliation Summary, 2011**

<b>Total Allowances Held (2003–2011 Vintage)</b>	<b>1,017,412</b>	Held by Affected Facility Accounts	878,921
		Allowances Held by Other Accounts (General and Non-Affected Facilities)	138,491
<b>Allowances Deducted for CAIR NO<sub>x</sub> Ozone Season Trading Program</b>	<b>-566,237</b>		
<b>Penalty Allowance Deductions (2012 Vintage)</b>	<b>0</b>		
<b>Banked Allowances</b>	<b>451,175</b>	Held by Affected Facility Accounts	312,684
		Held by Other Accounts (General, State Holding, and Non-Affected Facilities)	138,491

Source: EPA, 2012

**Table 5: CAIR NO<sub>x</sub> Annual Allowance Reconciliation Summary, 2011**

<b>Total Allowances Held (2009–2011 Vintage)</b>	<b>1,882,226</b>	Held by Affected Facility Accounts	1,723,690
		Held by Other Accounts (General, State Holding, and Non-Affected Facilities)	158,536
<b>Allowances Deducted for CAIR NO<sub>x</sub> Annual Trading Program</b>	<b>-1,352,403</b>		
<b>Penalty Allowance Deductions</b>	<b>-9</b>		
<b>Banked Allowances</b>	<b>529,814</b>	Held by Affected Facility Accounts	371,278
		Held by Other Accounts (General, State Holding, and Non-Affected Facilities)	158,536

Source: EPA, 2012

## Controls and Monitoring

To meet the ARP and CAIR emission reduction targets, some sources opt to install control technologies. A wide set of controls are available to help reduce emissions. The following is an analysis of controls on ARP and CAIR program coal-fired units and CAIR NO<sub>x</sub> program combined cycle units in 2011.

**Table 6: SO<sub>2</sub> Controls in 2011 on Coal-Fired Units in the ARP and CAIR Annual SO<sub>2</sub> Program**

SO <sub>2</sub> Control Type	Number of Units	Share of Units	Share of MWh Generation
FGD	444	41%	61%
Other	44	4%	1%
Uncontrolled	593	55%	38%

Note: Due to rounding, percentages shown may not add up to 100%.  
Source: EPA, 2012

**Table 7: NO<sub>x</sub> Controls in 2011 CAIR NO<sub>x</sub> Ozone Season Program**

NO <sub>x</sub> Control Type	Number of Coal-Fired Units	Share of Coal-Fired MWh Generation	Number of Combined Cycle Units (Gas- or Oil-Fired)	Share of Combined Cycle (Gas- or Oil-Fired) MWh Generation
Combustion	421	38%	64	13%
Non-Controlled	112	2%	15	1%
Other Control	38	1%	87	5%
SCR	217	53%	348	82%
SNCR	121	6%	0	0%

Note: Due to rounding, percentages shown may not add up to 100%.  
Source: EPA, 2012

**Table 8: NO<sub>x</sub> Controls in 2011 CAIR NO<sub>x</sub> Annual Program**

NO <sub>x</sub> Control Type	Number of Coal-Fired Units	Share of Coal-Fired MWh Generation	Number of Combined Cycle Units (Gas- or Oil-Fired)	Share of Combined Cycle (Gas- or Oil-Fired) MWh Generation
Combustion	411	38%	117	19%
Non-Controlled	91	2%	19	1%
Other Control	40	2%	85	4%
SCR	229	51%	403	76%
SNCR	120	7%	0	0%

Note: Due to rounding, percentages shown may not add up to 100%.  
Source: EPA, 2012

## SO<sub>2</sub> Controls in 2011

SO<sub>2</sub> control options available to sources include switching to low sulfur coal, employing various types of flue gas desulfurization (FGDs), or utilizing fluidized bed limestone units. FGDs on coal-fired generators are the principal means of controlling SO<sub>2</sub>. As discussed in detail on pages 6–7, 15 units in the ARP added new SO<sub>2</sub> controls in 2011. Of those 15 units, 11 are in the CAIR SO<sub>2</sub> annual program. Across both programs the share of generation, measured in megawatt hours (MWh), at controlled units grew to 61 percent of coal-fired generation in 2011 (see Table 6).

