Addressing Air Emissions in the Power Sector

Presentation at

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Overview

- Air quality and emissions reduction policy context
- Emissions trading as a policy approach for controlling power sector emissions
- Key power sector emission trading programs
  - Acid Rain Program (ARP)
  - NO_X SIP Call
  - Clean Air Interstate Rule (CAIR)
  - Cross-State Air Pollution Rule (CSAPR)
- Program results and progress
  - Emission controls
  - Emission trends
  - Air quality
  - Acid Deposition
  - Ecological response
- Mercury and Air Toxics Standards (MATS)

Power Sector Air Pollution Contributes to Major Health and Environmental Effects

Public Health and Welfare

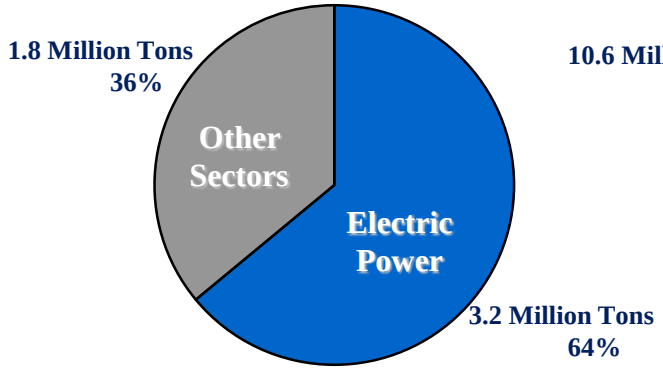
- Respiratory restrictions, aggravation of ailments (e.g., asthma attacks) and disease
- Heart ailments and attacks
- Premature deaths
- Neurological damage
- Loss of worker productivity and school days
- Emergency room visits and hospital admissions

Environment

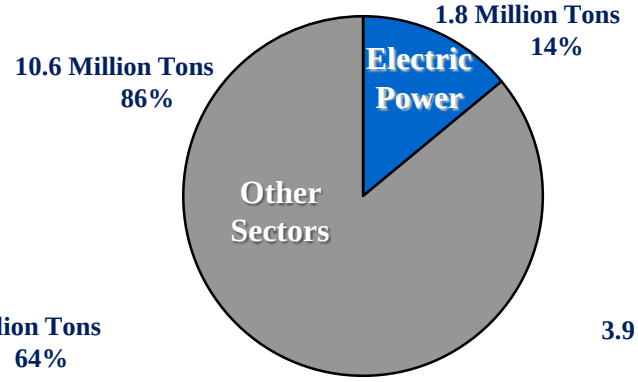
- Acid rain damage
- Eutrophication
- Visibility loss
- Changes to ecosystem functions
- Damage to commercial forests, crops, and urban ornamentals

Power Sector Provides Major Share of Air Emissions

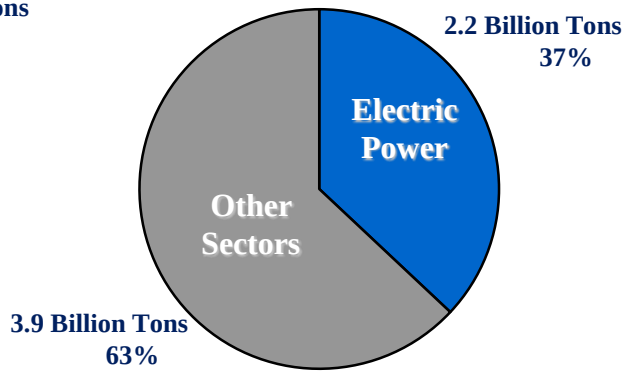
Sulfur Dioxide (SO_2), 2014
5.0 Million Tons



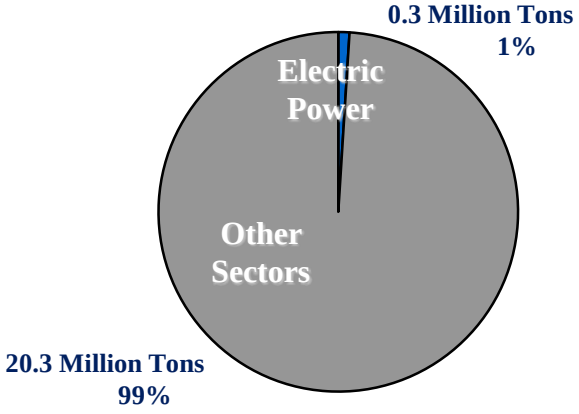
Nitrogen Oxides (NO_x), 2014
12.4 Million Tons



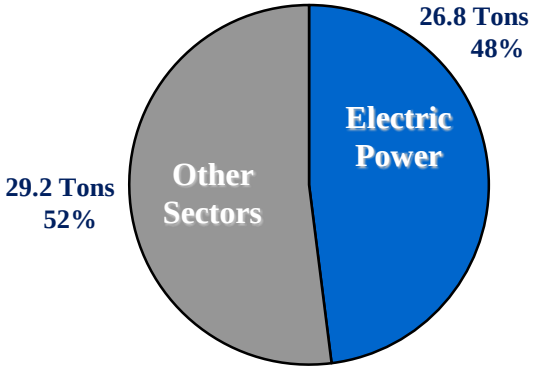
Carbon Dioxide (CO_2), 2014
6.1 Billion Tons



Particulate Matter (PM_{10}), 2014
20.6 Million Tons



Mercury (Hg), 2011
56.0 Tons



Other emissions include:

- Trace metals (nickel, arsenic, selenium and others)
- HCl, HF, other acid gases
- Dioxin/furans
- Trace organics
- Others (e.g., cyanide, radionuclides)

Emissions have substantial public health, environment, and other welfare implications

Sources:

NEI National Tier 1 Trends Data (2016) (SO_2, NO_X, PM_{10})
Version 2 of EPA's National Emissions Inventory 2011 (2015) (Hg)
Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014 (2016) (CO_2)
"Other" sources include transportation, other mobile sources, and industrial sources

Ways to Lower Power Sector Air Emissions

Clean Air Act (CAA)

- Acid Rain Program (ARP)
- National Ambient Air Quality Standards (NAAQS) implementation
  - Setting ambient standards
  - State Implementation Plans (SIPs)
- Authority to address interstate air pollution transport
  - NO_X SIP Call
  - Clean Air Interstate Rule (CAIR)
  - Cross State Air Pollution Rule (CSAPR)
- New Source Review/Prevention of Significant Deterioration (NSR/PSD)
- Maximum Achievable Control Technology Standards (MACT)
  - Mercury and Air Toxics Standards (MATS)
- Regional Haze (Visibility)
- New Source Performance Standards (NSPS)
  - GHG NSPS for new and existing power sector sources

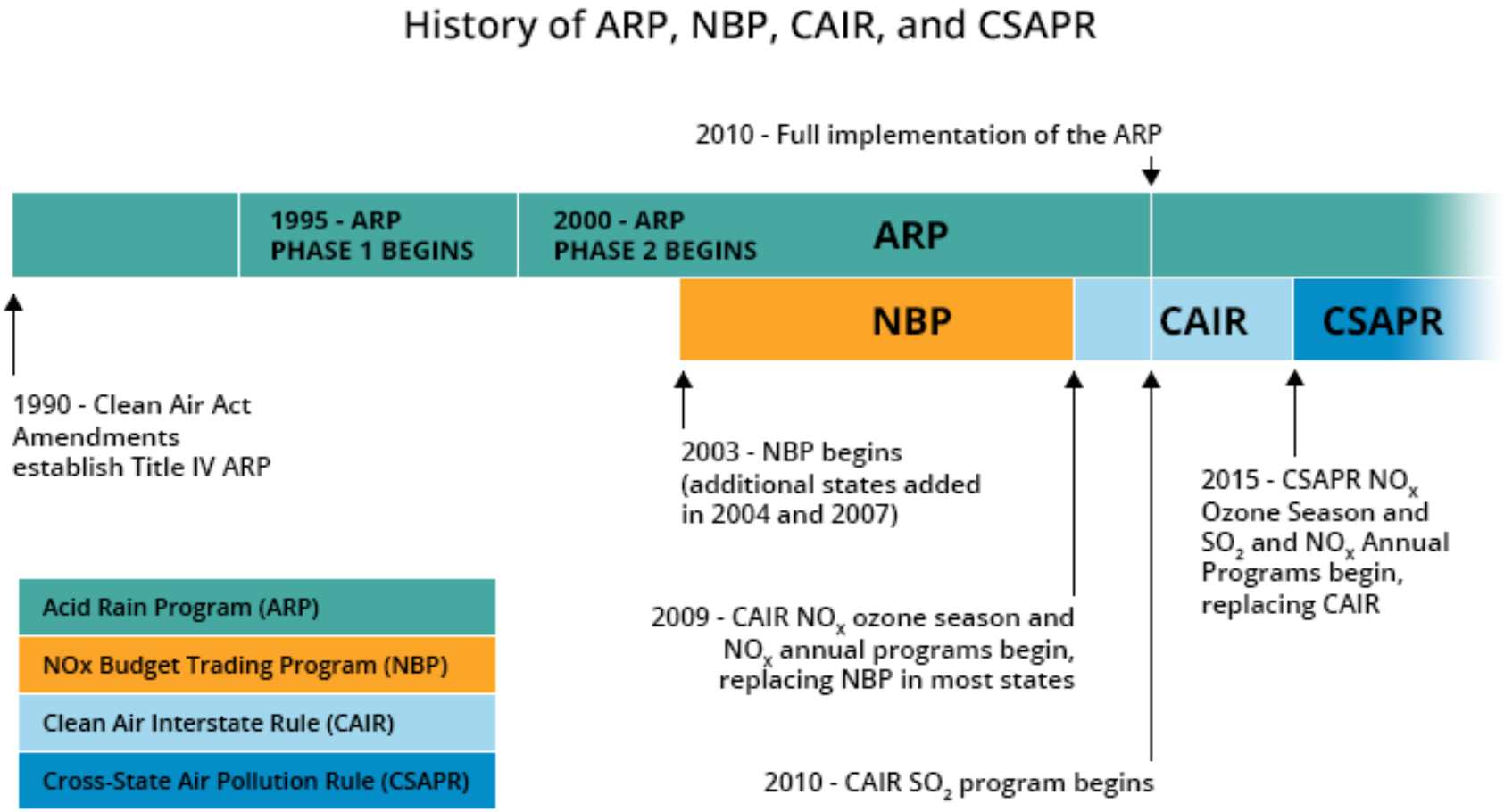
Partnership Programs

- EPA has several major partnership programs to increase investment in clean energy (energy efficiency, renewable energy & CHP)
  - ENERGY STAR (product labeling and residential, commercial and industrial sectors)
  - State Energy Efficiency Action Network (co-sponsored with DOE)
  - Green Power Partnership
  - Combined Heat and Power Partnership
  - State and Local Climate and Energy Program

State Programs

- States implement CAA through SIPs and other regulatory actions
- Many states have passed their own laws requiring emission reductions from power plants
- All states and DC have renewable portfolio standards and/or other programs to promote renewable energy and/or energy efficiency

Major Power Sector Emission Control Programs



Source EPA, 2014

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Emissions Trading

What is Emissions Trading?

