POWER SECTOR PROGRAMS
PROGRESS REPORT

2017

- Program Basics
- Emission Controls & Monitoring
- Affected Units
- Program Compliance
- Emission Reductions
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Executive Summary

Under the Clean Air Act, EPA implements several regulations that affect power plants, including the Acid Rain Program (ARP), the Cross-State Air Pollution Rule (CSAPR) and CSAPR Update, and the Mercury and Air Toxics Standards (MATS). These programs require fossil fuel-fired electric generating units to reduce emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_X), and hazardous air pollutants (including mercury (Hg)) to protect human health and the environment. This reporting year marks the third year of CSAPR implementation, the twenty-second year of ARP, and the first year of MATS implementation in which the majority of sources were required to report emissions for the full year. This report summarizes annual progress through 2017, highlighting data that EPA systematically collects on emissions for all three programs, on compliance, and environmental effects for ARP and CSAPR. Transparency and data availability are a hallmark of these programs, and a cornerstone of their success.

Sulfur dioxide, nitrogen oxides, and hazardous air pollutants, including mercury, are fossil fuel combustion byproducts that impact public health and the environment. SO_2 and NO_X, and their sulfate and nitrate byproducts, are transported and deposited as acid rain at levels harmful to sensitive ecosystems in many areas of the country. These pollutants also contribute to the formation of fine particles (sulfates and nitrates) and ground level ozone that are associated with significant human health effects and regional haze. Atmospheric mercury deposition accumulates in fish to levels of concern for human health and the health of fish-eating wildlife.

The Acid Rain Program, CSAPR, CSAPR Update and MATS have delivered substantial reductions in power sector emissions of SO_2, NO_X, and hazardous air pollutants, along with significant improvements in air quality and the environment. In addition to the demonstrated reductions achieved by the power sector emission control programs described in this report, SO_2, NO_X, and hazardous air pollutant emissions have declined steadily in recent years due to a variety of power industry trends that are expected to continue.

2017 ARP, CSAPR and MATS at a Glance

- **Annual SO_2 emissions:**
  CSAPR - 1.2 million tons (87 percent below 2005)
  ARP - 1.5 million tons (91 percent below 1990)
- **Annual NO_X emissions**:
  CSAPR - 0.8 million tons (69 percent below 2005)
  ARP - 1.2 million tons (81 percent below 1990)
- **CSAPR ozone season NO_X emissions:** 420,000 tons (53 percent below 2005)
- **Compliance:** 100 percent compliance for power plants in the market-based ARP and CSAPR allowance-trading programs.
- **Emissions reported under MATS:**
  Mercury - 4 tons (86 percent below 2010)
  Acid gases - 4,831 tons (96 percent below 2010)
  Non-mercury metals - 221 tons (81 percent below 2010)

Contents

Chapter 1: Program Basics

The Acid Rain Program (ARP), the Cross-State Air Pollution Rule (CSAPR), and the CSAPR Update are implemented through cap and trade programs designed to reduce emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_X) from covered power plants. Established under Title IV of the 1990 Clean Air Act Amendments, the Acid Rain Program was a landmark nationwide cap and trade program, with a goal of reducing the emissions that cause acid rain. The undisputed success of the program in achieving significant emission reductions in a cost-effective manner led to the application of the market-based cap and trade tool for other regional environmental problems, namely interstate air pollution transport, or pollution from upwind emission sources that impacts air quality in downwind areas. The interstate transport of pollution can make it difficult for downwind states to meet health-based air quality standards for regional pollutants, particularly $PM_{2.5}$ and ozone. EPA first employed trading to address regional criteria pollution in the NO_X Budget Trading Program (NBP), which helped northeastern states address the interstate transport of NO_X emissions causing ozone pollution in northeastern states. Next, NBP was effectively replaced by the ozone season NO_X program under the Clean Air Interstate Rule (CAIR), which required further summertime NO_X emission reductions from the power sector, and also required annual reductions of NO_X and SO_2 to address $PM_{2.5}$ transport. In response to a court decision on CAIR, CSAPR replaced CAIR beginning in 2015 and continued to reduce annual SO_2 and NO_X emissions, as well as seasonal NO_X emissions, to facilitate attainment of the fine particle and ozone NAAQS. Most recently, implementation of CSAPR Update began in 2017. CSAPR Update further reduces seasonal NO_X emissions to help states attain and maintain a newer ozone National Ambient Air Quality Standards (NAAQS).

The Mercury and Air Toxics Standards (MATS) set limits on emissions of hazardous air pollutants from covered power plants. EPA published the final standards in February 2012, and the compliance requirements generally went into effect in April 2015. with extensions for some plants until April 2016 and a small number until April 2017. As such, 2017 is the first full year for which the vast majority of sources covered by MATS have reported emissions data to the EPA.

Highlights

Acid Rain Program (ARP): 1995 - present

- ARP began in 1995 and covers fossil fuel-fired power plants across the contiguous United States. ARP was established under Title IV of the 1990 Clean Air Act Amendments and is designed to reduce SO_2 and NO_X emissions, the primary precursors of acid rain.
- The ARP's market-based SO_2 cap and trade program sets an annual cap on the total amount of SO_2 that may be emitted by covered electricity generating units (EGUs) throughout the contiguous U.S. The final annual SO_2 emissions cap was set at 8.95 million tons in 2010, a level of about one-half of the emissions from the power sector in 1980.
- NO_X reductions under ARP are achieved through a rate-based approach that applies to a subset of coal-fired EGUs.

Cross-State Air Pollution Rule (CSAPR): 2015 - present

- CSAPR addresses regional interstate transport of fine particle and ozone pollution for the 1997 ozone and $PM_{2.5}$ NAAQS and the 2006 $PM_{2.5}$ NAAQS. In 2015, CSAPR required a total of 28 eastern states to reduce SO_2 emissions, annual NO_X emissions and/or ozone season NO_X emissions. Specifically, CSAPR required reductions in annual emissions of SO_2 and NO_X from power plants in 23 eastern states and reductions of NO_X emissions during the ozone season from power plants in 25 eastern states.
- CSAPR includes four separate cap and trade programs to achieve these reductions: CSAPR SO_2 Group 1 and Group 2 trading programs, CSAPR NO_X Annual trading program, and CSAPR NO_X Ozone Season Group 1 trading program.

Cross-State Air Pollution Rule Update (CSAPR Update): 2017 - present

- CSAPR Update was developed to address regional interstate transport for the 2008 ozone NAAQS and to respond to the July 2015 court remand of certain CSAPR ozone season requirements.
- Starting in May 2017, CSAPR Update began further reducing ozone season NO_X emissions from power plants in 22 states in the eastern U.S.
- CSAPR Update achieves these reductions through the CSAPR NO_X Ozone Season Group 2 trading program. The total CSAPR Update budget equals the sum of the individual state budgets for those states included in the program. The CSAPR Update budget is set at 316,464 tons in 2017.

CSAPR and CSAPR Update Budgets

- The total CSAPR and CSAPR Update budget for each of the five trading programs equals the sum of the individual state budgets for those states affected by each program. In 2017, some original CSAPR budgets tightened, particularly in the SO_2 Group 1 program. Also, CSAPR Update replaced the original CSAPR ozone season NO_X program for most states. The total budget for each program was set at the following level in 2017:
    - SO_2 Group 1 – 1,372,631 tons
    - SO_2 Group 2 – 597,579 tons
    - NO_X Annual – 1,069,256 tons
    - NO_X Ozone Season Group 1 – 24,041 tons[1]
    - NO_X Ozone Season Group 2 – 316,464 tons

Mercury and Air Toxics Standards (MATS)

- EPA announced standards to limit mercury, acid gases, and other toxic pollution from power plants in December 2011 (published in February 2012). EPA provided the maximum 3-year compliance period so sources were generally required to comply no later than April 16, 2015. Some sources obtained a one-year extension from their state permitting authority, allowed under the CAA, and so, were required to comply with the final rule by April 16, 2016.

[1]The CSAPR NO_X Ozone Season Group 1 program applies only to sources in Georgia.

- Units subject to MATS must comply with emission rate limits for certain hazardous air pollutants (or surrogates). There are several ways to demonstrate compliance, including the use of continuous monitoring or through periodic measurement of emissions. Some units may choose to demonstrate compliance through periodic performance tests.
- This 2017 progress report only provides data from affected sources that submitted hourly emissions data in 2017. Units not reporting data (e.g. those monitoring using periodic testing) are not included in this report.

Background Information

Power Sector Trends

The widespread and dramatic emission reductions in the power sector over the last few decades have come about from several factors, including changes in markets for fuels and electricity as well as regulatory programs. While most coal-fired electricity generation comes from sources with state of the art emission controls, broad industry shifts from coal-fired generation to gas-fired generation as well as increases in zero-emitting generation sources also have reduced power sector emissions. Market factors, reduced electricity demand, and policy and regulatory efforts have resulted in a notable change in the last decade to the country's overall generation mix as natural gas and renewable energy generation increased while coal-fired generation decreased.

Looking ahead, the price of natural gas is expected to remain low for the foreseeable future as improvements in drilling technologies and techniques continue to reduce the cost of extraction. In addition, the existing fleet of coal-fired EGUs is aging and there are very few new coal-fired generation projects under development. With a continued (but reduced) tax credit and declining capital costs, solar capacity is projected to grow through 2050, while tax credits that phase out for plants entering service through 2024 provide incentives for new wind capacity in the near-term. Some power generators have announced that they expect to continue to change their generation mix away from coal-fired generation and toward natural-gas fired generation, renewables, and more deployment of energy efficiency measures. All of these factors, in total, have resulted in declining power sector emissions in recent years, a trend that is expected to continue going forward.

Acid Rain Program

Title IV of the 1990 Clean Air Act Amendments established ARP to address acid deposition nationwide by reducing annual SO_2 and NO_X emissions from fossil fuel-fired power plants. In contrast to traditional command and control regulatory methods that establish specific emissions limitations, the ARP SO_2 program introduced a landmark allowance trading system that harnessed the economic incentives of the market to reduce pollution. This market-based cap and trade program was implemented in two phases. Phase I began in 1995 and affected the most polluting coal-burning units in 21 eastern and midwestern states. Phase II began in 2000 and expanded the program to include other units fired by coal, oil, and gas in the contiguous U.S. Under Phase II, Congress also tightened the annual SO_2 emissions cap, with a permanent annual cap set at 8.95 million allowances starting in 2010. The NO_X program has a similar results-oriented approach and ensures program integrity through measurement and reporting. However, it does not cap NO_X emissions, nor does it utilize an allowance trading system. Instead, ARP NO_X program provisions apply boiler-specific NO_X emission limits – or rates – in pounds per million British thermal units (lb/mmBtu) on certain coal-fired boilers. There is a degree of flexibility,

however. Units under common control can comply through the use of emission rate averaging plans, subject to requirements ensuring that the total mass emissions from the units in an averaging plan do not exceed the total mass emissions the units would have emitted at their individual emission rate limits.

NO_X Budget Trading Program

NBP was a market-based cap and trade program created to reduce NO_X emissions from power plants and other large stationary combustion sources during the summer ozone season to address regional air pollution transport that contributes to the formation of ozone in the eastern United States. The program, which operated during the ozone seasons from 2003 to 2008, was a central component of the NO_X State Implementation Plan (SIP) Call, promulgated in 1998, to help states attain the 1997 ozone NAAQS. All 21 jurisdictions (20 states plus Washington, D.C.) covered by the NO_X SIP Call opted to participate in NBP. In 2009, CAIR's NO_X ozone season program began, effectively replacing NBP to continue achieving ozone season NO_X emission reductions from the power sector.

Clean Air Interstate Rule

CAIR required 25 eastern jurisdictions (24 states plus Washington, D.C.) to limit annual power sector emissions of SO_2 and NO_X to address regional interstate transport of air pollution that contributes to the formation of fine particulates. It also required 26 jurisdictions (25 states plus Washington, D.C.) to limit power sector ozone season NO_X emissions to address regional interstate transport of air pollution that contributes to the formation of ozone during the ozone season. CAIR used three separate market-based cap and trade programs to achieve emission reductions and to help states meet the 1997 ozone and fine particle NAAQS.

EPA issued CAIR on May 12, 2005 and the CAIR federal implementation plans (FIPs) on April 26, 2006. In 2008, the U.S. Court of Appeals for the DC Circuit remanded CAIR to the Agency, leaving existing CAIR programs in place while directing EPA to replace them as rapidly as possible with a new rule consistent with the Clean Air Act. The CAIR NO_X ozone season and NO_X annual programs began in 2009, while the CAIR SO_2 program began in 2010. As discussed below, CAIR was replaced by CSAPR in 2015.

Cross-State Air Pollution Rule

EPA issued CSAPR in July 2011, requiring 28 states in the eastern half of the United States to significantly improve air quality by reducing power plant emissions that cross state lines and contribute to fine particle and summertime ozone pollution in downwind states. CSAPR required 23 states to reduce annual SO_2 and NO_X emissions to help downwind areas attain the 2006 and/or 1997 annual $PM_{2.5}$ NAAQS. CSAPR also required 25 states to reduce ozone season NO_X emissions to help downwind areas attain the 1997 ozone NAAQS. CSAPR divides the states required to reduce SO_2 emissions into two groups (Group 1 and Group 2). Both groups were required to reduce their SO_2 emissions in Phase I. All Group 1 states, as well as some Group 2 states, were required to make additional reductions in SO_2 emissions in Phase II in order to eliminate their significant contribution to air quality problems in downwind areas.

CSAPR was scheduled to replace CAIR starting on January 1, 2012. However, the timing of CSAPR's implementation was affected by D.C. Circuit actions that stayed and then vacated CSAPR before implementation. On April 29, 2014, the U.S. Supreme Court reversed the D.C. Circuit's vacatur, and on

October 23, 2014, the D.C. Circuit granted EPA's motion to lift the stay and shift CSAPR compliance deadlines by three years. Accordingly, CSAPR Phase I implementation began on January 1, 2015, replacing CAIR, and CSAPR Phase II began January 1, 2017.

Cross-State Air Pollution Rule Update

On September 7, 2016, EPA finalized an update to CSAPR ozone season program by issuing the CSAPR Update. This rule addresses the summertime ozone pollution in the eastern U.S. that crosses state lines and will help downwind states and communities meet and maintain the 2008 ozone NAAQS. In May 2017, CSAPR Update began further reducing ozone season NO_X emissions from power plants in 22 states in the eastern U.S.

Cross-State Air Pollution Rule Close-Out

Under the Clean Air Act's "good neighbor" provision (section 110(a)(2)(D)(i)(I)), upwind states that contribute significantly to nonattainment or interfere with maintenance of NAAQS in downwind areas must implement emission reductions through a state implementation plan (SIP) or, in the absence of an approved SIP, a federal implementation plan (FIP). When issuing the CSAPR Update in September 2016, EPA found that, while it would result in meaningful, near-term reductions in ozone pollution that crosses state lines, the CSAPR Update may not be sufficient to fully address all covered states' good neighbor obligations with respect to the 2008 ozone NAAQS. However, based on additional analysis conducted after issuance of the rule, EPA determined in December 2018 that the emission reductions required by the CSAPR Update in fact would fully address all covered states' good neighbor obligations with respect to this NAAQS. As a result, the covered states do not need to submit SIPs to establish additional emission reduction requirements beyond the existing CSAPR Update requirements to further reduce transported ozone under the 2008 ozone NAAQS. Likewise, EPA has no obligation to establish additional emission reduction requirements for this purpose.

Mercury and Air Toxics Standards

On December 16, 2011, the EPA announced final standards to reduce emissions of toxic air pollutants from new and existing coal- and oil-fired electric utility steam generating units (EGUs) in all 50 states and U.S. territories. MATS established technology-based emission rate standards that reflect the level of hazardous air pollutant (HAP) emissions that had been achieved by the best-performing sources. These HAPs include mercury (Hg), non-mercury metals (such as arsenic (As), chromium (Cr), and nickel (Ni)), and acid gases, including hydrochloric acid (HCl) and hydrofluoric acid (HF). EPA provided the maximum 3-year compliance period so sources were generally required to comply no later than April 16, 2015. Some sources obtained a one-year extension from their state permitting authority, allowed under the CAA, and so, were required to comply with the final rule by April 16, 2016.

