



Chapter 3: Emissions Reductions

Sulfur Dioxide (SO₂)

The Acid Rain Program (ARP) and the Clean Air Interstate Rule (CAIR) programs significantly reduced annual SO₂ and NO_x emissions. These reductions occurred while electricity demand (measured as heat input) remained relatively stable, indicating that the reductions in emissions were not driven by decreased electric generation.

These emission reductions represent an overall increase in the environmental efficiency of these sources as power generators installed controls, ran their controls year round, switched to lower emitting fuels, or otherwise reduced their SO₂ and NO_x emissions while meeting the relatively steady electricity demand. Most of the emission reductions since 2005 are from early reduction incentives and stricter emission cap levels under CAIR.

Analysis and Background Information

Sulfur dioxide (SO₂) is a highly reactive gas that is generated primarily from the combustion of fossil fuels at power plants. In addition to contributing to the formation of fine particle pollution (PM_{2.5}), SO₂ is linked with a number of adverse effects to human health and ecosystems.

The states with the highest emitting sources in 1990 have generally seen the greatest SO₂ reductions under the ARP, and this trend continued under CAIR. Most of these states are located in the Ohio River Valley and are upwind of the areas the ARP and CAIR were designed to protect. Reductions under the ARP and CAIR have provided important environmental and health benefits over a large region.

Key Points

SO₂ Emission Trends

- Units in the ARP emitted 3.2 million tons of SO₂ in 2013, well below the ARP's statutory annual cap of 8.95 million tons. ARP sources reduced emissions by 12.5 million tons (80 percent) from 1990 levels and 14.1 million tons (81 percent) from 1980 levels.
- In 2013, the fourth year of operation of the CAIR SO₂ trading program, sources in both the CAIR SO₂ annual program and the ARP together reduced SO₂ emissions by 12.5 million tons (79 percent) from 1990 levels (before implementation of the ARP), 8.0 million tons (71 percent) from 2000 levels (ARP Phase II), and 7.1 million tons (69 percent) from 2005 levels (before implementation of CAIR).
- All ARP and CAIR sources together emitted a total of 3.2 million tons of SO₂ in 2013.
- Annual SO₂ emissions from sources in the CAIR SO₂ program alone fell from 9.1 million tons in 2005 to 2.7 million tons in 2013, a 70 percent reduction. Between 2012 and 2013, SO₂ emissions fell 65,000 tons (3 percent) and were about 920,000 tons below the regional CAIR emission budget.



<http://www.epa.gov/airmarkets/progress>

SO₂ State-by-State Emission Maps

- From 1990 to 2013, annual SO₂ emissions in the ARP and the CAIR SO₂ program dropped in 42 states and D.C. by a total of approximately 12 million tons. In contrast, annual SO₂ emissions increased by a total of 29,000 tons in six states (Arkansas, Idaho, Nebraska, Oregon, Rhode Island, and Vermont) from 1990 to 2013.
- Seventeen states and D.C. had emissions below their CAIR allowance budgets, collectively by about 1.1 million tons. Another seven states exceeded their 2013 budgets by a total of about 150,000 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.

SO₂ Emission Rates

- In 2013 the SO₂ emission rate fell to 0.26 lb/mmBtu. This indicates a 70 percent reduction from 2000 rates, with the majority of reductions from coal-fired units.
- Despite dramatic decreases in emissions since 2000, heat input has remained steady over the past thirteen years, indicating an improvement in emission rate at the sources. This is due in large part to greater use of control technology on coal-fired units and increased heat input at natural gas-fired units.