Emissions trading – also known as "Cap and trade" – involve programs where the government:

- Reduces air emissions by setting a mandatory cap on aggregate emissions below the existing pollutant levels; and
- Provides covered sources emission allowances equal to the cap that can be bought or sold (traded).
- Unused allowances can be "banked" (saved) from year to year.

Government and industry have different but complementary responsibilities to lower air pollution.

Government

- Sets a mandatory cap on aggregate air emissions from a select group of sources or industrial sector(s).
- Distributes allowances to emit equal to the mandatory cap to the affected sources.
- Allows trading of allowances between sources and others under fairly unrestrictive ground rules.
- Tracks allowance transfers and holdings.
- Compares allowance holdings and emissions to assess compliance and, in the event of noncompliance, levies automatic penalties for each excess ton of emissions.

Industry

- Holds sufficient allowances to cover total emissions.
- Develops a compliance strategy to lower emissions.
  - If emissions are below holdings, a source can trade or save (bank) allowances for future use.
  - If emissions are above holdings, a source can purchase allowances.
- Reduces overall costs because sources that have the lowest abatement costs generally sell allowances and sources with high abatement costs generally buy allowances.

Key Elements of Emissions Trading

- **Emissions budget (or cap)**: Establishes a fixed quantity of allowances for each compliance period (year, season, or other).
  - Budget is the mechanism to achieve and maintain the environmental goal.
- **Coverage**: Determines which sources and/or sectors included (existing and new).
  - Coverage should capture large share of emissions but be administratively manageable.
- **Emission monitoring, reporting, and verification**: Requires complete, accurate measurement and timely reporting of emissions to assure accountability and provide public access to data.
  - Leads to program integrity and confidence.
- **Allowance distribution**: Provides initial allowances to regulated community and others through mechanisms such as government allocation and auctioning.
- **Allowance trading**: Allows companies to choose (and change) compliance options – leads to significant cost savings.
- **Stringent, automatic penalties**: Ensure the environment is made whole and penalizes non-compliance.
- **Assessment**: Determines program effectiveness and whether more emission reductions are needed to maintain environmental and human health protection.

EPA United States Environmental Protection Agency

Major Power Sector Control Programs

Acid Rain Program

- Statutory driver – Title IV of 1990 CAAA:
  - "The purpose of this title is to reduce the adverse effects of acid deposition through reductions in annual emissions of sulfur dioxide of ten million tons from 1980 emission levels, and, in combination with other provisions of this Act, of nitrogen oxides emissions of approximately two million tons from 1980 emission levels, in the forty-eight contiguous States and the District of Columbia."
  - "It is the intent of this title to effectuate such reductions by requiring compliance by affected sources with prescribed emission limitations by specified deadlines, which limitations may be met through alternative methods of compliance provided by an emission allocation and transfer system."