More Information

- Acid Rain Program (ARP) https://www.epa.gov/airmarkets/acid-rain-program
- Interstate Air Pollution Transport https://www.epa.gov/airmarkets/interstate-air-pollution-transport
- Cross-State Air Pollution Rule (CSAPR) https://www.epa.gov/csapr

- Cross-State Air Pollution Rule Update (CSAPR Update) https://www.epa.gov/airmarkets/final-cross-state-air-pollution-rule-update
- Cross-State Air Pollution Rule Close-Out (CSAPR Close-Out) https://www.epa.gov/airmarkets/final-csapr-close-out
- Clean Air Interstate Rule (CAIR) https://archive.epa.gov/airmarkets/programs/cair/web/html/index.html
- NO_X Budget Trading Program (NBP) / NO_X SIP Call https://www.epa.gov/airmarkets/nox-budget-trading-program
- National Ambient Air Quality Standards (NAAQS) https://www.epa.gov/criteria-air-pollutants
- EPA's Clean Air Market Programs https://www.epa.gov/airmarkets/programs
- Emissions Trading https://www.epa.gov/emissions-trading-resources
- MATS https://www.epa.gov/mats

Figures

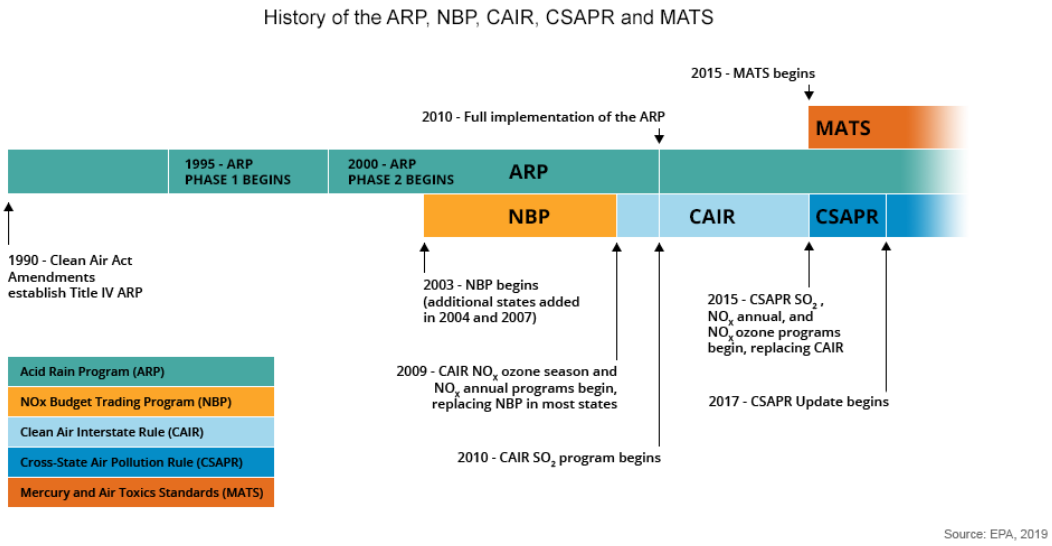


Figure 1. History of the ARP, NBP, CAIR, CSAPR and MATS

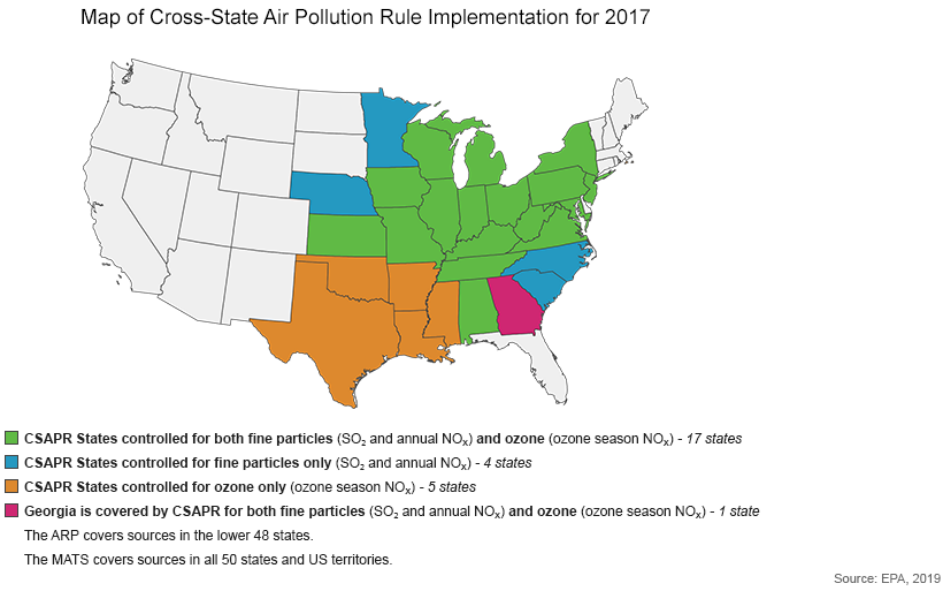
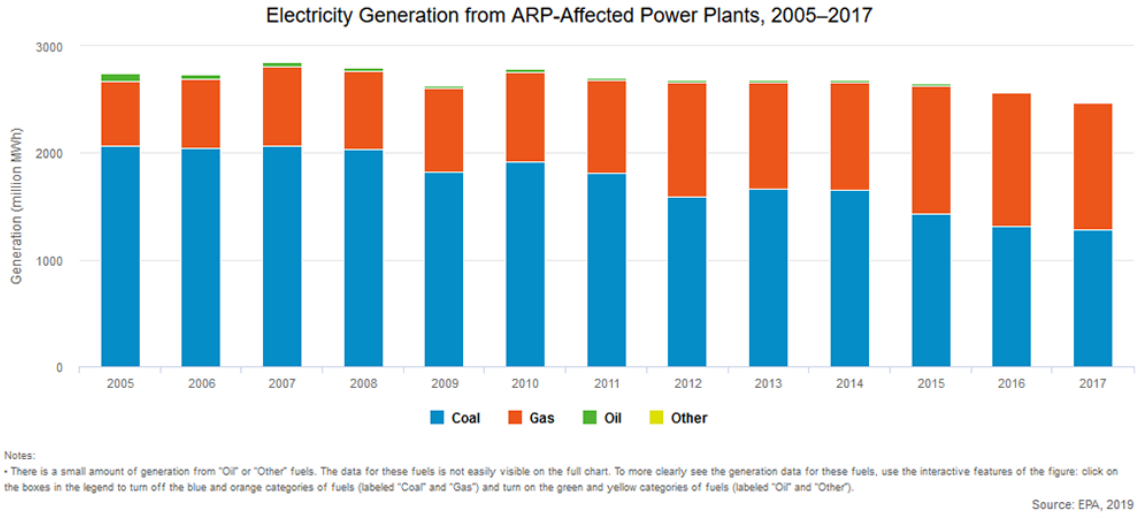


Figure 2. Map of Cross-State Air Pollution Rule Implementation for 2017



Notes:
• There is a small amount of generation from "Oil" or "Other" fuels. The data for these fuels is not easily visible on the full chart. To more clearly see the generation data for these fuels, use the interactive features of the figure: click on the boxes in the legend to turn off the blue and orange categories of fuels (labeled "Coal" and "Gas") and turn on the green and yellow categories of fuels (labeled "Oil" and "Other").

Source: EPA, 2019

Figure 3. Electricity Generation from ARP-Affected Power Plants, 2005–2017

Chapter 2: Affected Units

The Acid Rain Program (ARP), the Cross-State Air Pollution Rule's (CSAPR) sulfur dioxide (SO_2) and nitrogen oxides (NO_X) emission reduction programs, apply to large electricity generating units (EGUs) that burn fossil fuels to generate electricity for sale. The Mercury and Air Toxics Standards only cover large EGUs that burn coal or oil to generate electricity for sale. This is the primary reason that this report includes less units for MATS. This section covers units affected in 2017.

Highlights

Acid Rain Program (ARP)

- In 2017, ARP SO_2 requirements applied to 3,383 fossil fuel-fired combustion units at 1,195 facilities across the country; 657 units at 295 facilities were subject to the ARP NO_X program.

Cross-State Air Pollution Rule (CSAPR)

- In 2017, there were 2,287 affected EGUs at 712 facilities in the CSAPR SO_2 program. Of those, 1,805 (79 percent) were also covered by ARP.
- In 2017, there were 2,287 affected EGUs at 712 facilities in the CSAPR NO_X annual program and 2,623 affected EGUs at 837 facilities in the CSAPR NO_X ozone season program. Of those, 1,805 (79 percent) and 2,124 (81 percent), respectively, were also covered by ARP.

Mercury and Air Toxics (MATS)

- The Mercury and Air Toxics Standards (MATS) set limits on the emissions of hazardous air pollutants from coal- and oil-fired electric utility steam generating units (EGUs) in all 50 states and U.S. territories. MATS is issued under section 112 of the Clean Air Act and requires units to conduct testing and submit emissions data to EPA periodically. EPA is including a summary of the mercury data submitted by affected sources in this report.
- In 2017, 530 units at 235 facilities reported hourly mercury emissions to EPA under MATS.

Background Information

In general, ARP; the CSAPR SO_2, NO_X annual, and NO_X ozone season trading programs; apply to large EGUs – boilers, turbines, and combined cycle units – that burn fossil fuel, serve generators with nameplate capacity greater than 25 megawatts, and produce electricity for sale. MATS applies only to coal- and oil-fired steam generating EGUs (i.e., utility boilers). It does not apply to turbines, combined cycle units, or to natural gas-fired utility boilers. These EGUs include 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 only on peak demand days. The ARP NO_X program applies to a subset of these units that are older and historically coal-fired.

More Information

- Acid Rain Program (ARP) https://www.epa.gov/airmarkets/acid-rain-program
- Cross-State Air Pollution Rule (CSAPR) https://www.epa.gov/csapr

- Mercury and Air Toxics Standards (MATS) https://www.epa.gov/mats

Figures

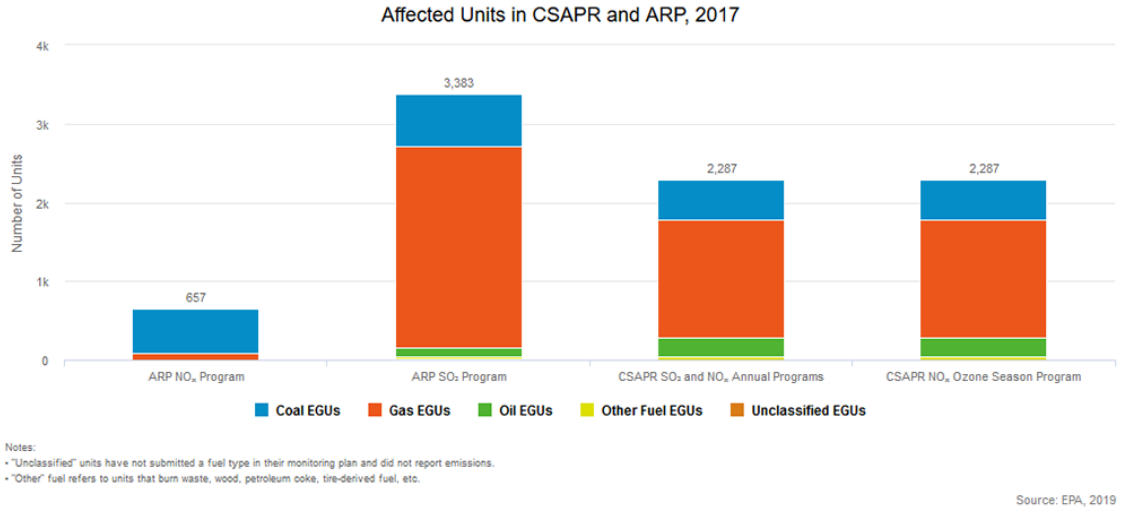


Figure 1. Affected Units in CSAPR and ARP, 2017

Affected Units in CSAPR and ARP, 2017

Fuel	ARP NO_x	ARP SO_2	CSAPR SO_2 and Annual NO_x	CSAPR Ozone Season NO_x
Coal	575	666	503	503
Gas	80	2,562	1,498	1,498
Oil	0	117	249	249
Other	2	29	37	37
Unclassified	0	9	0	0
Total Units	**657**	**3,383**	**2,287**	**2,287**

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, 2019

Figure 2. Affected Units in CSAPR and ARP, 2017

Chapter 3: Emission Reductions

The Acid Rain Program (ARP) and Cross-State Air Pollution Rule (CSAPR) programs significantly reduced sulfur dioxide (SO_2), annual nitrogen oxides (NO_X), and ozone season NO_X emissions from power plants. Most of the emission reductions since 2005 occurred in response to the Clean Air Interstate Rule (CAIR), which was replaced by CSAPR in 2015. The Mercury and Air Toxics Standards (MATS) set limits on the emissions of hazardous air pollutants from coal- and oil-fired electric utility steam generating units (EGUs) and have been one of the reasons for reductions in those emissions since 2010. This section covers changes in emissions at units affected by CSAPR, ARP, and MATS between 2017 and previous years.

Sulfur Dioxide (SO_2)

Highlights

Overall Results

- Under the ARP, CAIR, and now CSAPR, power plants have significantly lowered SO_2 emissions while electricity generation has remained relatively stable since 2000.
- These emission reductions are a result of an overall increase in the environmental efficiency at affected sources as power generators installed controls, switched to lower emitting fuels, or otherwise reduced their SO_2 emissions. These trends are discussed further in Chapter 1.

SO_2 Emission Trends

- **ARP:** Units in ARP emitted 1.3 million tons of SO_2 in 2017, well below the ARP's statutory annual cap of 8.95 million tons. ARP sources reduced emissions by 14.4 million tons (92 percent) from 1990 levels and 15.9 million tons (92 percent) from 1980 levels.
- **CSAPR and ARP:** In 2017, the third year of operation of the CSAPR SO_2 program, sources in both the CSAPR SO_2 annual program and ARP together reduced SO_2 emissions by 14.4 million tons (92 percent) from 1990 levels (before implementation of ARP), 9.9 million tons (88 percent) from 2000 levels (ARP Phase II), and 8.9 million tons (87 percent) from 2005 levels (before implementation of CAIR and CSAPR). All ARP and CSAPR sources together emitted a total of 1.3 million tons of SO_2 in 2017.
- **CSAPR:** Annual SO_2 emissions from sources in the CSAPR SO_2 program alone fell from 8.1 million tons in 2005 to 0.8 million tons in 2017, a 91 percent reduction. In 2017, SO_2 emissions were about 1.2 million tons below the regional CSAPR emission budgets (0.7 million in Group 1 and 0.5 million in Group 2); the CSAPR SO_2 annual program's 2017 regional budgets are 1,372,631 and 597,579 tons for Group 1 and Group 2, respectively.

SO_2 State-by-State Emissions

- **CSAPR and ARP:** From 1990 to 2017, annual SO_2 emissions from sources in ARP and the CSAPR SO_2 program dropped in 46 states plus Washington, D.C. by a total of 14.4 million tons. In

contrast, annual SO_2 emissions increased in two states (Idaho and Vermont) by a combined total of 7 tons from 1990 to 2017.

- **CSAPR:** All 22 states (16 states in Group 1 and 6 states in Group 2) had emissions below their CSAPR allowance budgets, collectively by about 1.2 million tons.

SO_2 Emission Rates

- The average SO_2 emission rate for units in ARP or CSAPR SO_2 program fell to 0.12 pounds per million British thermal units (lb/mmBtu). This indicates an 84 percent reduction from 2005 rates, with the majority of reductions coming from coal-fired units.
- Emissions have decreased dramatically since 2005, due in large part to greater use of control technology on coal-fired units and increased generation at natural gas-fired units that emit very little SO_2 emissions.

Background Information

SO_2 is a highly reactive gas that is generated primarily from coal-fired power plants. In addition to contributing to the formation of fine particle pollution ($PM_{2.5}$), SO_2 emissions are 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 SO_2 emission reductions under ARP, and this trend continued under CAIR and CSAPR. Most of these states are located in the Ohio River Valley and are upwind of the areas ARP and CSAPR were designed to protect. Reductions under these programs have provided important environmental and health benefits over a large region.