## NO<sub>x</sub> Controls in 2011

Sources have a variety of options by which to reduce NO<sub>x</sub> emissions. New selective catalytic reduction units (SCRs), the most efficient NO<sub>x</sub> controls, were installed at 28 generation units under the CAIR NO<sub>x</sub> ozone season program in 2011. Units with add-on controls — SCR or selective non-catalytic reduction (SNCR) — accounted for 59 percent of coal-fired generation and 82 percent of generation at combined cycle units (gas- or oil-fired). Although 112 coal-fired units and 15 combined cycle units remain uncontrolled, they represent only two percent of coal-fired generation and one percent of combined cycle generation under the CAIR NO<sub>x</sub> ozone season program (see Table 7).

Twenty-four units in the CAIR NO<sub>x</sub> annual program installed add-on controls in 2011. The 349 coal-fired units with add-on controls (either SCRs or SNCRs) generated 58 percent of annual generation, and the 403 combined cycle units with SCRs generated 76 percent of annual generation (see Table 8). Similar to the CAIR NO<sub>x</sub> ozone season program, uncontrolled units represent two percent of coal-fired generation and one percent of combined cycle generation under the CAIR NO<sub>x</sub> annual program.

## Continuous Emission Monitoring Systems

Accurate and consistent emissions monitoring is the foundation of a cap and trade system. EPA has developed detailed procedures (40 CFR Part 75) to ensure that sources monitor and report emissions with a high degree of precision, accuracy, reliability, and consistency. Sources use continuous emission monitoring systems (CEMS) or other approved methods. Part 75 requires sources to conduct stringent quality assurance tests of their monitoring systems, such as daily and quarterly calibration tests and a semiannual or annual relative accuracy test audit. These tests ensure that sources report accurate data and provide assurance to market participants that a ton of emissions measured at one facility is equivalent to a ton measured at a different facility.

While many CAIR units with low levels of emissions did not have to use CEMS, the vast majority of NO<sub>x</sub> emissions — over 99 percent — were measured by CEMS. Coal-fired units were required to use CEMS for NO<sub>x</sub> concentration and stack gas flow rate to calculate and record their NO<sub>x</sub> mass emissions. Oil-fired and gas-fired units could use a NO<sub>x</sub> CEMS in conjunction with a fuel flow meter to determine NO<sub>x</sub> mass emissions. Alternatively, for oil-fired and gas-fired units that either operated infrequently or had very low NO<sub>x</sub> emissions, Part 75 provided low-cost alternatives to conservatively estimate NO<sub>x</sub> mass emissions.

Similarly, CEMS monitored over 99 percent of SO<sub>2</sub> emissions from CAIR sources, including 100 percent from coal-fired units and 20 percent from oil-fired units. The relatively low percentage for oil-fired units is consistent with the decline in oil-fired heat input, as most of these units were used infrequently and qualified for reduced monitoring.

## Quality Assurance of Emissions Data

The quality of ARP and CAIR data rests on two founding principles: reporting a complete data record for every hour of operation and monitoring key parameters using CEMS or an approved alternative. The implementation of a strong quality assurance/quality control (QA) program is essential to ensuring that data are accurate and emission reductions are real.

The QA program encompasses the entire process of measuring pollutants, handling the data and reporting results. Regulations specify that monitors meet stringent standards to demonstrate their precision and reporters must use EPA software to validate and submit electronic reports. Standardized and centralized electronic reporting allows the Agency to efficiently track, process and validate the large volume of data using automation. All emissions are monitored and reported hourly including emissions during start-up, shutdown, and upset or uncontrolled conditions. This ensures that the record is complete and that QA rests on a solid statistical footing.