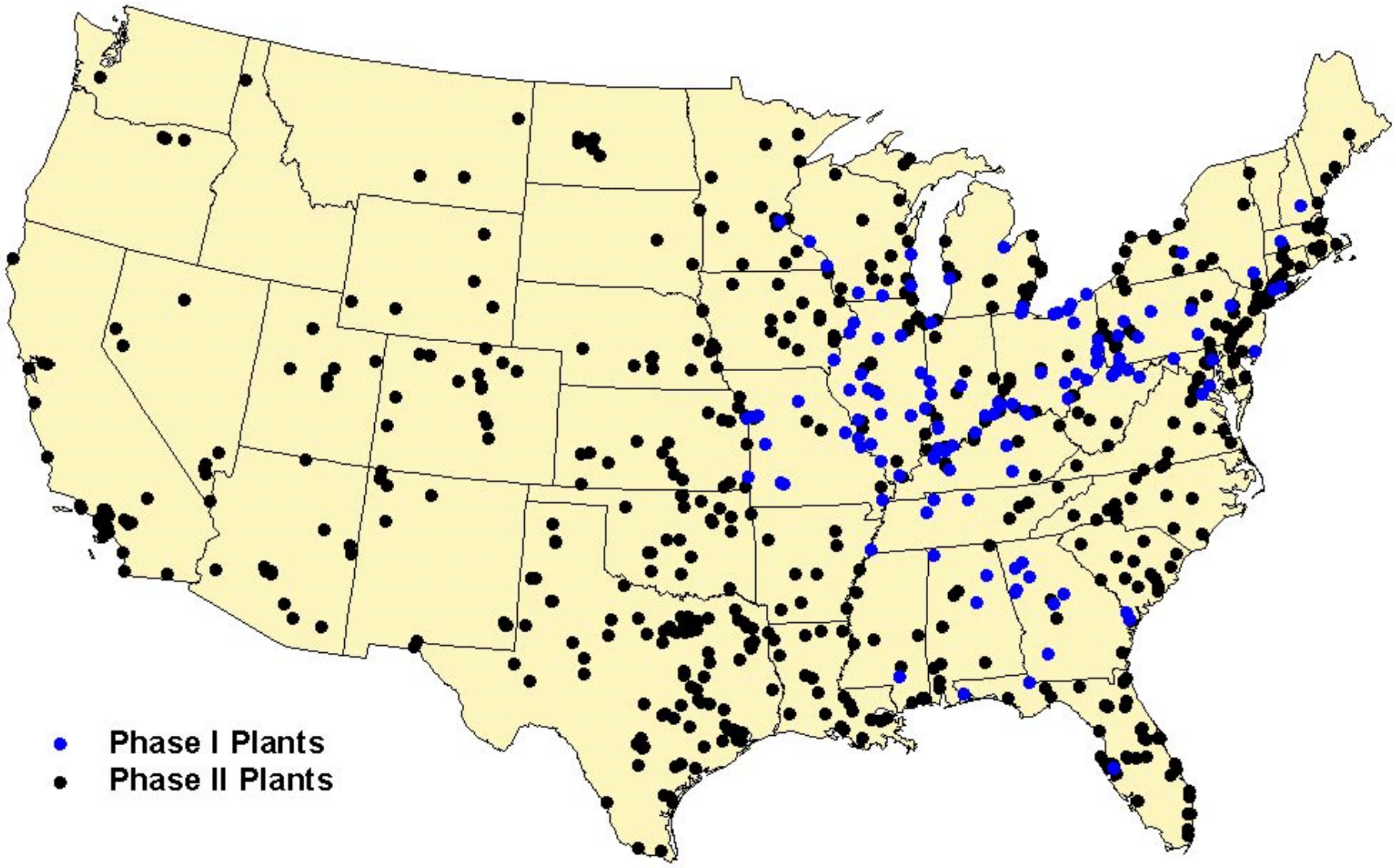
Acid Rain Program Basics

- The 1990 CAAA established the ARP, the world's first large-scale cap and trade program for air pollution.
- Environmental goal: reduce acid rain to protect sensitive ecosystems.
- The program is designed to reduce electric power sector emissions of SO_2 and NO_x
- Implemented through a national, market-based cap and trade system that permanently caps, or limits, SO_2 emissions from power plants and a NO_x rate-based program that applies to a subset of coal-fired units.
- Regulated sources must monitor, QA, and report to EPA hourly emissions of SO_2, NO_x and CO_2 and supplemental data used to QA emission data.
- In 2014, over 99% of SO2 and NOX emissions from sources regulated under the ARP were monitored using continuous emissions monitoring systems (CEMS)

Acid Rain Program Goals

- SO_2 emissions reduction goal -- 10 million ton reduction from 1980 levels by 2010
  - Utility emissions capped at 8.95 m tons/yr
  - Non-utility emissions capped at 5.6 m tons/yr
  - Achieved through allowance cap and trade program
- NO_X emissions reduction goal -- 2 million tons less than without Title IV
  - No cap on emissions
  - No NO_X emissions trading
- Implemented in two phases
  - Phase 1: 1995 – 2000
  - Phase 2: 2000 onwards
  - Full implementation: 2010

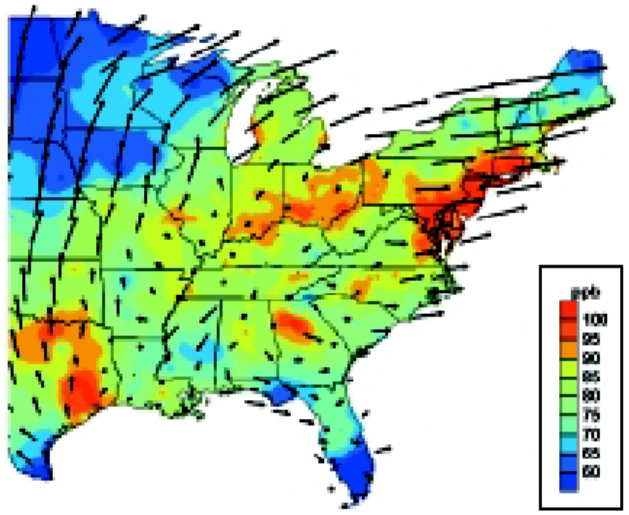
Affected Sources Under the Acid Rain Program