More Information

- Power Plant Emission Trends https://www.epa.gov/airmarkets/power-plant-emission-trends
- Air Markets Program Data (AMPD) https://ampd.epa.gov/ampd/
- Acid Rain Program (ARP) https://www.epa.gov/airmarkets/acid-rain-program
- Cross-State Air Pollution Rule (CSAPR) https://www.epa.gov/csapr
- Sulfur Dioxide (SO_2) Pollution https://www.epa.gov/so2-pollution
- Particulate Matter (PM) Pollution https://www.epa.gov/pm-pollution
- Power Profiler https://www.epa.gov/energy/power-profiler

Figures

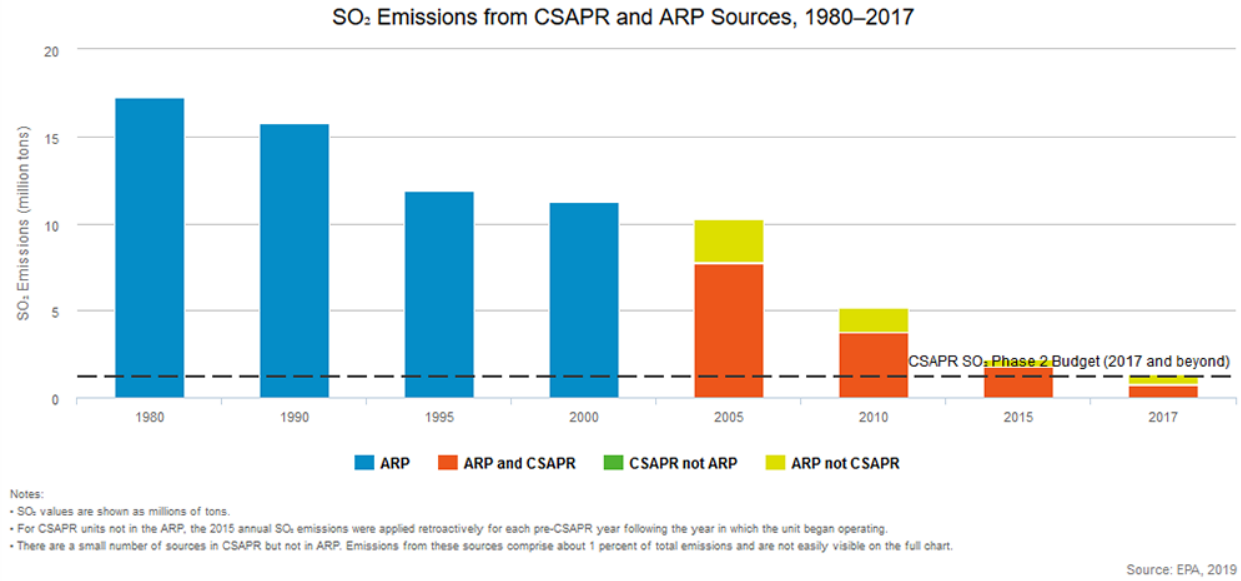


Figure 1. SO_2 Emissions from CSAPR and ARP Sources, 1980–2017

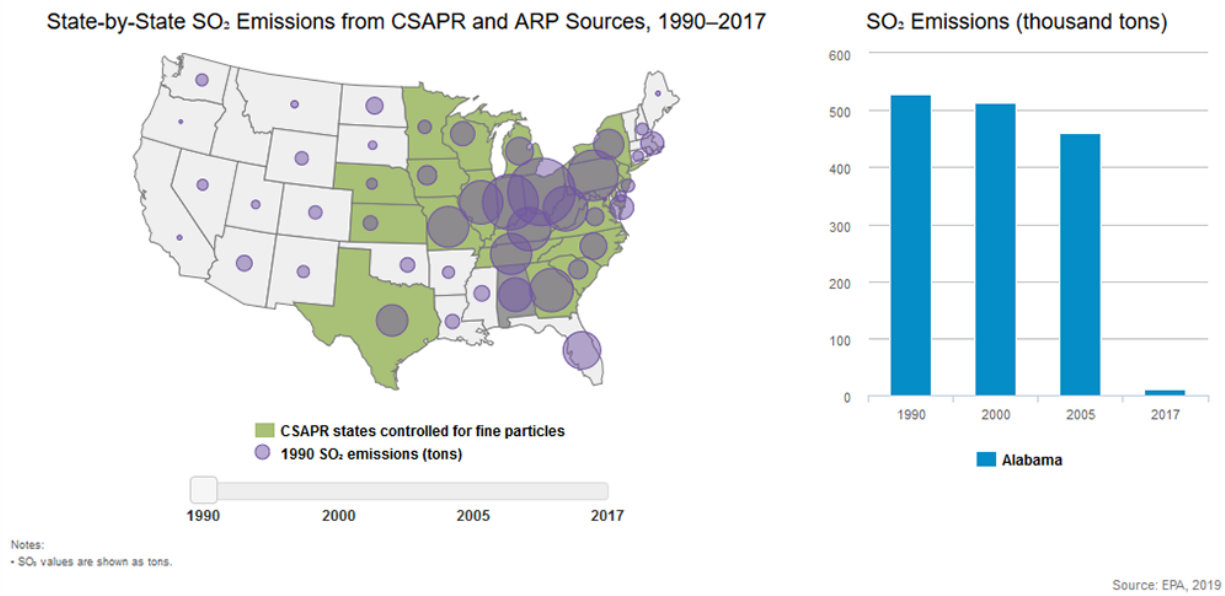


Figure 2. State-by-State SO_2 Emissions from CSAPR and ARP Sources, 1990–2017

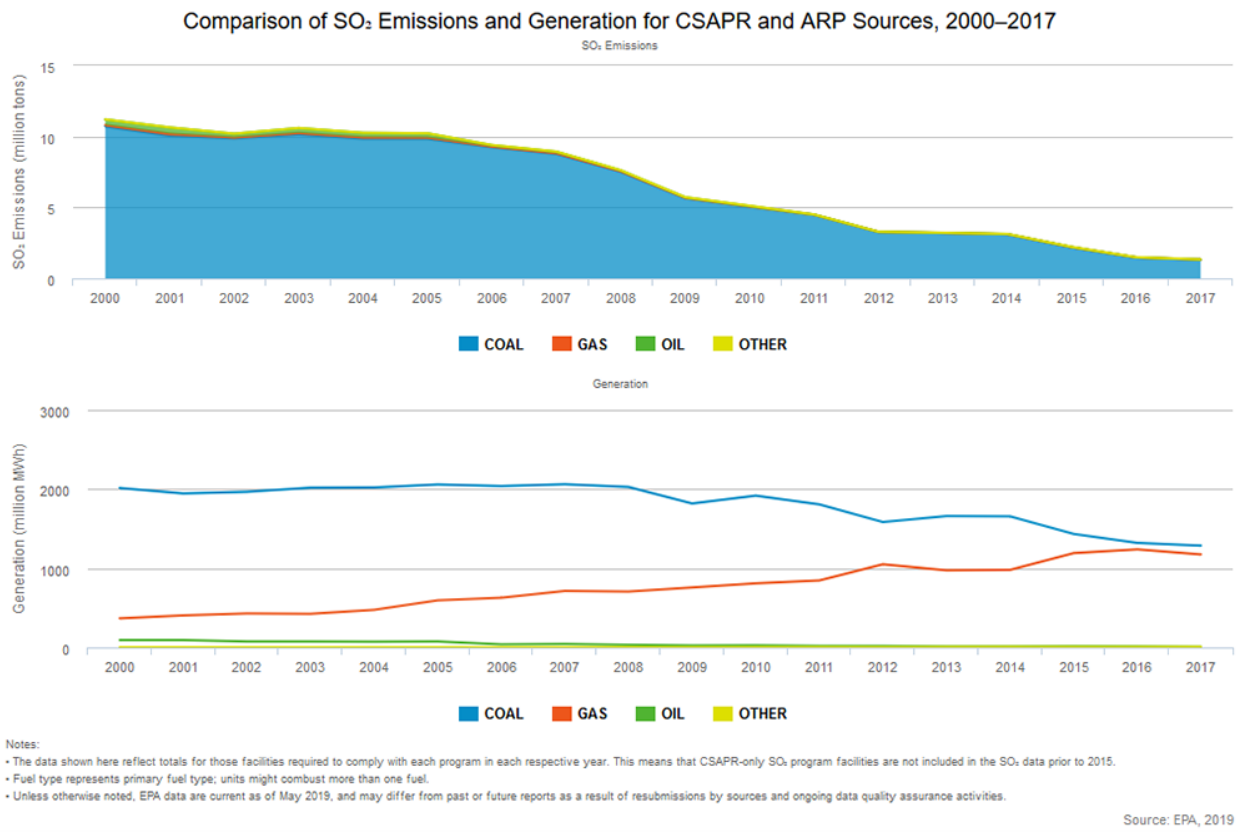


Figure 3. Comparison of SO_2 Emissions and Generation for CSAPR and ARP Sources, 2000–2017

CSAPR and ARP SO_2 Emissions Trends, 2017

	SO_2 Emissions (thousand tons)				SO_2 Rate (lb/mmBtu)			
Primary Fuel	**2000**	**2005**	**2010**	**2017**	**2000**	**2005**	**2010**	**2017**
Coal	10,708	9,835	5,051	1,316	1.04	0.95	0.53	0.14
Gas	108	91	19	8	0.06	0.03	0.01	0.03
Oil	384	292	28	2	0.73	0.70	0.19	0.11
Other	1	4	22	12	0.20	0.27	0.57	0.10
Total / Average	**11,201**	**10,222**	**5,120**	**1,338**	**0.88**	**0.75**	**0.39**	**0.09**

Notes:
- The data shown here reflect totals for those facilities required to comply with each program in each respective year. This means that CSAPR-only SO_2 program facilities are not included in the SO_2 emissions data prior to 2015.
- 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.
- The emission rate reflects the emissions (pounds) per unit of heat input (mmBtu) for each fuel category. The total SO_2 emission rate in each column of the table is not cumulative and does not equal the arithmetic mean of the four fuel-specific rates. The total for each year indicates the average rate across all units in the program because 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 May 2019, and may differ from past or future reports as a result of resubmissions by sources and ongoing data quality assurance activities.

Source: EPA, 2019

Figure 4. CSAPR and ARP SO_2 Emissions Trends, 2017

Annual Nitrogen Oxides

Highlights

Overall Results

- Annual NO_X emissions have declined dramatically under the ARP, CAIR, and CSAPR programs, with the majority of reductions coming from coal-fired units. These reductions have occurred while electricity generation has remained relatively stable since 2000.
- These emission reductions are a result of an overall increase in the environmental efficiency at affected sources as power generators installed controls, ran their controls year-round, switched to lower emitting fuels, or otherwise reduced their NO_X emissions. These trends are discussed further in Chapter 1.
- Other programs – such as regional and state NO_X emission control programs – also contributed significantly to the annual NO_X emission reductions achieved by sources in 2017.

Annual NO_X Emissions Trends

- **ARP:** Units in the ARP NO_X program emitted 1.0 million tons of NO_X emissions in 2017. Sources reduced emissions by 7.1 million tons from the projected level in 2000 without ARP, over three times the program's NO_X emission reduction objective.
- **CSAPR and ARP:** In 2017, the third year of operation of the CSAPR NO_X annual program, sources in both the CSAPR NO_X annual program and ARP together emitted 1.1 million tons, a reduction of 5.4 million tons (84 percent reduction) from 1990 levels, 4.1 million tons (79 percent reduction) from 2000, and 2.7 million tons (71 percent reduction) from 2005 levels.
- **CSAPR:** Emissions from CSAPR NO_X annual program sources alone were 586,000 tons in 2017. This is about 1.6 million tons (73 percent) lower than in 2005 and 480,000 tons (45 percent) below the CSAPR NO_X annual program's 2017 regional budget of 1,069,256 tons.

Annual NO_X State-by-State Emissions

- **CSAPR and ARP:** From 1990 to 2017, annual NO_X emissions in ARP and the CSAPR NO_X program dropped in 47 states plus Washington, D.C. by a total of approximately 5.4 million tons. In contrast, annual emissions increased in one state (Idaho) by 200 tons from 1990 to 2017.
- **CSAPR:** Twenty-one states had emissions below their CSAPR 2017 allowance budgets, collectively by 480,000 tons. A single state (Missouri) exceeded its 2017 budget by 950 tons.

Annual NO_X Emission Rates

- In 2017, the CSAPR and ARP average annual NO_X emission rate was 0.10 lb/mmBtu, a 64 percent reduction from 2005.
- Emissions have decreased dramatically since 2005, due in large part to greater use of control technology, primarily on coal-fired units, and increased generation at natural gas-fired units that emit less NO_X emissions than coal-fired units.

Background Information

Nitrogen oxides (NO_X) are made up of a group of highly reactive gases that are emitted from power plants and motor vehicles, as well as other sources. NO_X emissions contribute to the formation of ground-level ozone and fine particle pollution, which cause a variety of adverse health effects.

More Information

- Power Plant Emission Trends https://www.epa.gov/airmarkets/power-plant-emission-trends
- Air Markets Program Data (AMPD) https://ampd.epa.gov/ampd/
- Acid Rain Program (ARP) https://www.epa.gov/airmarkets/acid-rain-program
- Cross-State Air Pollution Rule (CSAPR) https://www.epa.gov/csapr
- Nitrogen Oxides (NO_X) Pollution https://www.epa.gov/no2-pollution
- Particulate Matter (PM) Pollution https://www.epa.gov/pm-pollution
- Power Profiler https://www.epa.gov/energy/power-profiler

Figures

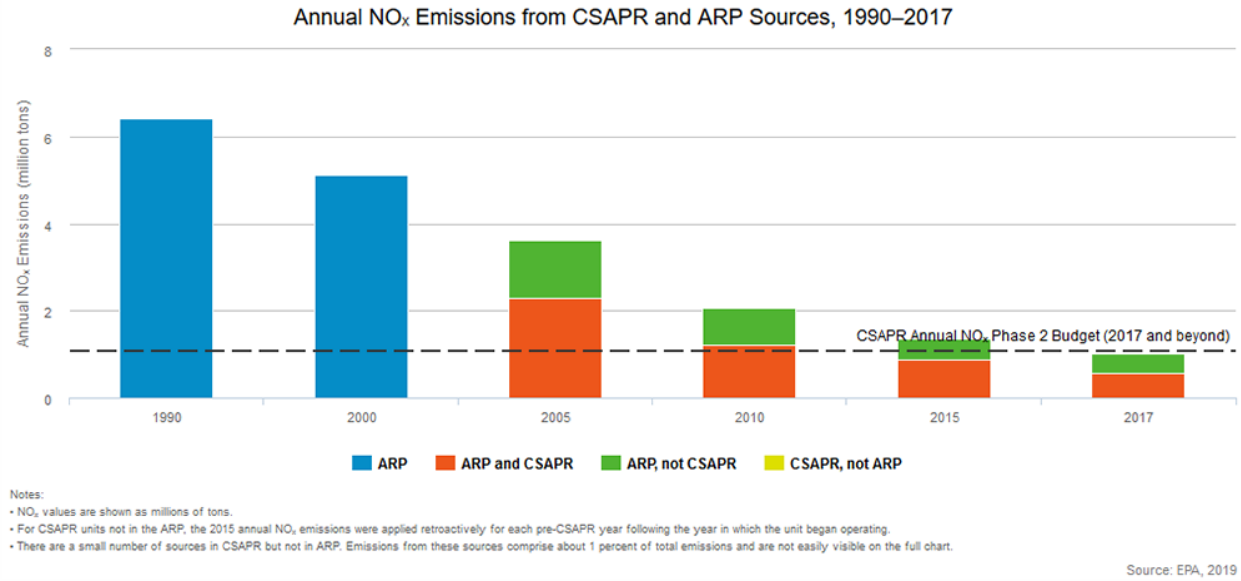


Figure 1. Annual NO_X Emissions from CSAPR and ARP Sources, 1990–2017

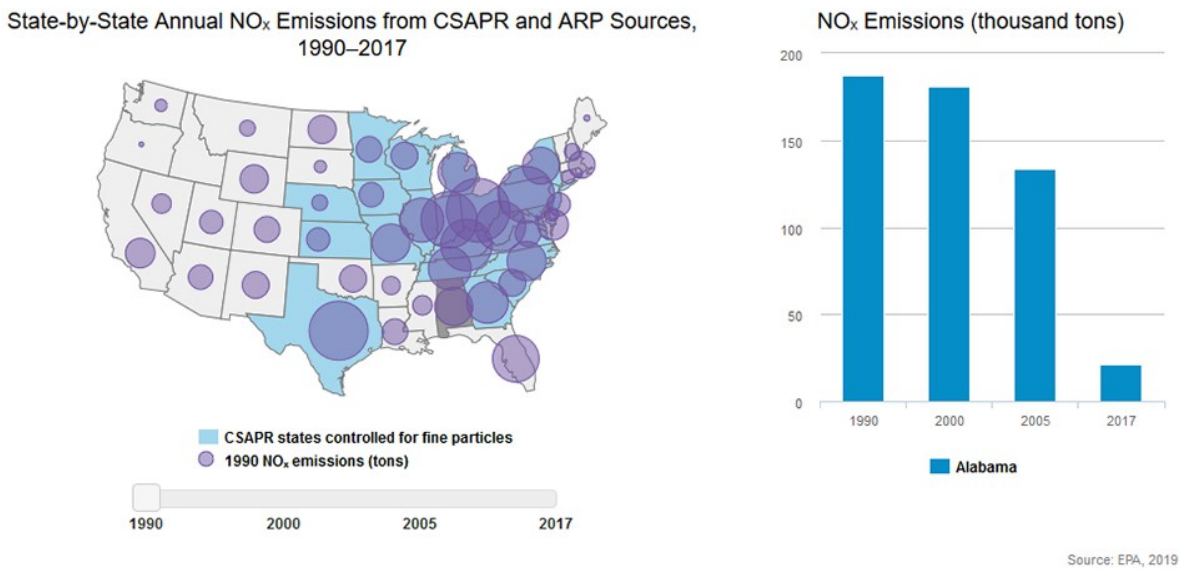


Figure 2. State-by-State Annual NO_X Emissions from CSAPR and ARP Sources, 1990-2017