In 2009, EPA launched the Emissions Collection and Monitoring Plan System (ECMPS) to reengineer several applications onto a unified platform. EPA provides the ECMPS client tool to the regulated community. ECMPS uses an XML-based data format to perform up to 6,000 QA checks on the reports generated by CEMS data acquisition systems. It provides an immediate feedback report that allows the user to correct problems before data submittal. ECMPS has cut resubmissions significantly by consistently applying comprehensive validation and verification. Making it easy for reporters to submit clean data promotes efficiency and focuses attention on what is important.

EPA performs two types of QA post-submission: a repeat of the ECMPS checks to verify data accuracy and completeness and electronic audits including statistical analyses. Statistical and ad hoc audits provide a test bed for developing new QA procedures and are one of the key avenues by which EPA continues to improve data collection. QA is further supported by field audits, the Protocol Gas Verification Program and the Minimum Competency Requirements for Air Emissions Testing. Put together, these efforts ensure that the programs are effective and comprehensive.

CAIR and ARP have achieved an unparalleled level of performance with respect to the accuracy, precision, and timeliness of emission reports. These high levels of data quality and source compliance were achieved through careful program implementation and continuous improvement while working closely with the regulated community.



## Market Activity

In a cap and trade program, sources may consider several emission reduction alternatives, and are allowed to trade allowances as part of their compliance strategy. Through trading, the overall market can achieve emission targets at a lower cost than through a command and control program because abatement costs are not the same for all sources, and allowance trading allows those sources to arrange for the cheapest possible reductions among covered sources to meet the overarching cap. A market for emission allowances will emerge, and the allowance price will reflect the marginal cost of emission reductions. Emission control decisions will be made based on the cost of control options relative to the market price of allowances. The allowance price motivates those who have relatively low cost opportunities for emission reductions to make those investments and then sell any surplus allowances to those with higher marginal abatement costs.

**Table 9: Characteristics of the SO<sub>2</sub> Allowance Market after Compliance (close of 2011)**

	Pre-CAIR Vintages	CAIR Vintages	Total
Total Value of the Banked ARP Allowances Remaining after Compliance	\$19.3 million	\$14.9 million	\$34.2 million
Year-End Price (per Allowance)	\$2.50	\$1.50	n/a
Total Allowance Volume after Compliance	7,708,272	9,933,598	n/a

Note: Total value of allowance market is a snapshot based on the 2011 year-end nominal prices and total allowance volume available after 2011 compliance and surrender of allowances required by EPA enforcement consent decrees. For 2011, CAIR compliance required the surrender of two CAIR ARP allowances or 1 Pre-CAIR ARP allowance for each ton emitted. Source: EPA, 2012 and BGC Environmental Brokerage Services Market Price Index, 2012

## SO<sub>2</sub> Allowance Market in 2011

ARP allowance prices declined over the course of 2011 and prices continued to be significantly lower than prices projected as part of the final CAIR rulemaking.<sup>1</sup> In this second year of CAIR SO<sub>2</sub> compliance, prices for pre-CAIR and CAIR ARP allowance vintages were below \$5.00 per ton for all or part of the year. Total emissions decreased by 543,000 tons and were 4.41 million tons below the ARP cap, but emissions exceeded the CAIR cap by about 940,000 tons. Sources were able to use banked ARP allowances for compliance above the cap. After 2011 compliance surrenders, about 7.7 million pre-CAIR ARP allowances and 9.9 million CAIR ARP allowances were banked for possible future use. The availability of these banked allowances put downward pressure on allowance prices in both markets. See Table 9 for a summary of the SO<sub>2</sub> allowance market at the close of 2011.