Air Pollution is a Regional Problem

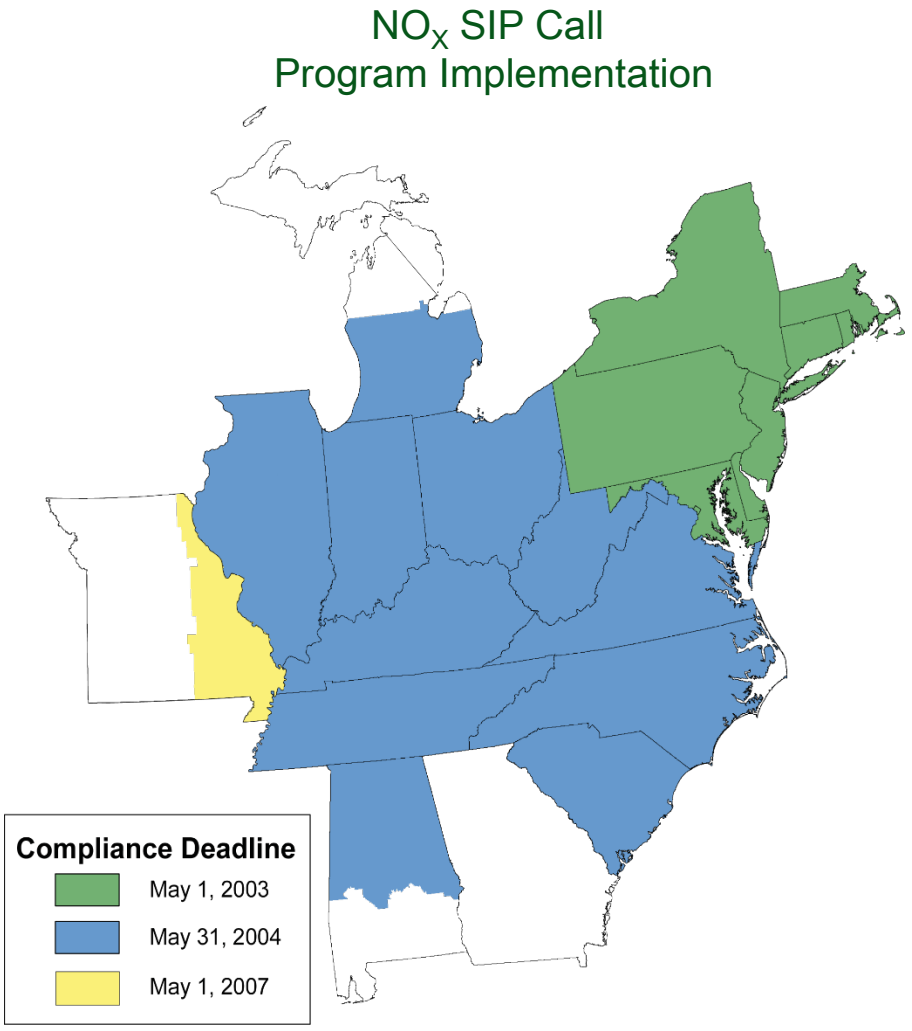
- Air pollution can travel hundreds of miles and cause multiple health and environmental problems on regional or national scales.
- Particularly relevant for emission reduction programs implemented under CAA Section 110(a)(2)(D)(i)(I).
- Attaining national ambient air quality standards requires some combination of emission reductions from:
  - Sources located in or near nonattainment areas (local pollution),
  - Sources located further from the nonattainment area (transported pollution), and
  - Pollution emitted by power plants, cars, trucks, and other industrial facilities.

Transport Winds and Ozone Patterns on High Ozone Days



The NO_X SIP Call

- The NO_X SIP Call, finalized in 1998, was designed to reduce regional transport of ozone and ozone-forming pollutants in the East from May 1 – September 30 (ozone season).
  - Intended to address regional interstate transport for the 1997 ozone NAAQS.
- 20 states and the District of Columbia were affected by the NO_X SIP Call.
- Majority of states had to comply by 2004 ozone season.
- All affected states chose to meet their emission reduction requirements by participating in the EPA administered NO_X Budget Trading Program.



NO_X Budget Trading Program (NBP)

- The NBP was an emissions trading program developed to implement the NO_X SIP Call by reducing emissions from electric generators and large industrial combustion sources.
- Required states, collectively, to meet a regional emission cap (sum of states' emissions budgets) and gave sources flexibility to develop control strategies to meet those caps.
- Through SIPs, states were responsible for developing and implementing the necessary programs to achieve the NO_X emissions budget.
  - EPA issued a model rule that established the parameters for the voluntary cap and trade program.
  - Individual state rules linked together to form a multi-state program.
- Sources had a variety of compliance options under the NBP, for example:
  - Simple combustion controls
  - Adding advanced post-combustion control technology at larger, higher emitting units
  - Optimizing installed controls or operating cleaner units more often
  - Purchasing allowances from the market
- At the end of every ozone season, each source was required to surrender sufficient allowances to cover its ozone season NO_x emissions.