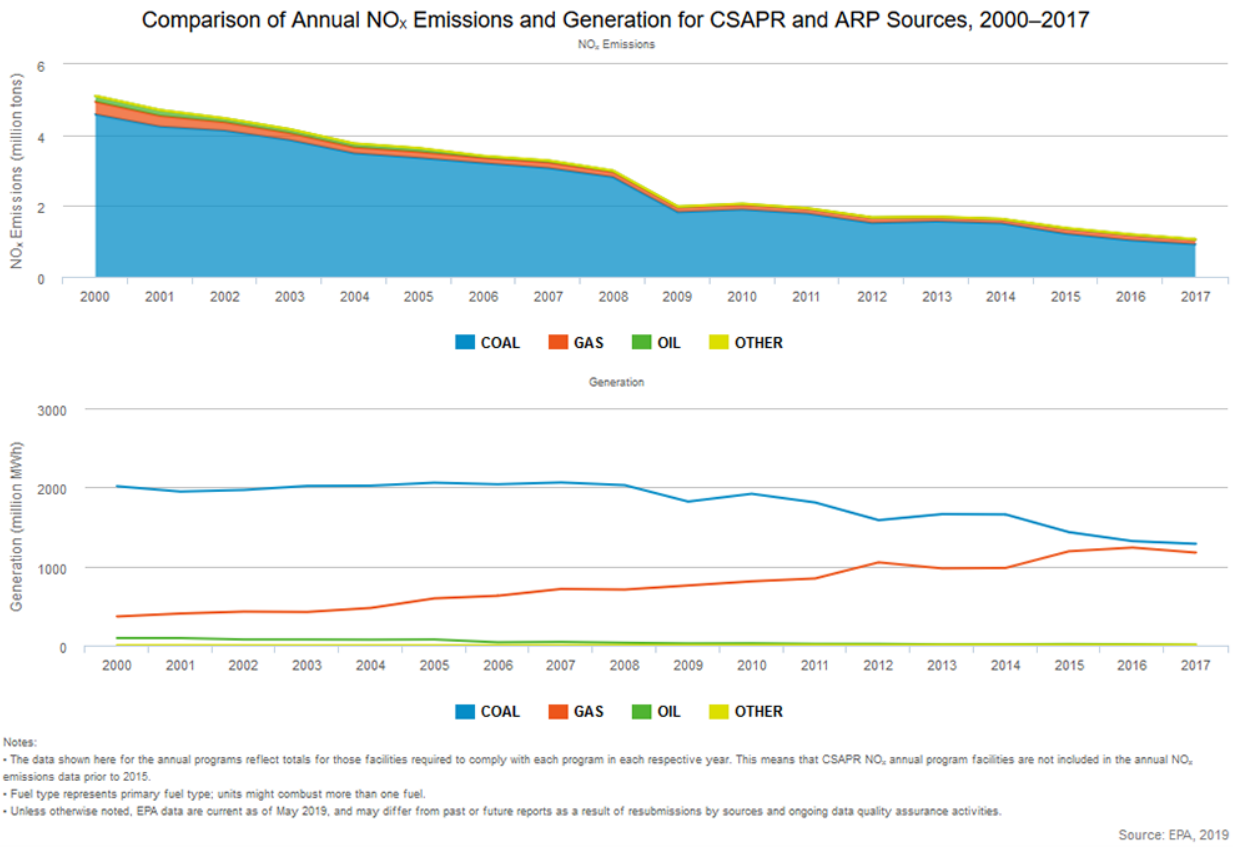


Figure 3. Comparison of Annual NO_X Emissions and Generation for CSAPR and ARP Sources, 2000–2017

CSAPR and ARP Annual NO_x Emissions Trends, 2017

	NO_x Emissions (thousand tons)				NO_x Rate (lb/mmBtu)			
Primary Fuel	**2000**	**2005**	**2010**	**2017**	**2000**	**2005**	**2010**	**2017**
Coal	4,587	3,356	1,896	918	0.44	0.32	0.20	0.14
Gas	355	167	142	131	0.18	0.06	0.04	0.03
Oil	162	104	20	4	0.31	0.25	0.13	0.11
Other	2	6	5	7	0.24	0.42	0.13	0.10
Total / Average	**5,106**	**3,633**	**2,063**	**1,060**	**0.40**	**0.27**	**0.16**	**0.09**

Notes:
- The data shown here reflect totals for those facilities required to comply with each program in each respective year. This means that CSAPR-only annual NO_x program facilities are not included in the NO_x emissions data prior to 2015.
- 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.
- The emission rate reflects the emissions (pounds) per unit of heat input (mmBtu) for each fuel category. The total annual NO_x emission rate in each column of the table is not cumulative and does not equal the arithmetic mean of the four fuel-specific rates. The total for each year indicates the average rate across all units in the program because 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 May 2019, and may differ from past or future reports as a result of resubmissions by sources and ongoing data quality assurance activities.

Source: EPA, 2019

Figure 4. CSAPR and ARP Annual NO_X Emissions Trends, 2017

Ozone Season Nitrogen Oxides

Highlights

Overall Results

- Ozone season NO_X emissions have declined dramatically under ARP, NBP, CAIR, and CSAPR programs.
- States with the highest emitting sources of ozone season NO_X emissions in 2000 have seen the greatest reductions under the CSAPR NO_X ozone season program. Most of these states are in the Ohio River Valley and are upwind of the areas CSAPR was designed to protect. Reductions by sources in these states have resulted in important environmental and human health benefits over a large region.
- These reductions have occurred while electricity generation has remained relatively stable since 2000. These trends are discussed further in Chapter 1.
- Other programs—such as regional and state NO_X emission control programs—also contributed significantly to the ozone season NO_X emission reductions achieved by sources in 2017.

Ozone Season NO_X Emissions Trends

- Units in the CSAPR NO_X ozone season program emitted 300,000 tons in 2017
  - A reduction of 1.7 million tons (85 percent) from 1990,
  - 1.0 million tons lower (76 percent reduction) than in 2000 (before implementation of NBP),
  - 350,000 tons lower (53 percent reduction) than in 2005 (before implementation of CAIR), and
  - 87,000 tons lower (22 percent reduction) than in 2015.
- In 2017, CSAPR NO_X ozone season program emissions were 11 percent below the regional emission budget of 340,505 tons (24,041 tons for Group 1 and 316,464 tons for Group 2).

Ozone Season NO_X State-by-State Emissions

- Between 2005 and 2017, ozone season NO_X emissions from CSAPR sources fell in every state participating in the CSAPR NO_X ozone season program.
- Seventeen states had emissions below their CSAPR 2017 allowance budgets, collectively by about 43,000 tons. Six states (Arkansas, Ohio, Tennessee, Texas, West Virginia, and Wisconsin) exceeded their 2017 budgets by about 3,900 tons combined.

Ozone Season NO_X Emission Rates

- In 2017, the average NO_X ozone season emission rate fell to 0.08 lb/mmBtu for CSAPR ozone season program states and 0.09 lb/mmBtu nationally. This represents a 50 and 56 percent reduction, respectively, from 2005 emission rates, with the majority of reductions coming from coal-fired units.

- Emissions have decreased dramatically since 2005, due in large part to greater use of control technology, primarily on coal-fired units, and increased generation at natural gas-fired units, which emit less NO_X emissions than coal-fired units.

Background Information

Nitrogen oxides (NO_X) are made up of a group of highly reactive gases that are emitted from power plants and motor vehicles, as well as other sources. NO_X emissions contribute to the formation of ground-level ozone and fine particle pollution, which cause a variety of adverse human health effects.

The CSAPR NO_X ozone season program was established to reduce interstate transport during the ozone season (May 1 – September 30), the warm summer months when ozone formation is highest, and to help eastern U.S. counties attain the 1997 ozone standard.

More Information

- Power Plant Emission Trends https://www.epa.gov/airmarkets/power-plant-emission-trends
- Air Markets Program Data (AMPD) https://ampd.epa.gov/ampd/
- Cross-State Air Pollution Rule (CSAPR) https://www.epa.gov/csapr
- Pollution from Nitrogen Oxides (NO_X) https://www.epa.gov/no2-pollution
- Pollution from Ozone https://www.epa.gov/ozone-pollution

Figures

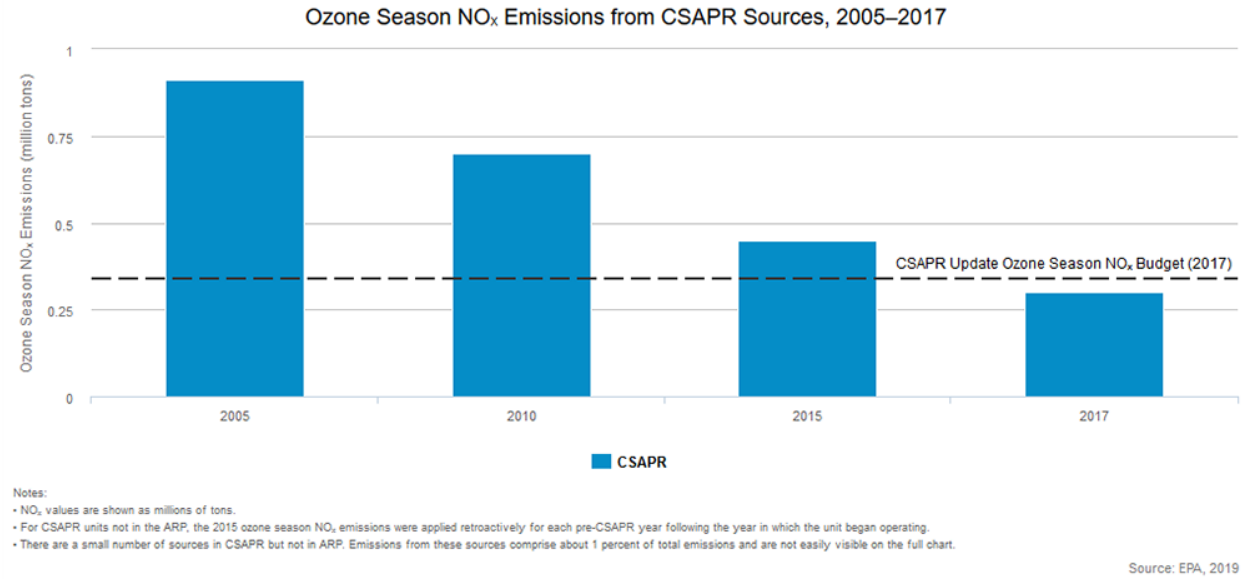
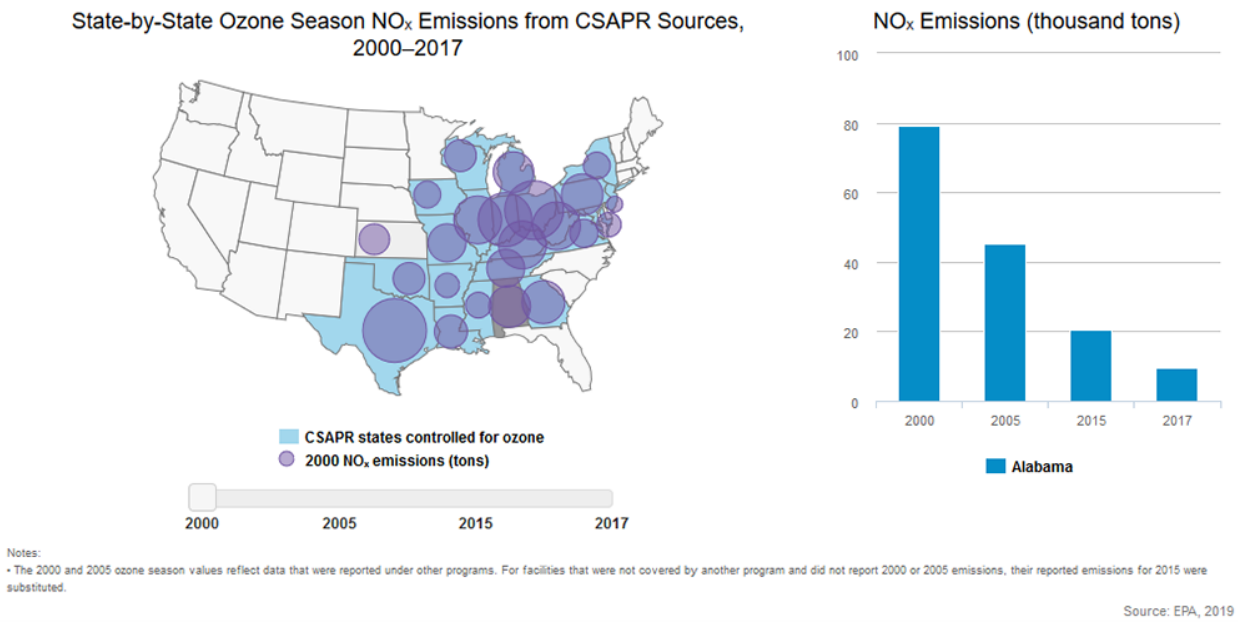


Figure 1. Ozone Season NO_X Emissions from CSAPR Sources, 2005–2017



Notes:
• The 2000 and 2005 ozone season values reflect data that were reported under other programs. For facilities that were not covered by another program and did not report 2000 or 2005 emissions, their reported emissions for 2015 were substituted.

Source: EPA, 2019

Figure 2. State-by-State Ozone Season NO_X Emissions from CSAPR Sources, 2000–2017

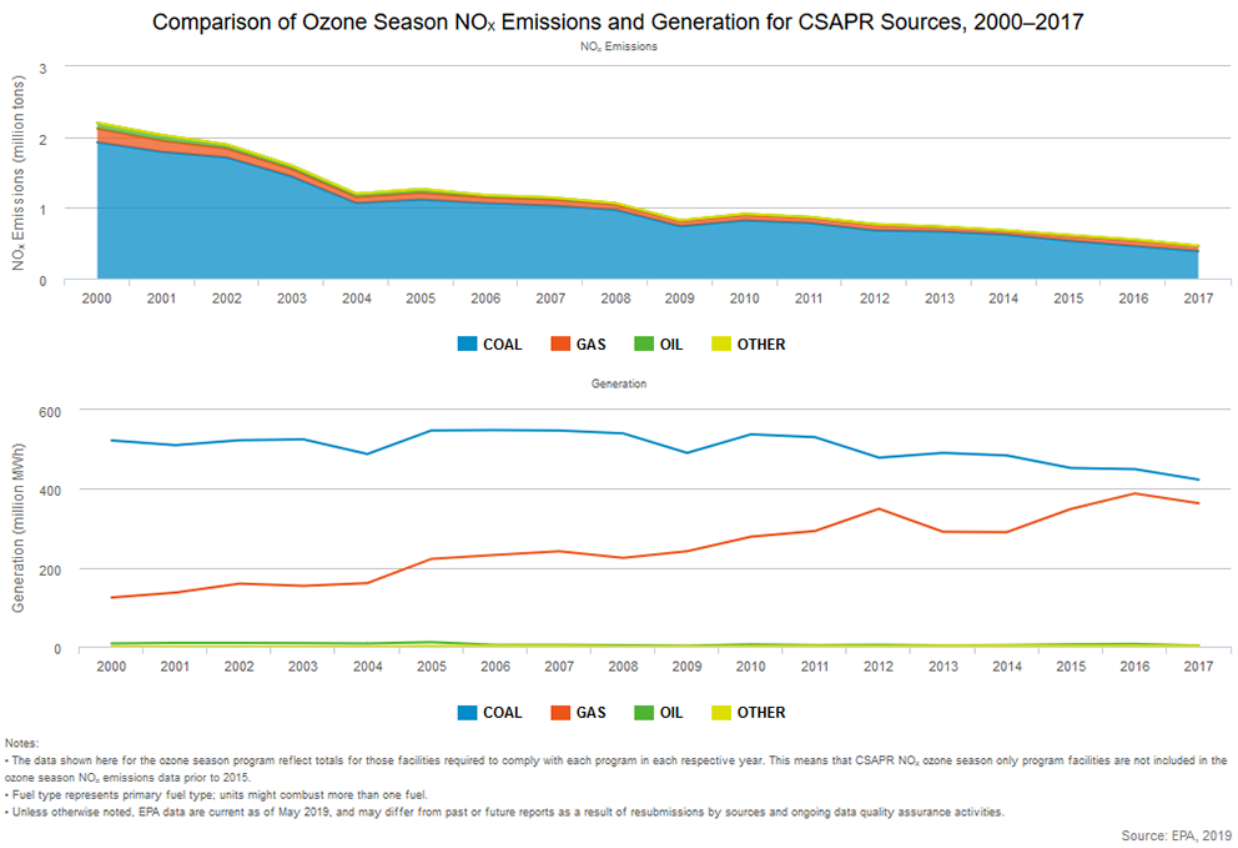


Figure 3. Comparison of Ozone Season NO_X Emissions and Generation for CSAPR Sources, 2000–2017

CSAPR Ozone Season NO_X Emissions Trends, 2017

	Ozone Emissions (thousand tons)				Ozone Rate (lb/mmBtu)			
Primary Fuel	**2000**	**2005**	**2010**	**2017**	**2000**	**2005**	**2010**	**2017**
Coal	1,926	1,117	821	389	0.43	0.25	0.19	0.13
Gas	195	95	78	69	0.19	0.06	0.04	0.03
Oil	79	53	13	2	0.31	0.25	0.13	0.10
Other	1	2	2	3	0.21	0.39	0.11	0.08
Total / Average	**2,201**	**1,267**	**915**	**463**	**0.38**	**0.20**	**0.15**	**0.09**

Notes:
- The data shown here reflect totals for those facilities required to comply with each program in each respective year. This means that CSAPR NO_x ozone season only program facilities are not included in the ozone season NO_x emissions data prior to 2015.
- 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.
- The emission rate reflects the emissions (pounds) per unit of heat input (mmBtu) for each fuel category. The total NO_x ozone season emission rate in each column of the table is not cumulative and does not equal the arithmetic mean of the four fuel-specific rates. The total for each year indicates the average rate across all units in the program because 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 May 2019, and may differ from past or future reports as a result of resubmissions by sources and ongoing data quality assurance activities.