## NO<sub>x</sub> Allowance Markets in 2011

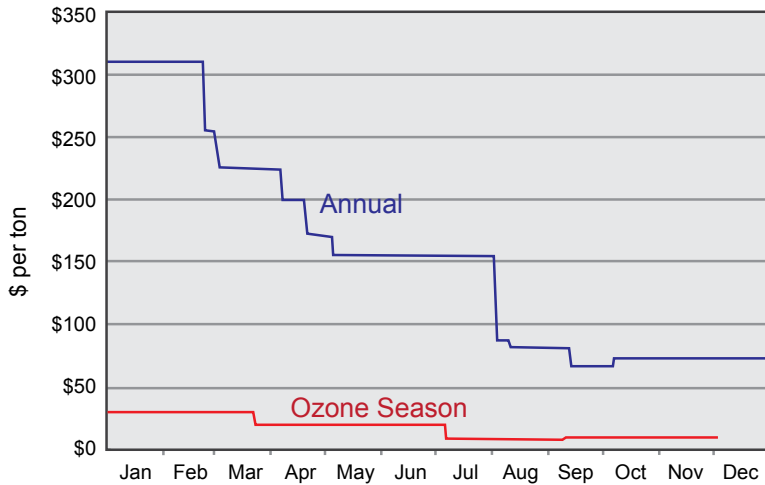
The 2011 CAIR NO<sub>x</sub> Ozone Season allowance market continued its price decline from the previous year closing at the end of December at \$9 per ton (see Figure 10). The NO<sub>x</sub> Annual allowance price followed the same trend, declining to around \$74 per ton by the end of the year.

In 2011, the third year of the CAIR Ozone Season and Annual NO<sub>x</sub> programs, CAIR sources emitted about 566,000 tons of NO<sub>x</sub> during the ozone season (May through September), below the overall budget and a 5 percent decrease from 2010 levels. CAIR sources emitted about 59,000 tons less than their overall ozone season budget, thereby increasing the CAIR ozone season NO<sub>x</sub> allowance bank to reach about 451,000 allowances. Not surprisingly, the downward tendency of ozone season allowance prices continued through most of 2011. Emissions of CAIR Annual NO<sub>x</sub> were 1.35 million tons, about 146,000 tons less than the overall budget. The CAIR Annual NO<sub>x</sub> bank grew to more than 529,000 allowances. Current annual and ozone-season CAIR NO<sub>x</sub> allowance prices are well below the marginal cost for NO<sub>x</sub> reductions projected at the time of the final rule, and are in part subject to downward pressure from the available banks of allowances.<sup>2</sup>

<sup>1</sup> U.S. EPA, Regulatory Impact Analysis for the Final Clean Air Interstate Rule, Docket No. EPA-HQ-OAR-2003-0053-2158, 7-9.

<sup>2</sup> *Ibid.*

**Figure 10: NO<sub>x</sub> Annual and Ozone Season Allowance Spot Price (Prompt Vintage), January–December 2011**



Note: Prompt vintage is the vintage for the “current” compliance year.  
 Source: BGC Environmental Brokerage Services Market Price Index, 2012

**Transaction Types and Volumes**

Allowance transfer activity includes two types of transfers: EPA transfers to accounts and private transactions. EPA transfers to accounts include the initial allocation of allowances by states or EPA, as well as transfers into accounts related to special set-asides. This category does not include transfers due to allowance retirements. Private transactions include all transfers initiated by authorized account representatives for any compliance or general account purposes.

To help better understand the trends in market performance and transfer history, EPA classifies private transfers of allowance transactions into two categories:

- Transfers between separate and distinct economic entities, which may include companies with contractual relationships such as power purchase agreements, but excludes parent-subsidiary types of relationships.
- Transfers within a company or between related entities (e.g., holding company transfers between a unit compliance account and any account held by a company with an ownership interest in the unit).

While all transactions are important to proper market operation, EPA follows trends in the distinct transaction category with particular interest because these transactions represent an actual exchange of assets between unaffiliated participants. In 2011, about a third of each program’s traded allowances were exchanged between unrelated parties, often with a broker facilitating the trade (see Table 10). This proportion is similar to what was seen in 2010.

**Table 10: 2011 Allowance Transfers under CAIR and ARP**

		Allowances Transferred	Share of Program’s 2011 Transfers
CAIR NO <sub>x</sub> Ozone Season Program	Distinct organizations	80,634	27%
	Related organizations	216,383	73%
CAIR NO <sub>x</sub> Annual Program	Distinct organizations	337,949	44%
	Related organizations	423,289	56%
ARP and CAIR SO <sub>2</sub> Annual Program	Distinct organizations	3,109,777	37%
	Related organizations	5,320,041	63%

Source: EPA, 2012