Power Sector Programs to Support the NAAQS

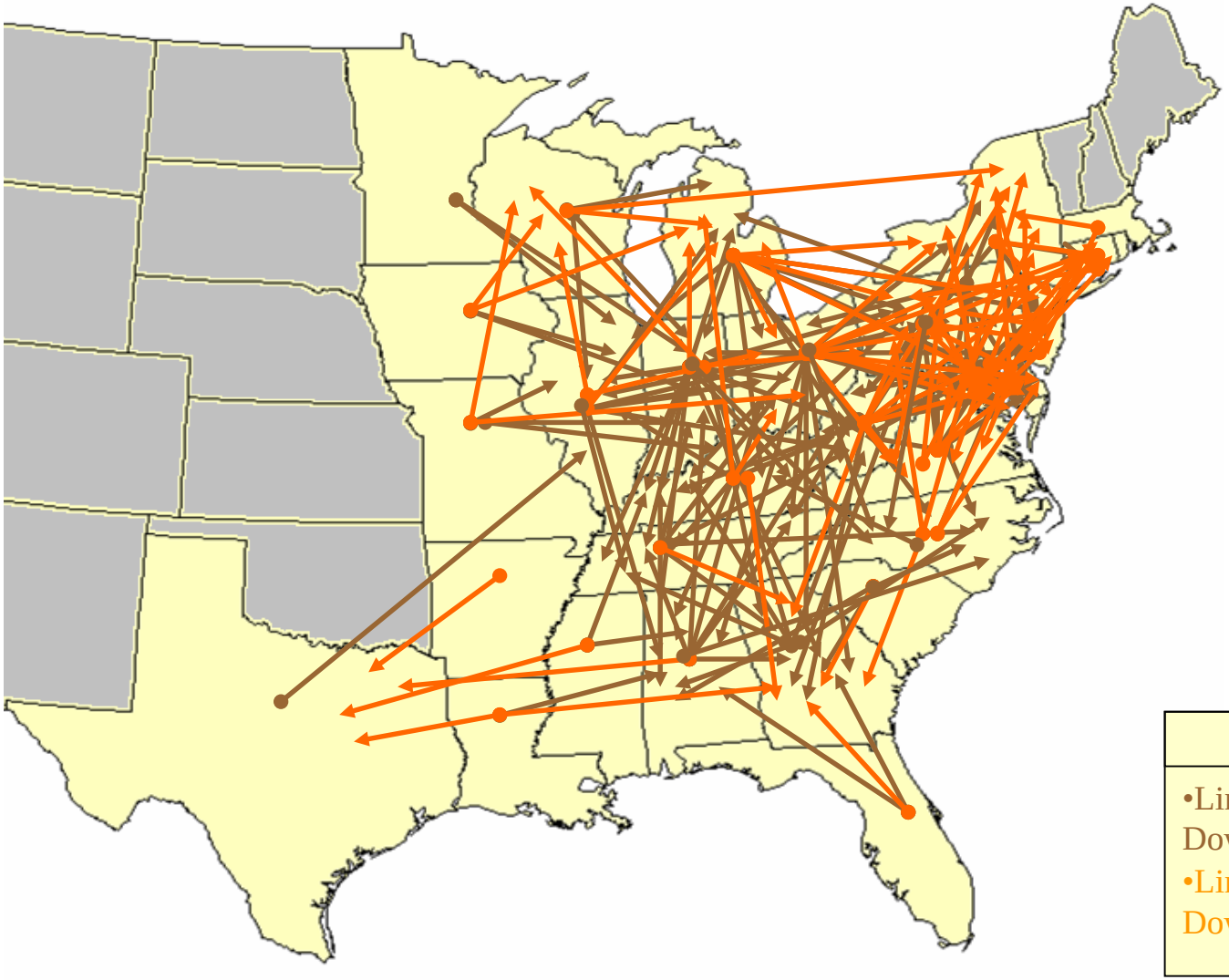
- Statutory Authority to Address Interstate Transport of Air Pollution:
  - The Clean Air Act's "good neighbor" provision requires EPA and states to address interstate transport of air pollution that affects downwind states' ability to attain and maintain National Ambient Air Quality Standards (NAAQS).
  - Specifically, Clean Air Act section 110(a)(2)(D)(i)(I) requires each state in its State Implementation Plan (SIP) to prohibit emissions that will significantly contribute to nonattainment of a NAAQS, or interfere with maintenance of a NAAQS, in a downwind state.
  - "Good neighbor" SIPs "contain adequate provisions - prohibiting, consistent with the provisions of this subchapter, any source or other type of emissions activity within the state from emitting any air pollutant in amounts which will... contribute significantly to nonattainment in, or interfere with maintenance by, any other state with respect to any such national primary or secondary ambient air quality standard."
- Programs implemented under this authority:
  - NO_X SIP Call
  - Clean Air Interstate Rule (CAIR)
  - Cross-State Air Pollution Rule (CSAPR)

Clean Air Interstate Rule (CAIR)

- CAIR required 27 eastern states and the District of Columbia to reduce power sector SO_2 and/or NO_x emissions to address regional interstate transport for the 1997 $PM_{2.5}$ and ozone National Ambient Air Quality Standards (NAAQS).
- CAIR required reductions in annual emissions of SO_2 and NO_x from power plants in 24 states and D.C. and emission reductions of NO_x during the ozone season from 25 states and D.C.
- CAIR set an emission reduction requirement for each State, based on capping power plant emissions collectively at levels that EPA believed were highly cost-effective to achieve.
- Provided an optional cap and trade program based on successful Acid Rain and NO_X Budget Trading programs as a method to implement the necessary reductions.
- Included a two-phase program with declining power plant emission caps:
  - SO_2 annual caps: 3.6 million tons in 2010 and 2.5 million in 2015
  - NO_X annual caps: 1.5 million tons in 2009 and 1.3 million in 2015
  - NO_X ozone season caps: 580,000 tons in 2009 and 480,000 tons in 2015
  - Emission caps are divided into State SO_2 and NO_X budgets.
- Allowed States flexibility on how to achieve the required reductions, including which sources to control and whether to join the trading program.
- All states chose to achieve emissions reductions by joining the emissions trading program.