Source: EPA, 2019

Figure 4. CSAPR Ozone Season NO_X Emissions Trends, 2017

Mercury and Air Toxics

Highlights

Overall Results

- Mercury and other hazardous air pollutant (HAP) emissions have declined significantly since 2010 estimates. These emission reductions were driven by the installation of new pollution controls and enhancements of existing pollution controls that reduce multiple pollutants. Emissions have also decreased due to operational changes, such as fuel switching and increased generation at natural gas-fired units that emit very little mercury and HAP. These trends are discussed in Chapter 1.
- Other programs – such as regional and state SO_2 and NO_X emission control programs – also contributed to the mercury and other HAP emission reductions achieved by covered sources in 2017.

Mercury and Hazardous Air Pollutant Emission Trends

- Compared to 2010[1], units covered under MATS in 2017 emitted
  - 25 fewer tons of mercury (86% reduction),[2]
  - 120,877 fewer tons of acid gases (96% reduction),[3] and
  - 949 fewer tons of non-mercury metals (81% reduction).[4]

Reducing Mercury Emissions from Coal-Fired Power Plants Since 2010

Over the past decade, the power sector has undergone significant changes in the mix of generating sources (e.g., coal, gas, and renewables), as well as in the prevalence of pollution control technologies. These changes have led to substantial decreases in mercury emissions, from about 29 tons in 2010 to 4 tons in 2017. These drivers are explained in more detail below.

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[1] Emissions from 2010 are estimated as described in *Memorandum: Emissions Overview: Hazardous Air Pollutants in Support of the Final Mercury and Air Toxics Standard.* EPA-454/R-11-014. November 2011; Docket ID No. EPA-HQ-OAR-2009-0234-19914.

[2] Certain units did not report from January-May 2017. Also, data do not include emissions from low emitting electric generating units (LEEs). Mercury emissions from 87 LEEs are estimated to be 326 pounds. Emissions from 24 additional LEEs are not available.

[3] Most coal- and oil- fired EGUs report emissions of SO_2 as a surrogate to demonstrate compliance with standards for the acid gas HAP. The EPA used those SO_2 emissions to estimate emission of the acid gas HAP (hydrogen chloride and hydrogen fluoride).

[4] Most coal- and oil- fired EGUs report emissions of filterable particulate matter (fPM) as a surrogate to demonstrate compliance with standards for the non-mercury metal HAP. The EPA used those fPM emissions to estimate emission of the non-mercury metal HAP (e.g., lead, arsenic, selenium, etc.).

Decreasing Coal-Fired Generation

Coal-fired EGUs are the main source of mercury emissions in the power sector, so reductions in the amount of generation from coal will have an impact on power sector mercury emissions. Reductions in coal-fired generation at the EGU-level can occur in a number of ways: decreased utilization of an existing EGU, retirement of an EGU, or conversion from coal to other fuels with lower or no mercury emissions. The following trends in coal-fired generation since 2010 have contributed to the observed reduction of mercury emissions:

- Electricity generation from all coal-fired EGUs decreased by approximately one-third between 2010 and 2017.
- In 2010, nearly 10 percent of electricity generation from coal-fired EGUs was from 259 units that have since retired.
- In addition, 74 EGUs that were coal-fired in 2010 have been converted to burn natural gas or other fuel sources (which do not emit as much mercury as coal).

Controlling Mercury Emissions at Coal-Fired EGUs

Coal-fired EGUs have also installed post-combustion pollution control technologies, like activated carbon injection (ACI) and flue-gas desulfurization (FGD), to comply with air quality regulatory programs. ACI controls are designed to specifically capture mercury, while FGD are designed to reduce sulfur dioxide (SO_2) and other acid gases, but, in certain situations, can also capture mercury effectively. These technologies can work independently or in combination with other technologies to improve mercury control. Circulating fluidized bed (CFB) boilers can also reduce emissions of SO_2 through the addition of lime or limestone during the combustion process or downstream using a dry sorbent injection system. The following trends in pollution control technology have contributed to the observed reduction of mercury emissions:

- Half of all electricity generation from coal-fired EGUs in 2010 was from units that had installed a post-combustion control device, like ACI or FGD; in 2017, that share increased to more than 90 percent.
- Generation from coal-fired EGUs that had no post-combustion pollution control technology declined 91 percent between 2010 and 2017.
- In 2010, only 4 percent of coal generation was from units that reported using ACI; in 2017, that share increased to nearly 40 percent.

Background Information

Hazardous air pollutants (HAPs) emitted by power plants include mercury, acid gases (e.g., HCl, HF), non-mercury metallic toxics (e.g., arsenic, nickel, and chromium) and organic HAPs (e.g., formaldehyde, dioxin/furan). Exposure to these pollutants at certain concentrations and durations can increase chances of cancer and immune system damage, along with neurological, reproductive, developmental, respiratory, and other health problems.

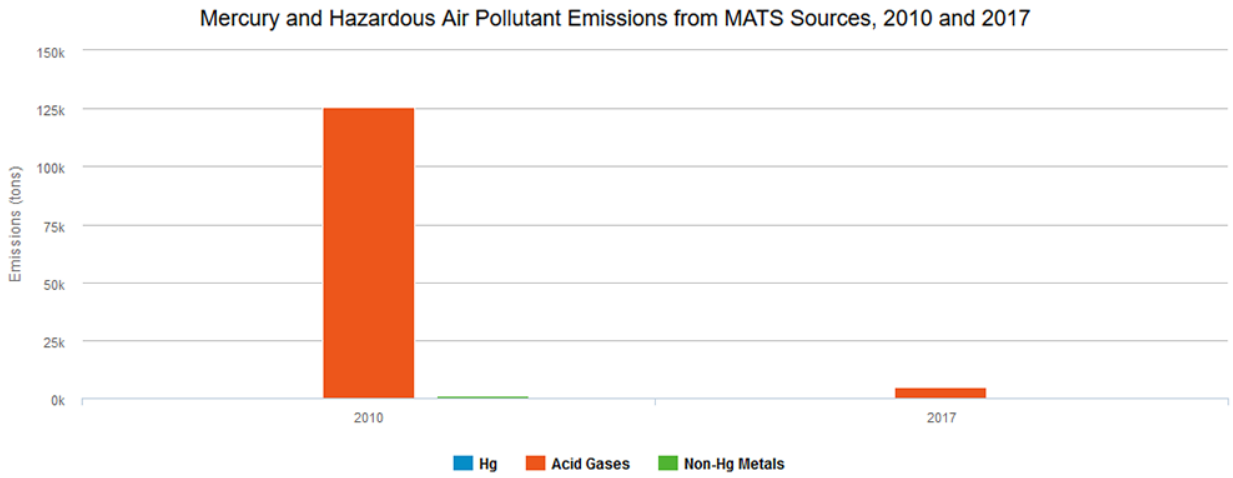
In 2011, EPA issued MATS, establishing national emission standards for mercury and other hazardous air pollutants for new and existing coal- and oil-fired power plants. The standards were finalized under

section 112 of the 1990 Clean Air Act amendments. The MATS emission standards were established using data from a 2010 information collection request (ICR) that was sent to selected coal- and oil- fired EGUs.

More Information

- Air Markets Program Data (AMPD) https://ampd.epa.gov/ampd/
- MATS https://www.epa.gov/mats
- HAPs https://www.epa.gov/haps

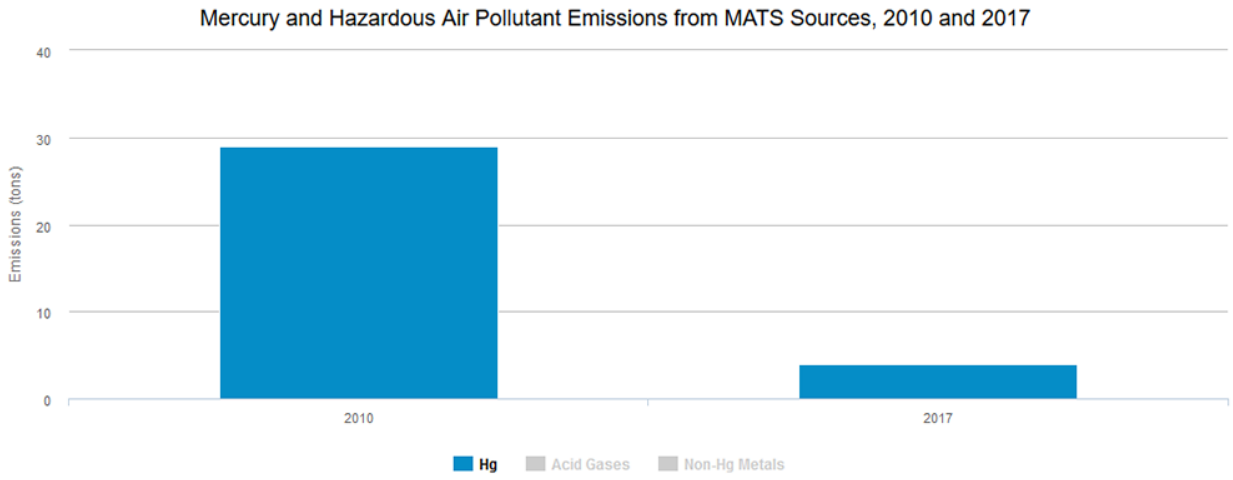
Figures



Notes:
• Data do not include emissions from low emitting electric generating units (LEEs). Mercury emissions from 87 LEEs are estimated to be 326 pounds. Emissions from 24 additional LEEs are not available.
• There is a small amount of generation from "Hg" and "Non-Hg Metals". The data for these emissions is not easily visible on the full chart. To more clearly see the generation data for these emissions, use the interactive features of the figure: click on the boxes in the legend to turn off the orange category (labeled "Acid Gases") and turn on the blue and green categories (labeled "Hg" and "Non-Hg Metals").

Source: EPA, 2019

Figure 1. Mercury and Hazardous Air Pollutant Emissions from MATS Sources, 2010 and 2017



Notes:
• Data do not include emissions from low emitting electric generating units (LEEs). Mercury emissions from 87 LEEs are estimated to be 326 pounds. Emissions from 24 additional LEEs are not available.
• There is a small amount of generation from "Hg" and "Non-Hg Metals". The data for these emissions is not easily visible on the full chart. To more clearly see the generation data for these emissions, use the interactive features of the figure: click on the boxes in the legend to turn off the orange category (labeled "Acid Gases") and turn on the blue and green categories (labeled "Hg" and "Non-Hg Metals").

Source: EPA, 2019

Mercury and Hazardous Air Pollutant Emission Trends, 2017

Pollutant	2010 Emissions (tons)	2017 Emissions (tons)	Reduction (%)
Hg	29	4	86%
Acid Gases	125,708	4,831	96%
Non-Hg Metals	1,170	221	81%
Organic HAP	Not Available	< 3	Not Available

Notes:
• Data do not include emissions from low emitting electric generating units (LEEs). Mercury emissions from 87 LEEs are estimated to be 326 pounds. Emissions from 24 additional LEEs are not available.
• MATS units could request up to two one-year compliance extensions under the rule. Units under this extension were not required to report emissions and comply with the standards until April of 2017.

Source: EPA, 2019

Figure 2. Mercury and Hazardous Air Pollutant Emission Trends, 2017

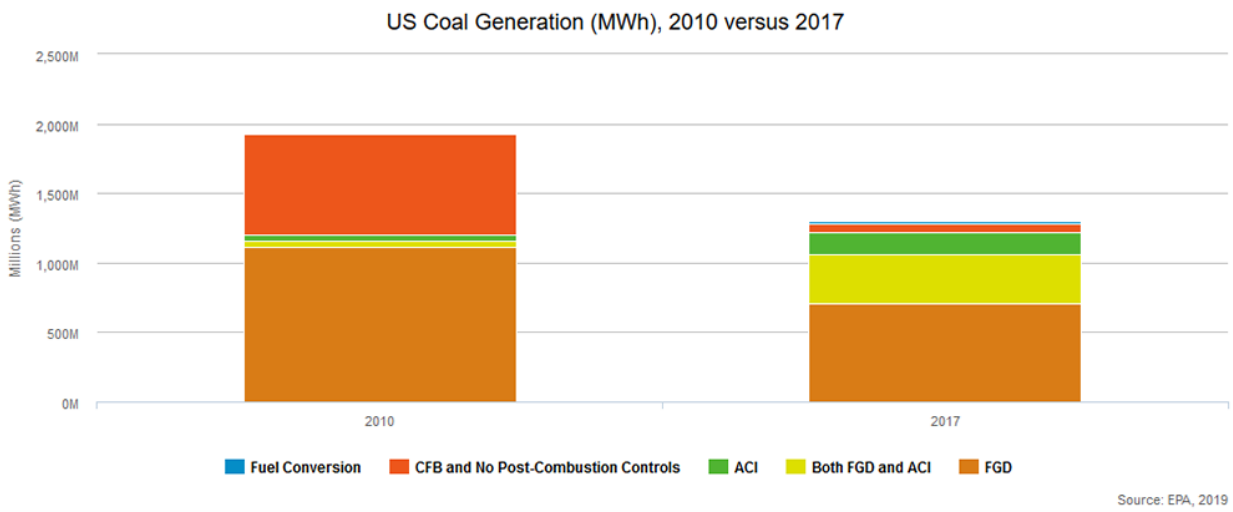


Figure 3. US Coal Generation (MWh), 2010 versus 2017

Chapter 4: Emission Controls and Monitoring

Many sources opted to install control technologies to meet the Acid Rain Program (ARP) and Cross-State Air Pollution Rule (CSAPR) emission reduction targets. A wide range of controls is available to help reduce emissions. Affected units under the Mercury and Air Toxics Standards (MATS) also have several options for reducing hazardous air pollutants, and have some flexibility in how they monitor emissions. These programs hold sources to high standards of accountability for emissions. Accurate and consistent emissions monitoring data is critical to ensure program results. Most emissions from affected sources are measured by continuous emission monitoring systems (CEMS).

Highlights

ARP and CSAPR SO_2 Program Controls and Monitoring

- Units with advanced flue gas desulfurization (FGD) controls (also known as scrubbers) accounted for 76 percent of coal-fired units and 83 percent of coal-fired electricity generation, measured in megawatt hours, or MWh, in 2017.
- In 2017, 30 percent of CSAPR units (including 100 percent of coal-fired units) monitored SO_2 emissions using CEMS. Ninety-nine percent of SO_2 emissions were measured by CEMS.