More Information

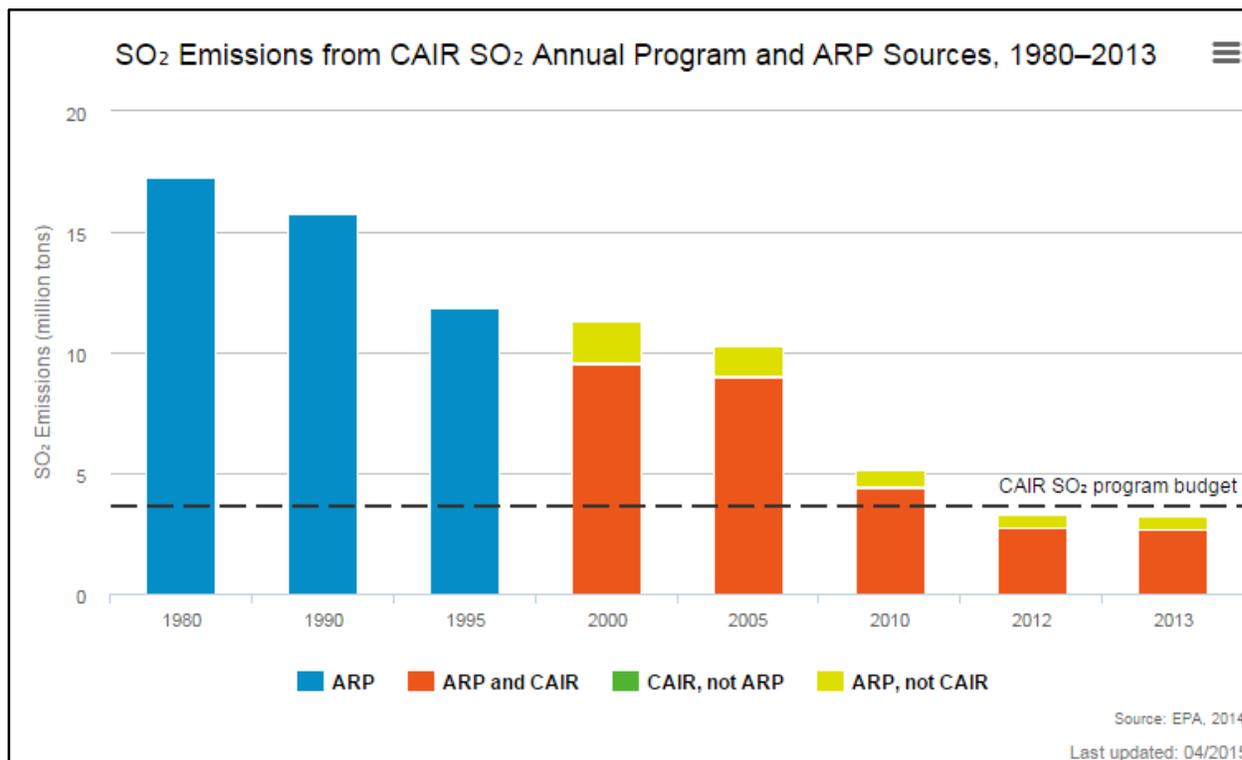
Acid Rain Program (ARP) <http://www.epa.gov/airmarkets/programs/arp/index.html>

Clean Air Interstate Rule (CAIR) <http://www.epa.gov/airmarkets/programs/cair/index.html>



Figures

Subtopic: Sulfur Dioxide (SO₂)



Notes:

- For CAIR units not in the ARP, the 2009 annual SO₂ emissions were applied retroactively for each pre-CAIR year following the year in which the unit began operating.