Upwind-Downwind Linkages in CAIR States

United States Environmental Protection Agency



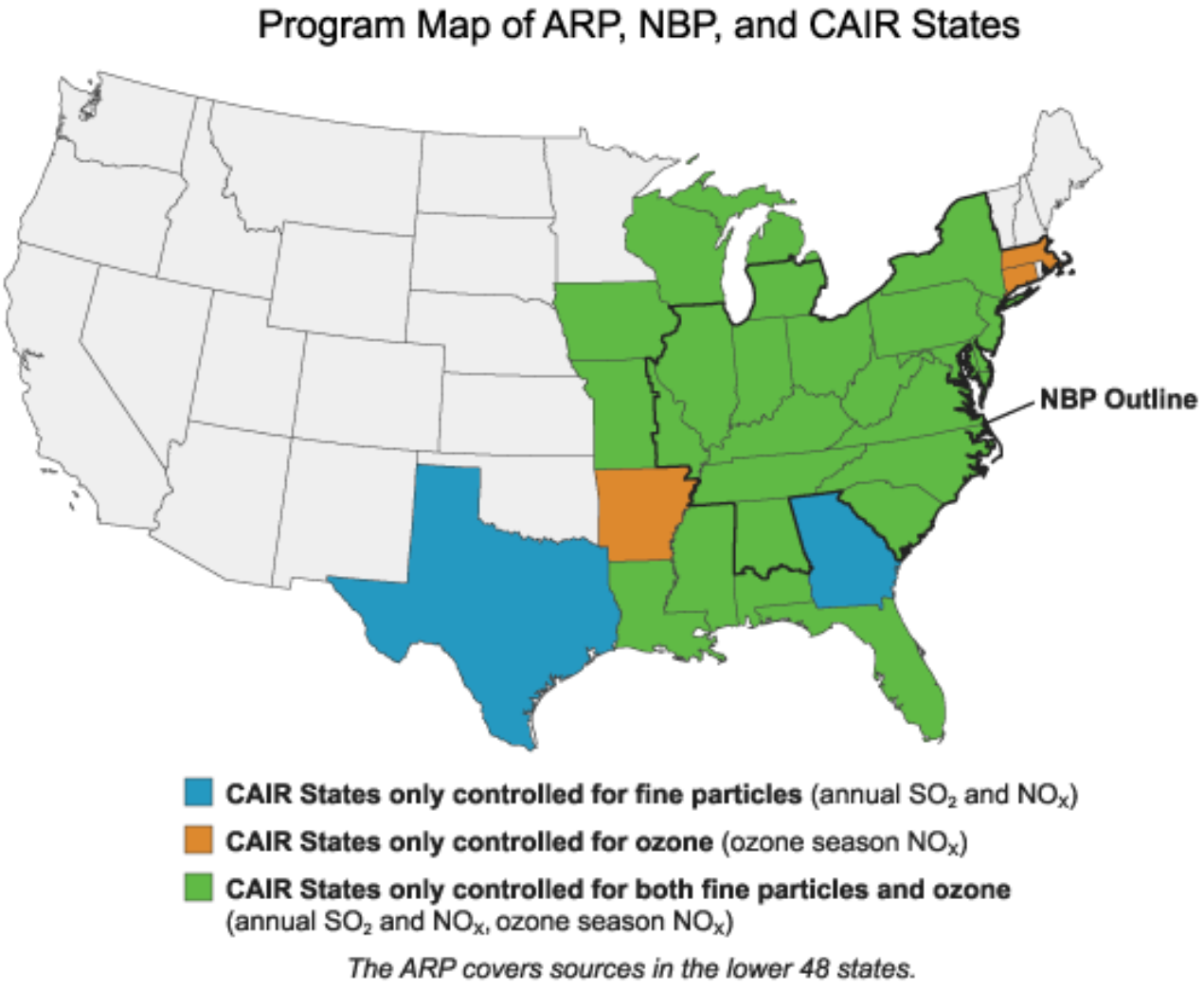
Upwind/downwind issues are not transparent

State demonstrations will need to show individual source contributions

Key to Arrows

- Linkage of Upwind to Downwind for PM2.5
- Linkage of Upwind to Downwind for Ozone