CSAPR NO_X Annual Program Controls and Monitoring

- Seventy-nine percent of fossil fuel-fired generation (as measured in megawatt hours, or MWh) was produced by units with advanced pollution controls (either selective catalytic reduction [SCR] or selective non-catalytic reduction [SNCR]).
- In 2017, the 298 coal-fired units with advanced add-on controls (either SCRs or SNCRs) generated 77 percent of coal-fired electricity. At oil- and natural gas-fired units, SCR- and SNCR-controlled units produced 82 percent of generation.
- In 2017, 69 percent of CSAPR units (including 100 percent of coal-fired units) monitored NO_X emissions using CEMS. Ninety-nine percent of NO_X emissions were measured by CEMS.

CSAPR NO_X Ozone Season Program Controls and Monitoring

- Seventy-one percent of all the fossil fuel-fired generation (as measured in megawatt hours, or MWh) was produced by units with advanced pollution controls (either SCRs or SNCRs).
- In 2017, 278 units with advanced add-on controls (either SCR or SNCR) accounted for 71 percent of coal-fired generation. At oil- and natural gas-fired units, SCR- and SNCR-controlled units produced 71 percent of generation.
- In 2017, 75 percent of CSAPR units (including 100 percent of coal-fired units) monitored ozone season NO_X emissions using CEMS. Ninety-nine percent of ozone season NO_X emissions were measured by CEMS.

MATS Controls and Monitoring

- In 2017, 530 units at 235 facilities reported continuous mercury emissions data to EPA under MATS. Fifty-six percent of MATS units reporting mercury emissions and 44 percent of the

electricity generation at MATS reporting units used activated carbon injection (ACI), a mercury-specific pollution control method to reduce mercury emissions and SO_2.

- About 78 percent of units that reported continuous mercury emissions data (or 87 percent of the total electricity generation from units that reported data) reported the use of advanced controls, such as wet scrubbers, dry scrubbers, or ACI, to reduce hazardous air pollutant emissions in 2017. These controls also reduce other pollutants, including SO2. Some oil-fired units are able to meet the MATS emission limits through the use of particulate matter (PM) controls such as electrostatic precipitators (ESPs) or fabric filters (FFs).

Background Information

Continuous Emission Monitoring Systems (CEMS)

EPA has developed detailed procedures codified in federal regulations (40 CFR Part 75) to ensure that sources monitor and report emissions with a high degree of precision, reliability, accuracy, and timeliness. Sources are required to use CEMS or other approved methods to record and report pollutant emissions data. Sources conduct stringent quality assurance tests of their monitoring systems to ensure the accuracy of emissions data and to provide assurance to market participants that a ton of emissions measured at one facility is equivalent to a ton measured at a different facility. EPA conducts comprehensive electronic and field data audits to validate the reported data. While some units with low levels of SO_2 and NO_X emissions are allowed to use other approved monitoring methods, the vast majority of SO_2 and NO_X emissions are measured by CEMS.

Under MATS measurement regulations (40 CFR part 63), affected units can continuously measure emissions using CEMS for mercury, SO_2, HCl, PM, and HF, or sorbent traps for Hg. Some qualifying units with low emissions can conduct periodic stack tests in lieu of continuous monitoring.

SO_2 Emission Controls

Sources in ARP and the CSAPR SO_2 program have a number of SO_2 emission control options available. These include switching to low sulfur coal or natural gas, employing various types of FGDs, or, in the case of fluidized bed boilers, injecting limestone into the furnace. FGDs – also known as scrubbers – on coal-fired electricity generating units are the principal means of controlling SO_2 emissions and tend to be present on the highest generating coal-fired units.

NO_X Emission Controls

Sources in ARP and the CSAPR NO_X annual and ozone season programs have a variety of options by which to reduce NO_X emissions, including advanced post-combustion controls such as SCR or SNCR, and combustion controls, such as low NO_X burners.

Hazardous Air Pollutant Controls

Sources in MATS have a number of options available to reduce hazardous air pollutants (HAPs), including mercury, PM (a surrogate for toxic non-mercury metals), HCl, HF, and other acid gases. Sources can improve operation of existing controls, add pollution controls, and switch fuels (including coal blending). Specific pollution control devices that reduce mercury and HCl include wet FGDs (scrubbers), activated carbon injection (ACI), dry sorbent injection (DSI), and fabric filters.

More Information

- Power Plant Emission Trends https://www.epa.gov/airmarkets/power-plant-emission-trends
- Air Markets Program Data (AMPD) https://ampd.epa.gov/ampd/
- Emissions Monitoring https://www.epa.gov/airmarkets/emissions-monitoring
- Plain English guide to 40 CRF Part 75 https://www.epa.gov/airmarkets/plain-english-guide-part-75-rule
- Continuous Emission Monitoring Systems (CEMS) https://www.epa.gov/emc/emc-continuous-emission-monitoring-systems

Figures

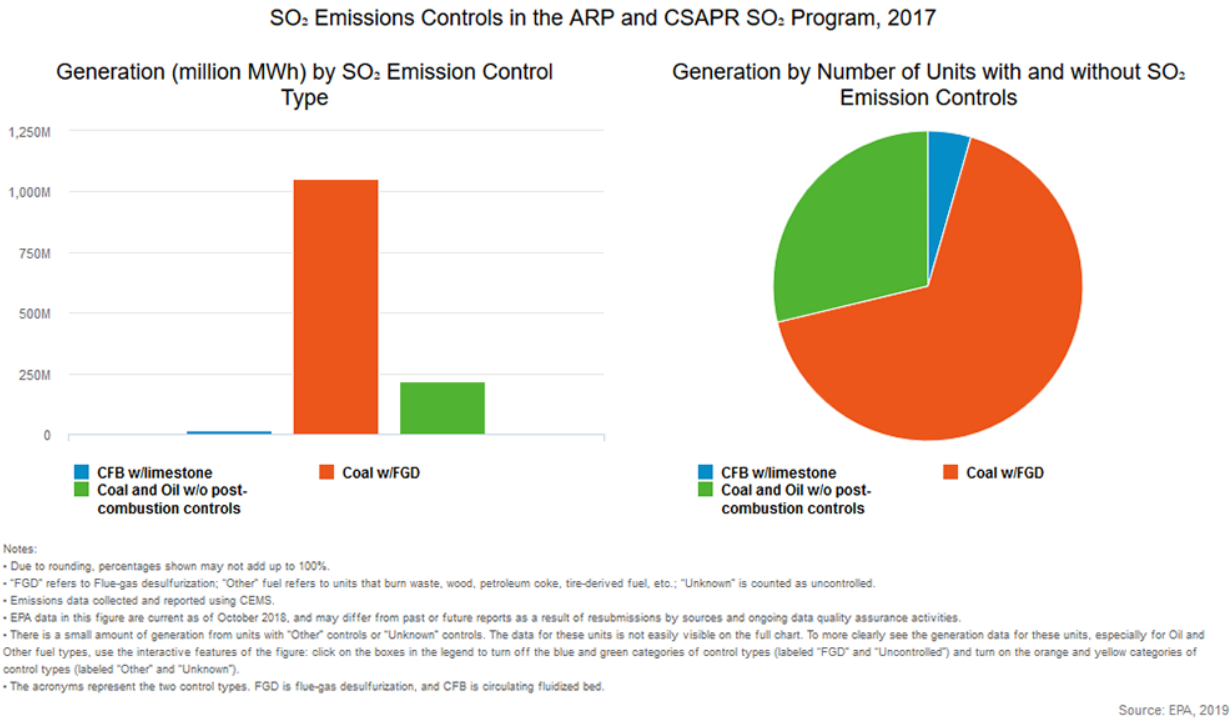


Figure 1. SO_2 Emission Controls in the ARP and CSAPR SO_2 Program, 2017

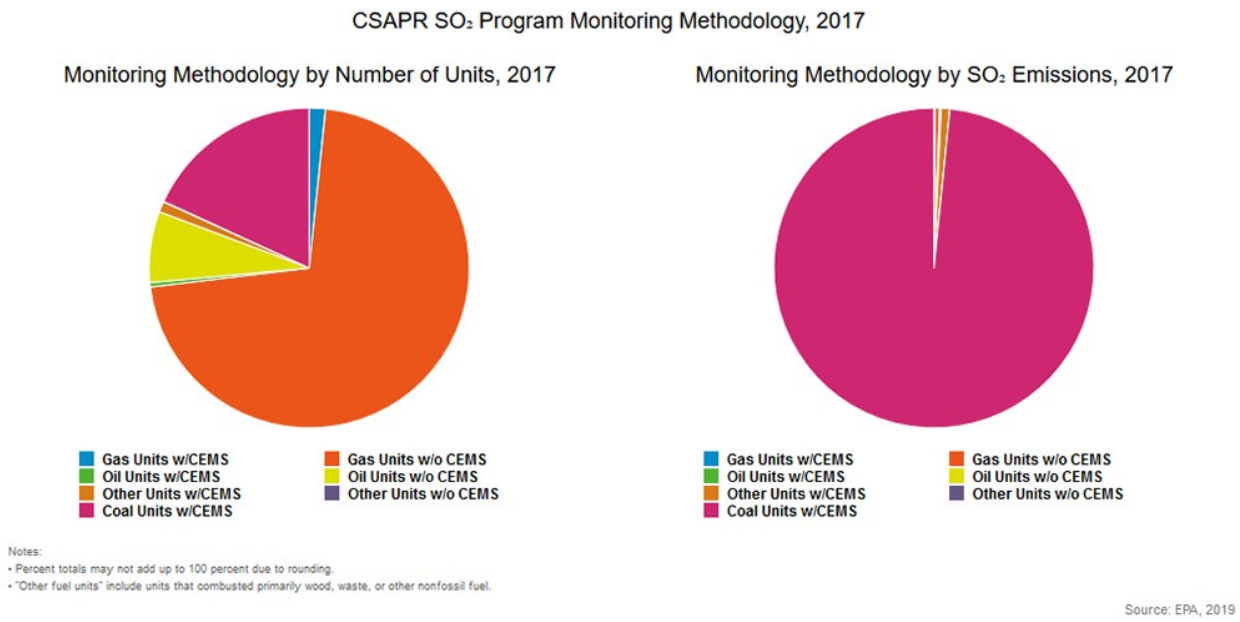
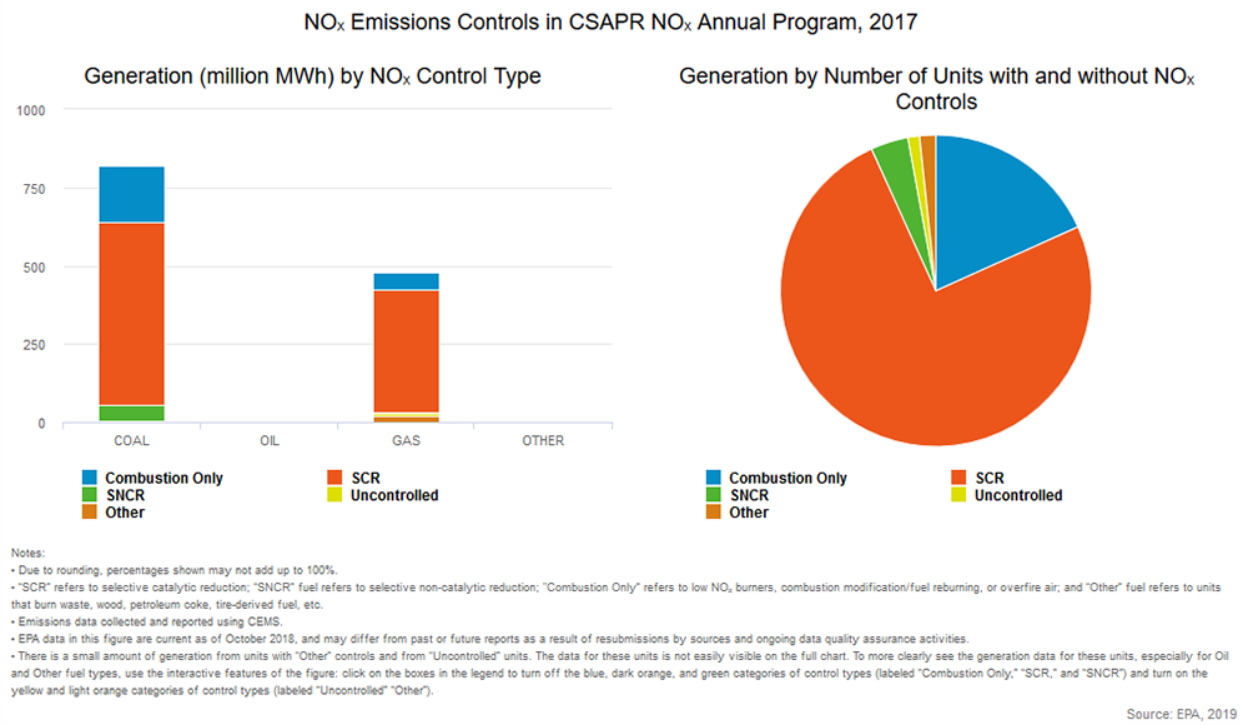


Figure 2. CSAPR SO_2 Program Monitoring Methodology, 2017



Notes:
- Due to rounding, percentages shown may not add up to 100%.
- "SCR" refers to selective catalytic reduction; "SNCR" fuel refers to selective non-catalytic reduction; "Combustion Only" refers to low NO_x burners, combustion modification/fuel reburning, or overfire air; and "Other" fuel refers to units that burn waste, wood, petroleum coke, tire-derived fuel, etc.
- Emissions data collected and reported using CEMS.
- EPA data in this figure are current as of October 2018, and may differ from past or future reports as a result of resubmissions by sources and ongoing data quality assurance activities.
- There is a small amount of generation from units with "Other" controls and from "Uncontrolled" units. The data for these units is not easily visible on the full chart. To more clearly see the generation data for these units, especially for Oil and Other fuel types, use the interactive features of the figure: click on the boxes in the legend to turn off the blue, dark orange, and green categories of control types (labeled "Combustion Only," "SCR," and "SNCR") and turn on the yellow and light orange categories of control types (labeled "Uncontrolled" "Other").