Figure 1. SO₂ Emissions from CAIR SO₂ Annual Program and ARP Sources, 1980-2013

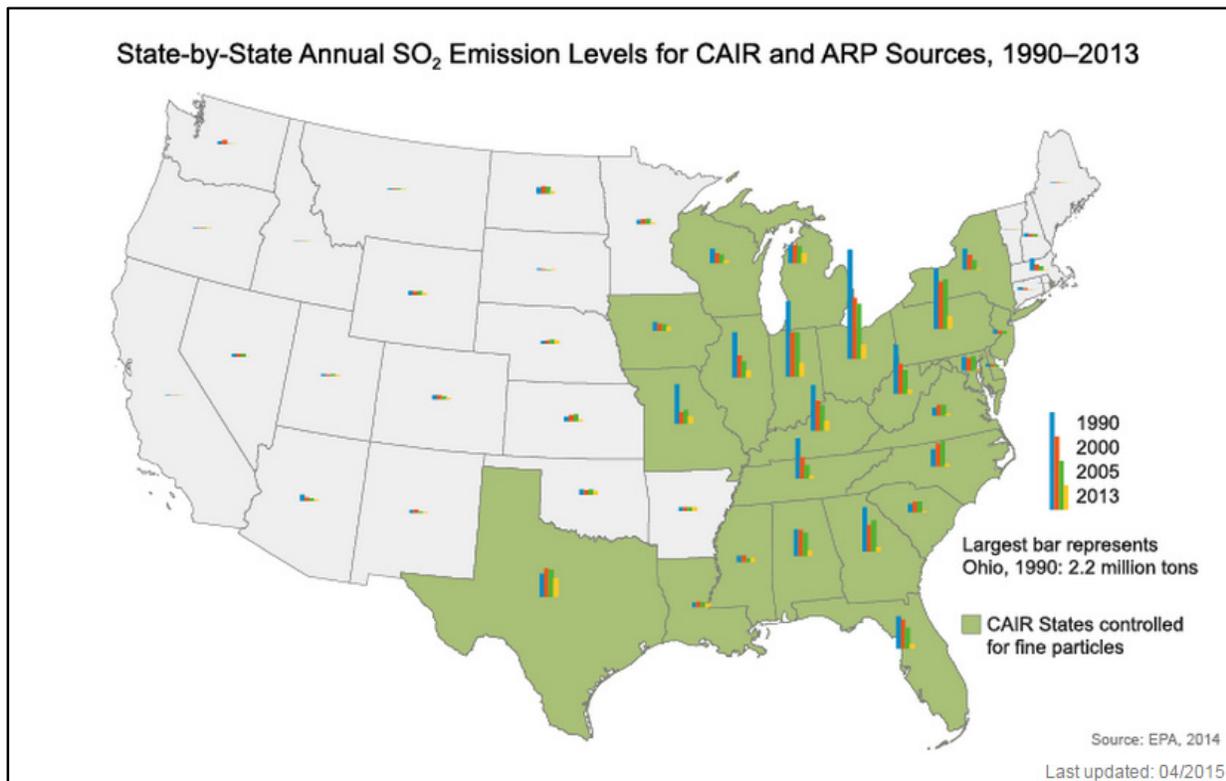
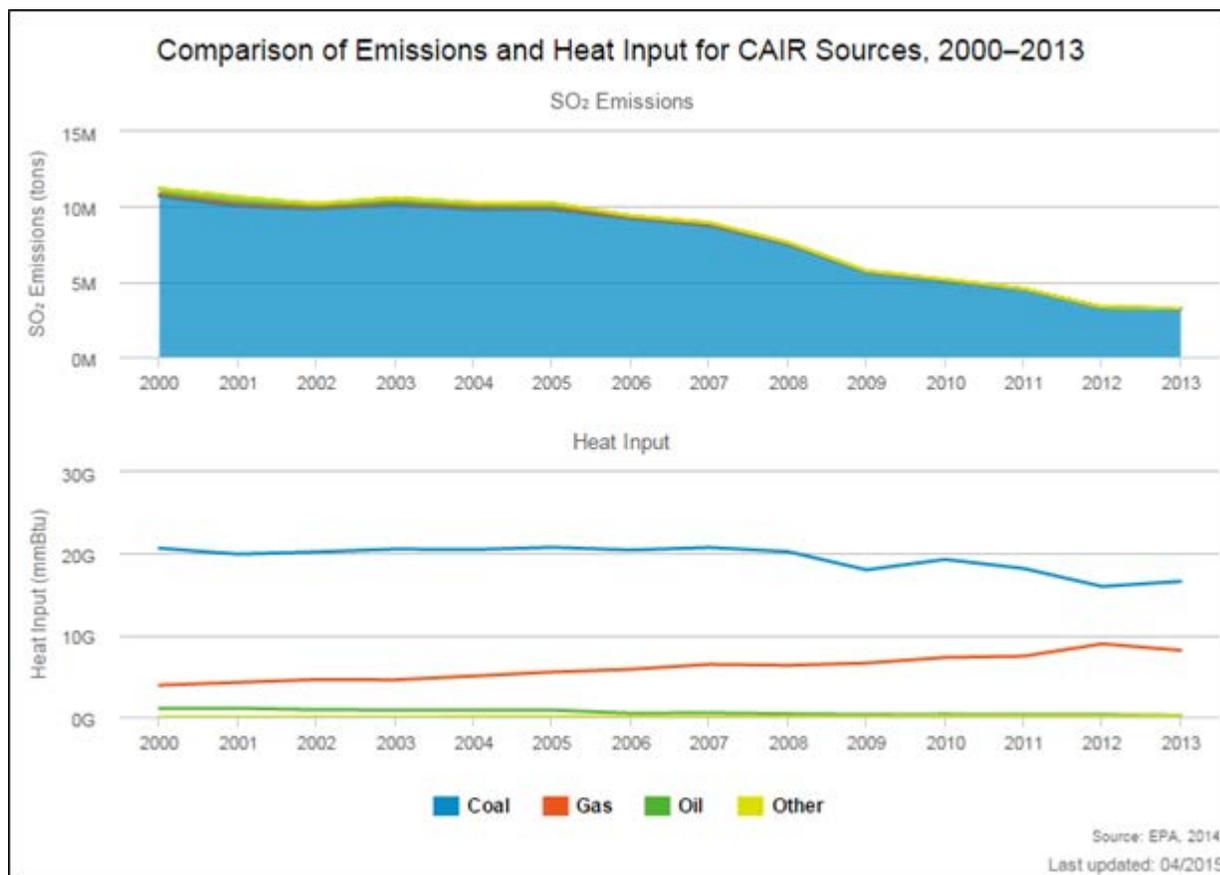