Source: EPA, 2019

Figure 3. NO_X Emissions Controls in CSAPR NO_X Annual Program, 2017

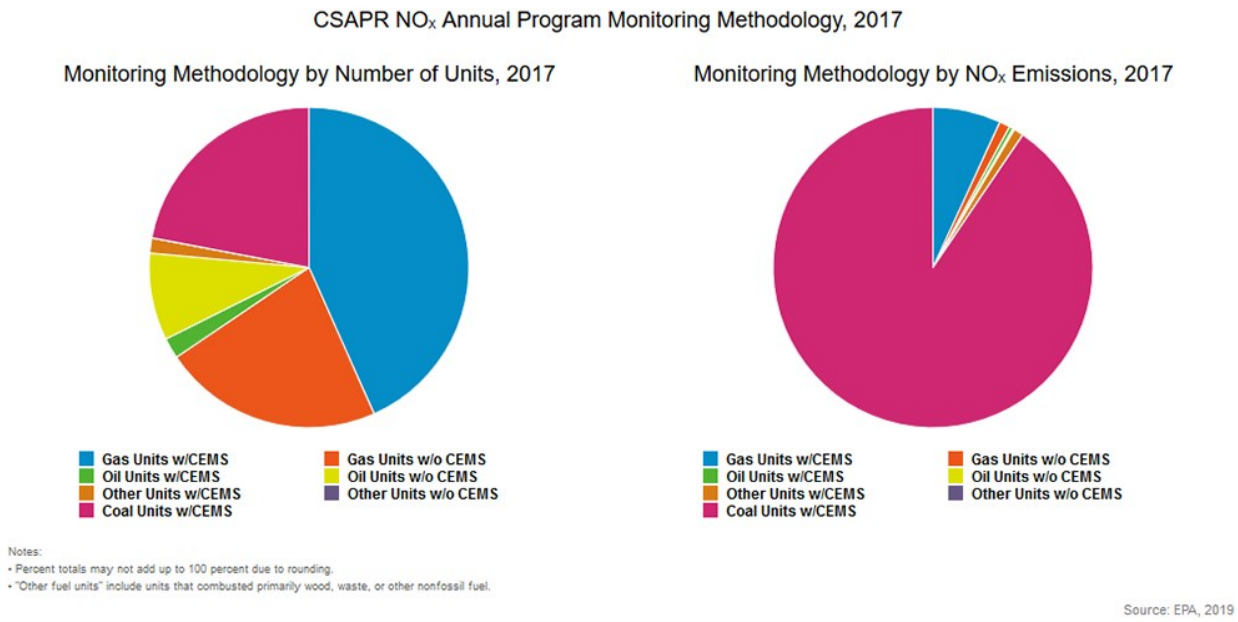
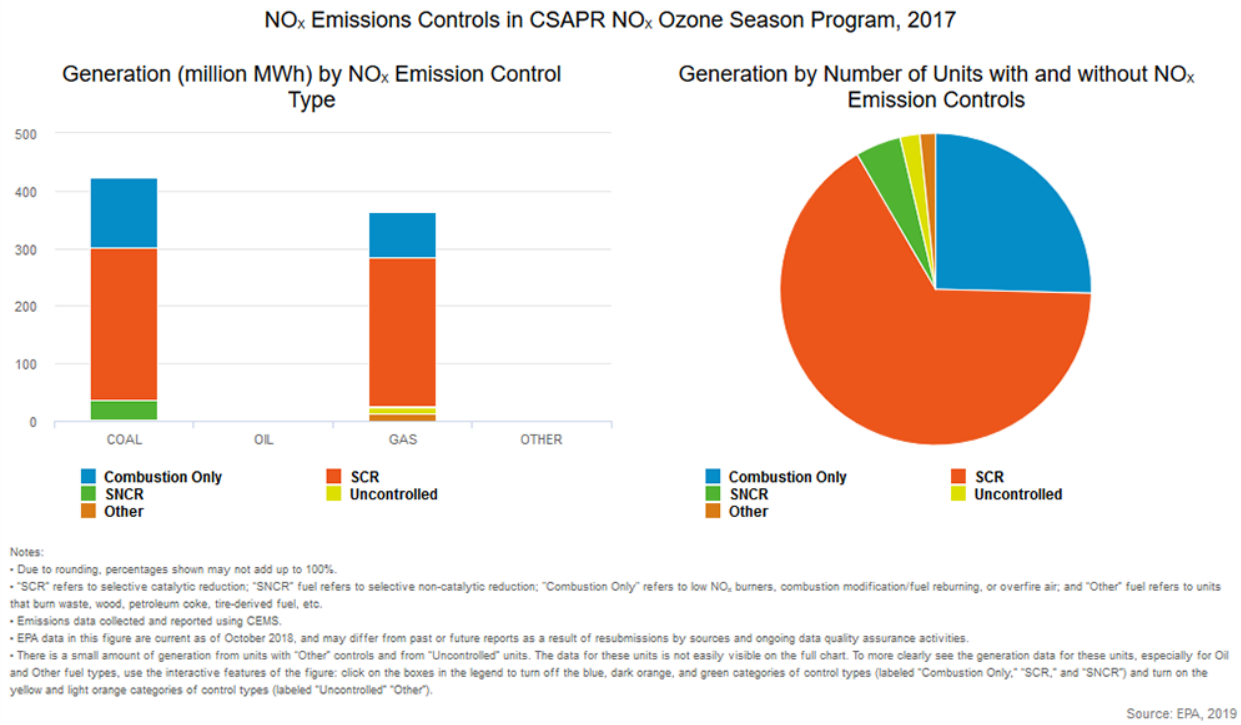


Figure 4. CSAPR NO_X Annual Program Monitoring Methodology, 2017



Notes:
- Due to rounding, percentages shown may not add up to 100%.
- "SCR" refers to selective catalytic reduction; "SNCR" fuel refers to selective non-catalytic reduction; "Combustion Only" refers to low NO_x burners, combustion modification/fuel reburning, or overfire air; and "Other" fuel refers to units that burn waste, wood, petroleum coke, tire-derived fuel, etc.
- Emissions data collected and reported using CEMS.
- EPA data in this figure are current as of October 2018, and may differ from past or future reports as a result of resubmissions by sources and ongoing data quality assurance activities.
- There is a small amount of generation from units with "Other" controls and from "Uncontrolled" units. The data for these units is not easily visible on the full chart. To more clearly see the generation data for these units, especially for Oil and Other fuel types, use the interactive features of the figure: click on the boxes in the legend to turn off the blue, dark orange, and green categories of control types (labeled "Combustion Only," "SCR," and "SNCR") and turn on the yellow and light orange categories of control types (labeled "Uncontrolled" "Other").

Source: EPA, 2019

Figure 5. NO_X Emissions Controls in the CSAPR NO_X Ozone Season Program, 2017

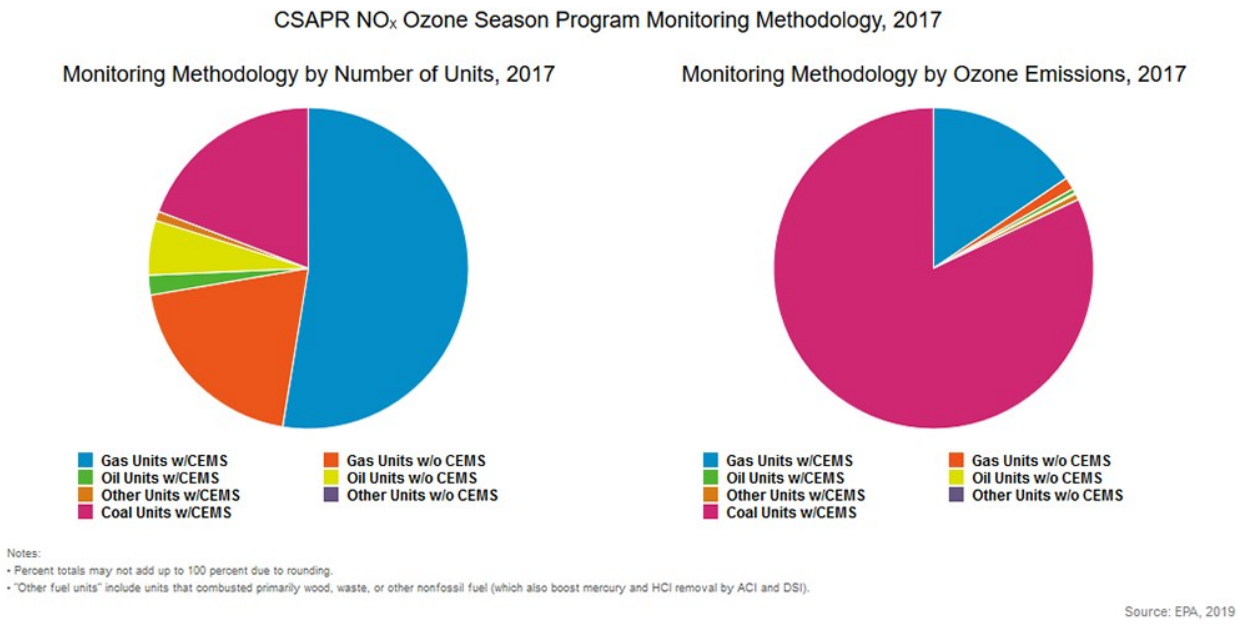


Figure 6. CSAPR NO_X Ozone Season Program Monitoring Methodology, 2017

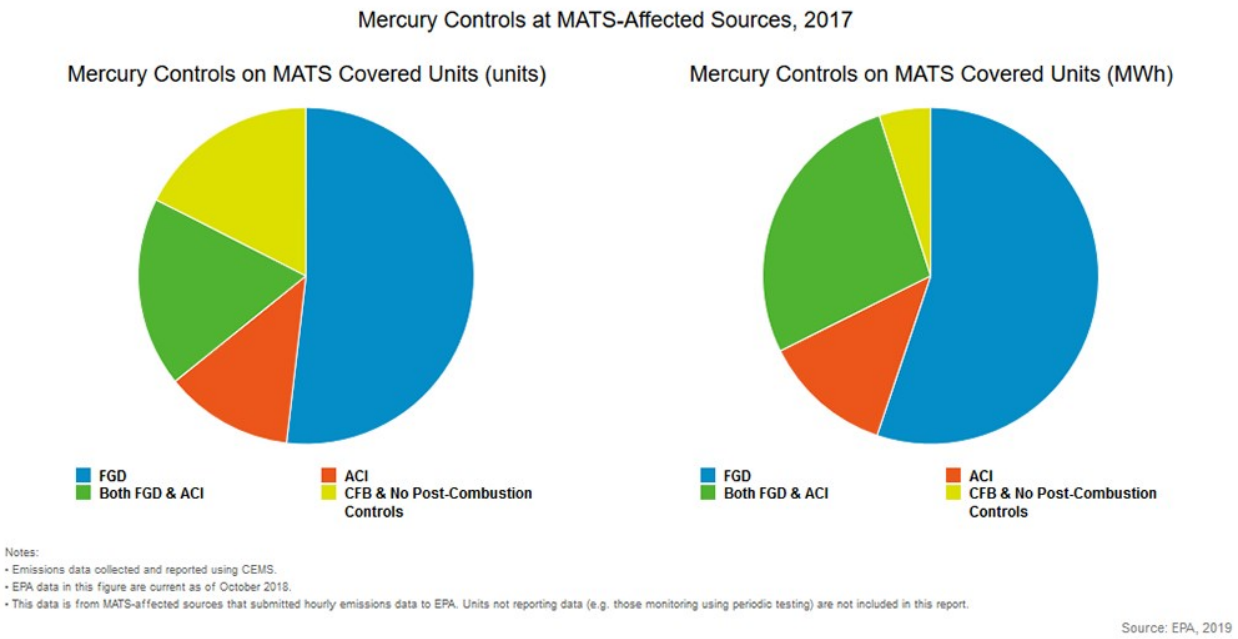


Figure 7. Mercury Controls at MATS-Affected Sources, 2017

Mercury Compliance and Monitoring Methods used by Units Reporting Hourly Data under MATS, 2017

Reporting Hourly data		Compliance Method (# of Units)		Monitoring Method		
Number of reporting units	Number of reporting facilities	Electrical Output	Heat Input	Sorbent Trap	CEMS	CEMS and Sorbent Trap
530	235	160	370	232	255	43

Notes:
- Emissions data collected and reported using CEMS.
- EPA data in this figure are current as of October 2018.
- This data is from MATS-affected sources that submitted hourly emissions data to EPA and does not show complete data from all MATS-affected sources because many sources received compliance extensions or chose to demonstrate compliance through methods other than continuously monitored emissions.

Source: EPA, 2019

Figure 8. Mercury Compliance and Monitoring Methods used by Units Reporting Hourly Data under MATS, 2017

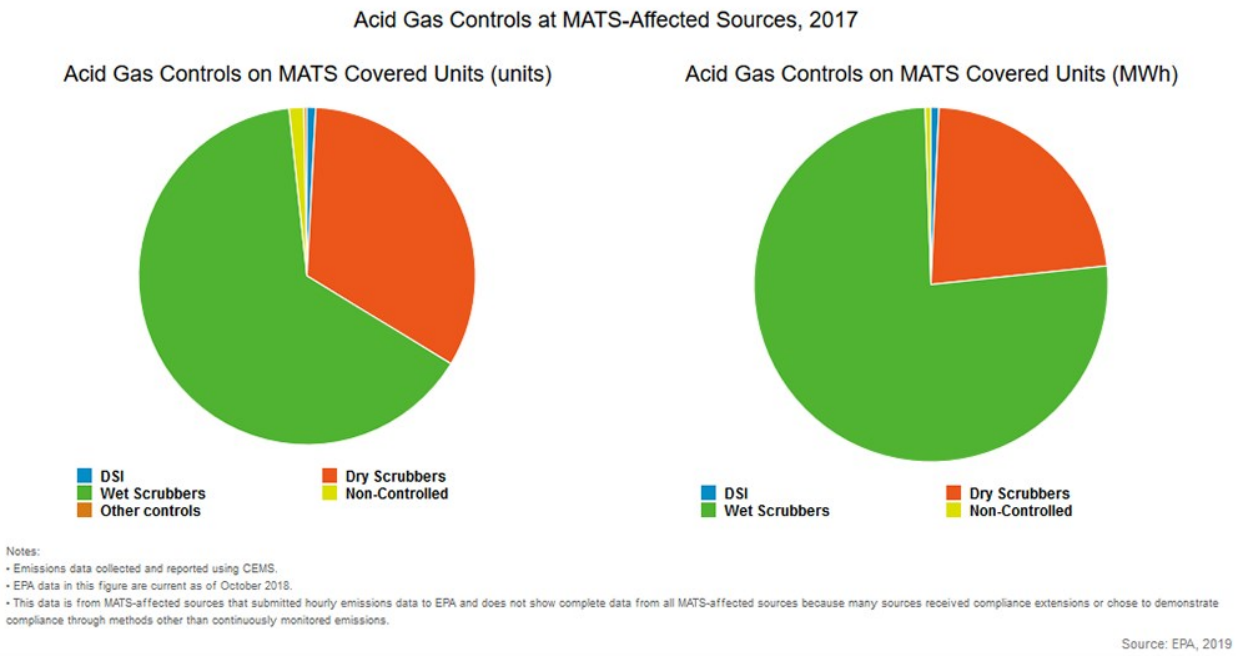


Figure 9. Acid Gas Controls at MATS-Affected Sources, 2017

Acid Gas Compliance and Monitoring Methods used by Units Reporting Hourly Data under MATS, 2017

Acid Gas	Reporting Hourly data		Compliance Method (# of Units)		Monitoring Method
	Number of reporting units	Number of reporting facilities	Electrical Output	Heat Input	CEMS
HCl	4	3	1	3	4
SO2 as a surrogate for HCl	354	168	6	348	354

Notes:
- Emissions data collected and reported using CEMS.
- EPA data in this figure are current as of October 2018.
- This data is from MATS-affected sources that submitted hourly emissions data to EPA and does not show complete data from all MATS-affected sources because many sources received compliance extensions or chose to demonstrate compliance through methods other than continuously monitored emissions.

Source: EPA, 2019

Figure 10. Acid Gas Compliance and Monitoring Methods used by Units Reporting Hourly Data under MATS, 2017

Chapter 5: Program Compliance

This section shows how the Acid Rain Program (ARP) and Cross-State Air Pollution Rule (CSAPR) allowances were used for compliance under the allowance trading programs in 2017. In contrast to ARP and CSAPR, MATS is issued under section 112 of the Clean Air Act and is not an allowance trading program.

Highlights

ARP SO_2 Program

- The reported 2017 SO_2 emissions by ARP sources totaled 1,318,755 tons.
- Over 47 million SO_2 allowances were available for compliance (9 million vintage 2017 and nearly 38 million banked from prior years).
- EPA deducted just over 1.3 million allowances for ARP compliance. After reconciliation, over 46 million ARP SO_2 allowances were banked and carried forward to the 2018 ARP compliance year.
- All ARP SO_2 facilities were in compliance in 2017 (holding sufficient allowances to cover their SO_2 emissions).

CSAPR SO_2 Group 1 Program

- The reported 2017 SO_2 emissions by CSAPR Group 1 sources totaled 653,658 tons.
- Over 4.2 million SO_2 Group 1 allowances were available for compliance.
- EPA deducted over 653,000 allowances for CSAPR SO_2 Group 1 compliance. After reconciliation, over 3.6 million CSAPR SO_2 Group 1 allowances were banked and carried forward to the 2018 compliance year.
- All CSAPR SO_2 Group 1 facilities were in compliance in 2017 (holding sufficient allowances to cover their SO_2 emissions).

CSAPR SO_2 Group 2 Program

- The reported 2017 SO_2 emissions by CSAPR Group 2 sources totaled 99,739 tons.
- Over 1.5 million SO_2 Group 2 allowances were available for compliance.
- EPA deducted just under 100,000 allowances for CSAPR SO_2 Group 2 compliance. After reconciliation, over 1.4 million CSAPR SO_2 Group 2 allowances were banked and carried forward to the 2018 compliance year.
- All CSAPR SO_2 Group 2 facilities were in compliance in 2017 (holding sufficient allowances to cover their SO_2 emissions).

CSAPR NO_X Annual Program

- The reported 2017 annual NO_X emissions by CSAPR sources totaled 585,855 tons.
- Over 1.8 million NO_X Annual allowances were available for compliance.

- EPA deducted just under 586,000 allowances for CSAPR NO_X Annual compliance. After reconciliation, almost 1.3 million CSAPR NO_X Annual allowances were banked and carried forward to the 2018 compliance year.
- One facility was out of compliance with the CSAPR NO_X Annual program and had 44 tons of excess emissions.

CSAPR NO_X Ozone Season Group 1 Program

- The reported 2017 ozone season NO_X emissions by CSAPR sources totaled 7,136 tons.
- Over 42,000 NO_X Ozone Season Group 1 allowances were available for compliance.
- EPA deducted over 7,000 allowances for CSAPR NO_X Ozone Season Group 1 compliance. After reconciliation, over 35,000 CSAPR NO_X Ozone Season Group 1 allowances were banked.
- All CSAPR NO_X Ozone Season Group 1 facilities were in compliance (holding sufficient allowances to cover their NO_X emissions).

CSAPR NO_X Ozone Season Group 2 Program

- The reported 2017 ozone season NO_X emissions by CSAPR sources totaled 294,468 tons.
- Just under 412,000 NO_X Ozone Season Group 2 allowances were available for compliance.
- EPA deducted over 294,000 allowances for CSAPR NO_X Ozone Season Group 2 compliance. After reconciliation, over 117,000 CSAPR NO_X Ozone Season Group 2 allowances were banked.
- All CSAPR NO_X Ozone Season Group 2 facilities were in compliance (holding sufficient allowances to cover their NO_X emissions).

Background Information

The year 2017 was the third year of compliance for the CSAPR SO_2 (Group 1 and Group 2), NO_X Annual and NO_X Ozone Season Group 1 programs, while it was the first year of compliance for the CSAPR NO_X Ozone Season Group 2 program. Each program has its own distinct set of allowances, which cannot be used for compliance with the other programs (e.g., CSAPR SO_2 Group 1 allowances cannot be used to comply with the CSAPR SO_2 Group 2 Program).

The compliance summary emissions number cited in "Highlights" may differ slightly from the sums of emissions used for reconciliation purposes shown in the "Allowance Reconciliation Summary" figures because of variation in rounding conventions, changes due to resubmissions by sources, and compliance issues at certain units. Therefore, the allowance totals deducted for actual emissions in those figures differ slightly from the number of emissions shown elsewhere in this report.

More Information

- Allowance Markets https://www.epa.gov/airmarkets/allowance-markets
- Air Markets Business Center https://www.epa.gov/airmarkets/business-center
- Air Markets Program Data (AMPD) https://ampd.epa.gov/ampd/

- Emissions Trading https://www.epa.gov/emissions-trading-resources

Figures

Acid Rain Program SO_2 Program Allowance Reconciliation Summary, 2017

Total Allowances Held (1995 - 2017 Vintage)	**47,388,615**	Held by Affected Facility Accounts	30,860,477
		Held by Other Accounts (General and Non-Affected Facility Accounts)	16,528,138
Allowances Deducted for Acid Rain Compliance*	1,339,308		
Penalty Allowance Deductions	0		
Banked Allowances	**46,049,307**	Held by Affected Facility Accounts	29,521,169
		Held by Other Accounts (General and Non-Affected Facility Accounts)	16,528,138

* Allowances deducted for ARP Compliance Includes 20,625 allowances deducted from opt-ins for reduced utilization.

ARP SO_2 Program Compliance Results

Reported Emissions (tons)	1,318,755
Compliance issues, rounding, and report resubmission adjustments (tons)	-72
Emissions not covered by allowances (tons)	0
Total allowances deducted for emissions	1,318,683

Notes:
- Compliance emissions data may vary from other report sections as a result of variation in rounding conventions, changes due to resubmissions by sources, or allowance compliance issues at certain units.
- Reconciliation and compliance data are current as of June 2018 and subsequent allowance deduction adjustments and penalties are not reflected.

Source: EPA, 2019

Figure 1. Acid Rain Program SO_2 Program Allowance Reconciliation Summary, 2017

Cross-State Air Pollution Rule SO_2 Group 1 Program Allowance Reconciliation Summary, 2017

Total Allowances Held (2015 - 2017 Vintage)	**4,263,345**	**Held by Affected Facility Accounts**	**3,656,070**
		Held by Other Accounts (General, State Holding and Non-Affected Facility Accounts)	**607,275**
Allowances Deducted for Cross-State Air Pollution Rule SO_2 Group 1 Program	653,650		
Penalty Allowance Deductions	0		
Banked Allowances	**3,609,695**	**Held by Affected Facility Accounts**	**3,002,420**
		Held by Other Accounts (General, State Holding and Non-Affected Facility Accounts)	**607,275**

CSAPR SO_2 Group 1 Program Compliance Results

Reported Emissions (tons)	653,658
Compliance issues, rounding, and report resubmission adjustments (tons)	-8
Emissions not covered by allowances (tons)	0
Total allowances deducted for emissions	653,650

Notes:
- Compliance emissions data may vary from other report sections as a result of variation in rounding conventions, changes due to resubmissions by sources, or allowance compliance issues at certain units.
- Reconciliation and compliance data are current as of June 2018 and subsequent allowance deduction adjustments and penalties are not reflected.

Source: EPA, 2019

Figure 2. Cross-State Air Pollution Rule SO_2 Group 1 Program Allowance Reconciliation Summary, 2017

Cross-State Air Pollution Rule SO_2 Group 2 Program Allowance Reconciliation Summary, 2017

Total Allowances Held (2015 - 2017 Vintage)	**1,554,461**	**Held by Affected Facility Accounts**	**1,186,746**
		Held by Other Accounts (General, State Holding and Non-Affected Facility Accounts)	**367,715**
Allowances Deducted for Cross-State Air Pollution Rule SO_2 Group 2 Program	**99,724**		
Penalty Allowance Deductions	**0**		
Banked Allowances	**1,454,737**	**Held by Affected Facility Accounts**	**1,087,022**
		Held by Other Accounts (General, State Holding and Non-Affected Facility Accounts)	**367,715**

CSAPR SO_2 Group 2 Program Compliance Results

Reported Emissions (tons)	99,739
Compliance issues, rounding, and report resubmission adjustments (tons)	-15
Emissions not covered by allowances (tons)	0
Total allowances deducted for emissions	99,724

Notes:
- Compliance emissions data may vary from other report sections as a result of variation in rounding conventions, changes due to resubmissions by sources, or allowance compliance issues at certain units.
- Reconciliation and compliance data are current as of June 2018 and subsequent allowance deduction adjustments and penalties are not reflected.

Source: EPA, 2019

Figure 3. Cross-State Air Pollution Rule SO_2 Group 2 Program Allowance Reconciliation Summary, 2017

Cross-State Air Pollution Rule NO_x Annual Program Allowance Reconciliation Summary, 2017

Total Allowances Held (2015 - 2017 Vintage)	**1,852,814**	**Held by Affected Facility Accounts**	**1,604,243**
		Held by Other Accounts (General, State Holding and Non-Affected Facility Accounts)	**248,571**
Allowances Deducted for Cross-State Air Pollution Rule NO_x Annual Program	585,869		
Penalty Allowance Deductions (2018 Vintage)	88		
Banked Allowances	**1,266,945**	**Held by Affected Facility Accounts**	**1,018,374**
		Held by Other Accounts (General, State Holding and Non-Affected Facility Accounts)	**248,571**

CSAPR NO_x Annual Program Compliance Results

Reported Emissions (tons)	585,855
Compliance issues, rounding, and report resubmission adjustments (tons)	58
Emissions not covered by allowances (tons)	-44
Total allowances deducted for emissions	585,869

Notes:
- Compliance emissions data may vary from other report sections as a result of variation in rounding conventions, changes due to resubmissions by sources, or allowance compliance issues at certain units.
- Reconciliation and compliance data are current as of June 2018 and subsequent allowance deduction adjustments and penalties are not reflected.

Source: EPA, 2019

Figure 4. Cross-State Air Pollution Rule NO_X Annual Program Allowance Reconciliation Summary, 2017

Cross-State Air Pollution Rule NO_X Ozone Season Program Group 1 Allowance Reconciliation Summary, 2017

Total Allowances Held (2015 - 2017 Vintage)	**42,554**	**Held by Affected Facility Accounts**	**28,552**
		Held by Other Accounts (General, State Holding and Non-Affected Facility Accounts)	**14,002**
Allowances Deducted for Cross-State Air Pollution Rule NO_x Ozone Season Program Group 1	**7,093**		
Penalty Allowance Deductions	**0**		
Banked Allowances	**35,461**	**Held by Affected Facility Accounts**	**21,459**
		Held by Other Accounts (General, State Holding and Non-Affected Facility Accounts)	**14,002**

CSAPR NO_x Ozone Season Program Group 1 Compliance Results

Reported Emissions (tons)	7,136
Compliance issues, rounding, and report resubmission adjustments (tons)	-43
Emissions not covered by allowances (tons)	0
Total allowances deducted for emissions	7,093

Notes:
- Compliance emissions data may vary from other report sections as a result of variation in rounding conventions, changes due to resubmissions by sources, or allowance compliance issues at certain units.
- Reconciliation and compliance data are current as of June 2018 and subsequent allowance deduction adjustments and penalties are not reflected.

Source: EPA, 2019

Figure 5. Cross-State Air Pollution Rule NO_X Ozone Season Program Group 1 Allowance Reconciliation Summary, 2017

Cross-State Air Pollution Rule NO_X Ozone Season Program Group 2 Allowance Reconciliation Summary, 2017

Total Allowances Held (2017 Vintage)	**411,931**	**Held by Affected Facility Accounts**	**382,255**
		Held by Other Accounts (General, State Holding and Non-Affected Facility Accounts)	**29,676**
Allowances Deducted for Cross-State Air Pollution Rule NO_x Ozone Season Program Group 2	**294,488**		
Penalty Allowance Deductions	**0**		
Banked Allowances	**117,443**	**Held by Affected Facility Accounts**	**87,767**
		Held by Other Accounts (General, State Holding and Non-Affected Facility Accounts)	**29,676**

CSAPR NO_x Ozone Season Program Group 2 Compliance Results

Reported Emissions (tons)	294,468
Compliance issues, rounding, and report resubmission adjustments (tons)	20
Emissions not covered by allowances (tons)	0
Total allowances deducted for emissions	294,488

Notes:
- Compliance emissions data may vary from other report sections as a result of variation in rounding conventions, changes due to resubmissions by sources, or allowance compliance issues at certain units.
- Reconciliation and compliance data are current as of June 2018 and subsequent allowance deduction adjustments and penalties are not reflected.

Source: EPA, 2019

Figure 6. Cross-State Air Pollution Rule NO_X Ozone Season Program Group 2 Allowance Reconciliation Summary, 2017

Chapter 6: Market Activity

Cap and trade programs allow participants to independently determine their best compliance strategy. Participants that reduce their emissions below the number of allowances they hold may trade allowances, sell them, or bank them for use in future years. While ARP and CSAPR are cap and trade programs, MATS is not a market-based program; therefore this section does not report on market activity for MATS.

Highlights

Transaction Types and Volumes

- In 2017, more than 970,000 allowances were traded across all five of the CSAPR trading programs.
- Just under one-quarter of the transactions within the CSAPR programs were between distinct organizations. In 2017, over 6 million ARP allowances were traded, the majority (67 percent) between related organizations.

2017 Allowance Prices[1]

- ARP SO_2 allowance prices averaged less than $1 per ton in 2017.
- CSAPR SO_2 Group 1 allowance prices started 2017 at $5.25 per ton and ended 2017 at $2.13 per ton.
- CSAPR SO_2 Group 2 allowance prices started 2017 at $5.25 per ton and ended 2017 at $2.63 per ton.
- CSAPR NO_X annual program allowances started 2017 at $6 per ton and ended 2017 at $2 per ton.
- CSAPR NO_X ozone season program allowances started 2017 at $525 per ton and ended 2017 at $175 per ton.[2]

Background Information

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 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.

[1] Allowance prices as reported by SNL Finance, 2017.

[2] These prices reflect CSAPR Update ozone season NO_X allowances. In October 2017, EPA published an update to the CSAPR ozone season allowance trading programs. On October 23rd, 2017, most CSAPR ozone season NO_X allowances were converted to CSAPR Update ozone season NO_X allowances.

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

- Transfers between separate and unrelated parties (distinct organizations), 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 facility compliance account and any account held by a company with an ownership interest in the facility).

While all transactions are important to proper market operation, EPA follows trends in transactions between distinct economic entities with particular interest. These transactions represent an actual exchange of assets between unaffiliated participants, which reflect companies making the most of the cost-minimizing flexibility of emission trading programs. Companies accomplish this by finding the cheapest emission reductions not only among their own generating assets, but across the entire marketplace of power generators.

Allowance Markets

The 2017 emissions were below emission budgets for the Acid Rain Program (ARP) and for all five Cross-State Air Pollution Rule (CSAPR) programs. As a result, CSAPR allowance prices were well below the marginal cost for reductions projected at the time of the final rule, and are subject, in part, to downward pressure from the available banks of allowances.

More Information

- Allowance Markets https://www.epa.gov/airmarkets/allowance-markets
- Air Markets Business Center https://www.epa.gov/airmarkets/business-center
- Air Markets Program Data (AMPD) https://ampd.epa.gov/ampd/
- Emissions Trading https://www.epa.gov/emissions-trading-resources

Figures

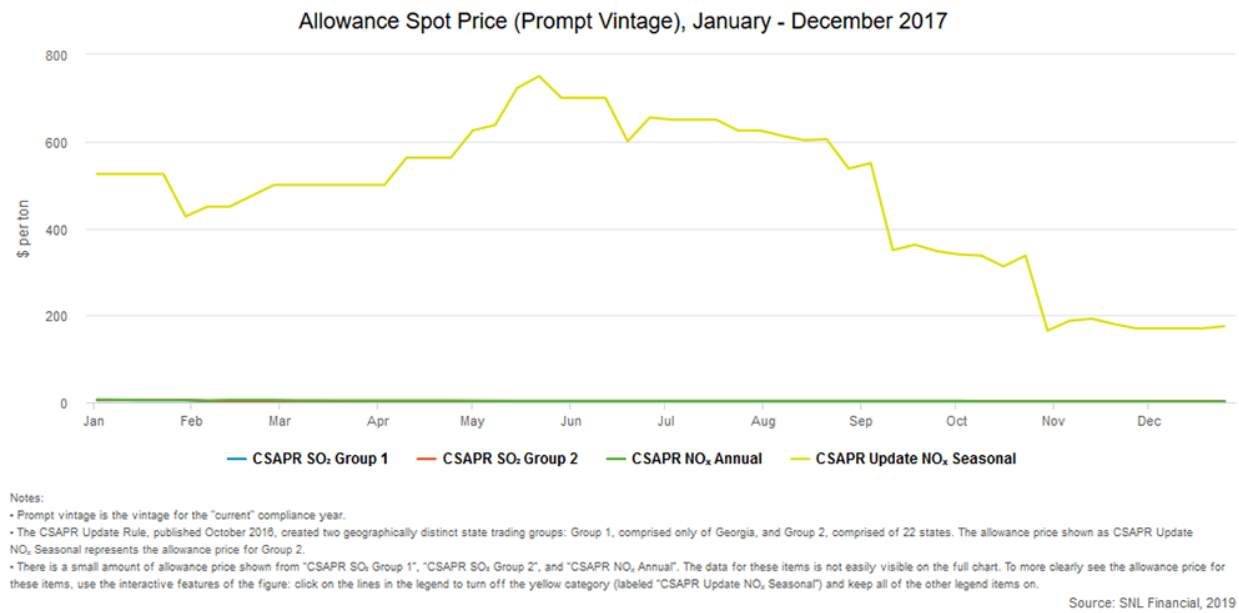
2017 Allowance Transfers under CSAPR and ARP

	Transactions Conducted	Allowances Transferred	Share of Program's Allowances Transferred	
			Related (%)	Distinct (%)
ARP SO_2	718	6,622,116	67%	33%
CSAPR SO_2 Group 1	355	304,224	85%	15%
CSAPR SO_2 Group 2	137	173,046	84%	16%
CSAPR NO_x Annual	800	388,382	68%	32%
CSAPR NO_x Ozone Season Group 1	18	13,239	100%	0%
CSAPR NO_x Ozone Season Group 2	490	92,804	53%	47%

Notes:
• The breakout between distinct and related organizations is not an exact value as relationships are often difficult to categorize in a simple bifurcated manner. EPA's analysis is conservative and the "Distinct Organizations" percentage is likely higher.
• Percentages may not add up to 100% due to rounding.

Source: EPA, 2019

Figure 1. 2017 Allowance Transfers under CSAPR and ARP



Notes:
• Prompt vintage is the vintage for the "current" compliance year.
• The CSAPR Update Rule, published October 2016, created two geographically distinct state trading groups: Group 1, comprised only of Georgia, and Group 2, comprised of 22 states. The allowance price shown as CSAPR Update NO_x Seasonal represents the allowance price for Group 2.
• There is a small amount of allowance price shown from "CSAPR SO_2 Group 1", "CSAPR SO_2 Group 2", and "CSAPR NO_x Annual". The data for these items is not easily visible on the full chart. To more clearly see the allowance price for these items, use the interactive features of the figure: click on the lines in the legend to turn off the yellow category (labeled "CSAPR Update NO_x Seasonal") and keep all of the other legend items on.

Source: SNL Financial, 2019

Figure 2. Allowance Spot Price (Prompt Vintage), January–December 2017