Figure 2. State-by-State Annual SO₂ Emission Levels
for CAIR and ARP Sources, 1990-2013



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 SO₂ annual program facilities are not included in the annual SO₂ data prior to 2009.
- Fuel type represents primary fuel type; units might combust more than one fuel.
- Unless otherwise noted, EPA data are current as of June 2014, and may differ from past or future reports as a result of resubmissions by sources and ongoing data quality assurance activities.

Figure 3. Comparison of Emissions and Heat Input for CAIR Sources, 2000-2013



CAIR and ARP Annual SO₂ Trends

| Primary Fuel | SO ₂ Emissions (thousand tons) | | | | | SO ₂ Rate (lb/mmBtu) | | | | | Heat Input (billion mmBtu) | | | | |
|--------------|---|---------------|--------------|--------------|--------------|---------------------------------|-------------|-------------|-------------|-------------|----------------------------|--------------|--------------|--------------|--------------|
| | 2000 | 2005 | 2009 | 2010 | 2013 | 2000 | 2005 | 2009 | 2010 | 2013 | 2000 | 2005 | 2009 | 2010 | 2013 |
| Coal | 10,708 | 9,835 | 5,653 | 5,090 | 3,210 | 1.04 | 0.95 | 0.63 | 0.53 | 0.39 | 20.67 | 20.77 | 18.02 | 19.30 | 16.61 |
| Gas | 108 | 91 | 22 | 20 | 6 | 0.06 | 0.03 | 0.01 | 0.01 | 0.00 | 3.88 | 5.49 | 6.59 | 7.28 | 8.16 |
| Oil | 385 | 292 | 38 | 31 | 7 | 0.73 | 0.70 | 0.27 | 0.19 | 0.07 | 1.06 | 0.84 | 0.29 | 0.33 | 0.21 |
| Other | 1 | 4 | 8 | 26 | 19 | 0.22 | 0.27 | 0.27 | 0.53 | 0.28 | 0.01 | 0.03 | 0.06 | 0.10 | 0.14 |
| Total | 11,201 | 10,223 | 5,722 | 5,168 | 3,242 | 0.88 | 0.75 | 0.46 | 0.38 | 0.26 | 25.61 | 27.13 | 24.96 | 27.00 | 25.10 |

Source EPA, 2014
Last updated: 04/2015

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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 SO₂ annual program facilities are not included in the annual SO₂ data prior to 2009.

- 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, and heat input is unevenly distributed across the fuel categories.
- Unless otherwise noted, EPA data are current as of June 2014, and may differ from past or future reports as a result of resubmissions by sources and ongoing data quality assurance activities.

Figure 4. CAIR and ARP Annual SO₂ Trends