Power Sector Programs: Landscape in 2009

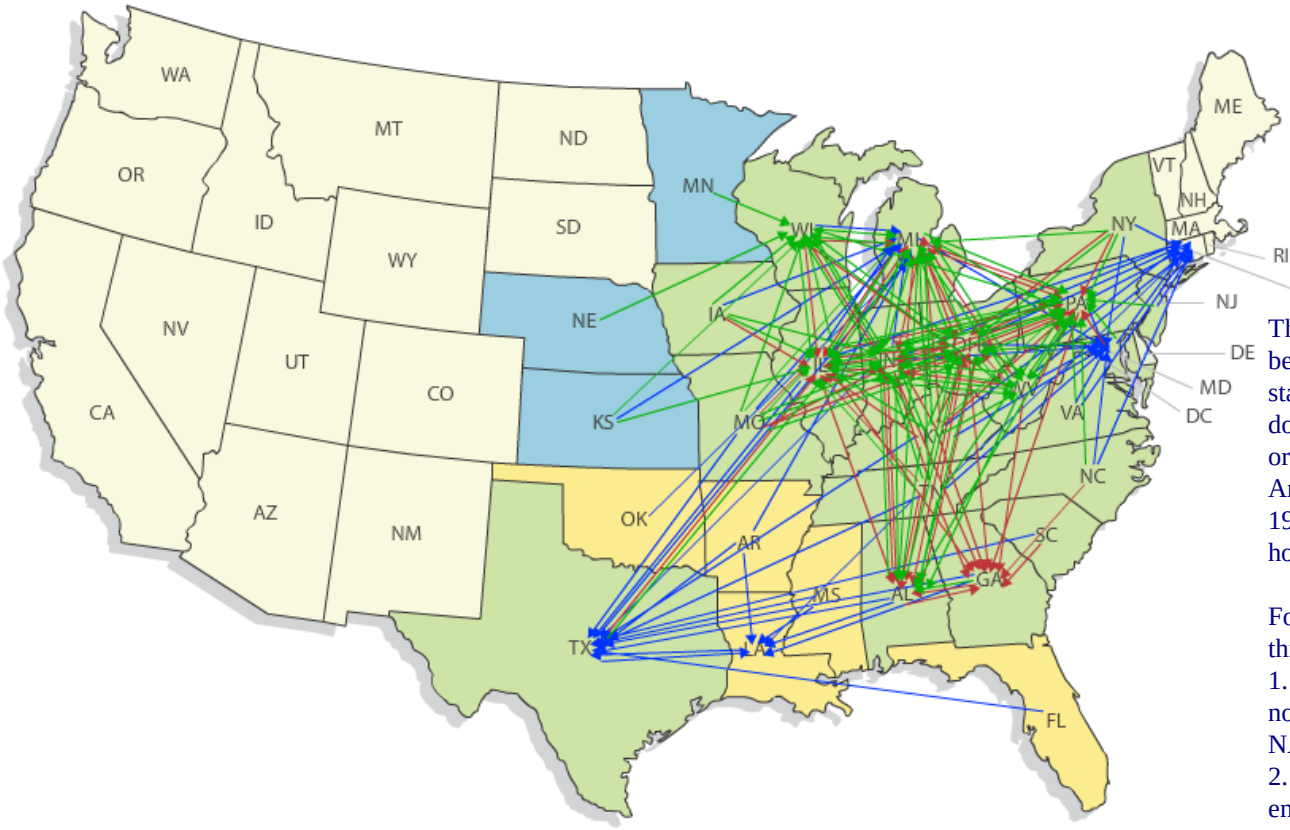


Source: EPA, 2014

Cross-State Air Pollution Rule (CSAPR)

- Responded to the Court decision instructing EPA to replace CAIR.
  - On July 11, 2008, Court issued a decision that upheld some aspects of CAIR and ruled against EPA on other aspects. Overall, the decision vacated the rule, but the Court ultimately remanded CAIR to EPA and instructed the agency to replace it.
- CSAPR defined upwind state obligations to reduce pollution significantly contributing to downwind nonattainment and maintenance areas based on:
  - Magnitude of a state's contribution,
  - Cost of controlling pollution from various sources, and
  - Air quality impacts of reductions.
- Once these obligations were determined, including the amount of necessary pollution reductions, state budgets were set accordingly.
- The rule allowed air quality-assured allowance trading among power plants, utilizing an allowance market infrastructure based on existing, successful emissions trading programs.
  - In contrast to CAIR, emissions trading was limited under CSAPR in order to address the CAIR court ruling.
  - State budgets were set with variability limits to assure that each state will meet its pollution control obligations.

Upwind-Downwind Linkages in Cross-State Air Pollution Rule States



This map shows the CSAPR "linkages" between states where pollution from upwind states is linked to one or more areas in downwind states that have problems attaining or maintaining the 1997 ozone National Ambient Air Quality Standards (NAAQS), 1997 annual $PM_{2.5}$ NAAQS, and the 2006 24-hour $PM_{2.5}$ NAAQS.

For states to be "linked" on this map, two things must occur:
1. The downwind state must have at least one nonattainment or maintenance area for these NAAQS; and,
2. Sources in the upwind state must emit enough SO_2 or NO_X pollution to affect air quality in that area at or above the threshold level set by EPA.

Legend

- States controlled for both fine particles (annual SO_2 and NOx) and ozone (ozone season NOx) (20 States)
- States controlled for fine particles only (annual SO_2 and NOx) (3 States)
- States controlled for ozone only (ozone season NOx) (5 States)
- States not covered by the Cross-State Air Pollution Rule

Key to Arrows

- Upwind-Downwind Linkage for Ozone
- Upwind-Downwind Linkage for Annual PM2.5
- Upwind-Downwind Linkage for Daily PM2.5

Budgets under CSAPR and CAIR

Comparison of emission budgets for states covered by both CSAPR and CAIR (million tons)

	Initial Phase	
	CAIR Budgets	CSAPR Budgets
Annual SO_2	3.25	3.24
Annual NO_X	1.33	1.16
Ozone Season NO_X	0.56	0.48

- The initial phase of CAIR compliance was 2009 for annual and ozone season NO_X programs and 2010 for the annual SO_2 program.
- The initial phase for CSAPR compliance was meant to begin in 2012 for all programs.
  - Sources covered by the CSAPR annual SO_2 and NO_X programs were meant to comply – that is, surrender allowances to cover their 2012 annual emissions – in March 2013.
  - Sources covered by the NO_X ozone season program were meant to comply on December 1, 2012 by surrendering allowances sufficient to cover their ozone season NO_X emissions.
- The second phase of CSAPR compliance was meant to begin in 2014 for all programs.
- Compared to 2005, EPA estimated that CSAPR would achieve a 73% reduction in SO_2 emissions, and a 54% reduction in annual NO_X emissions (including ozone season reductions).

Transition from CAIR to CSAPR

- CAIR was to be implemented through 2011 compliance periods.
- CSAPR covered emissions in 2012 and beyond.
- CSAPR established new allowances for all programs.
  - There was no carryover of Acid Rain Program, NO_X SIP Call/NBP, or CAIR allowances, meaning they could not be used for compliance.
- The timing of CSAPR's implementation has been affected by a number of court actions.
  - December 30, 2011, CSAPR was stayed prior to implementation.
  - April 29, 2014, the U.S. Supreme Court issued an opinion reversing an August 21, 2012 D.C. Circuit decision that had vacated CSAPR.
  - Following the remand of the case to the D.C. Circuit, EPA requested that the court lift the CSAPR stay and toll the CSAPR compliance deadlines by three years.
  - October 23, 2014, the D.C. Circuit granted EPA's request. Accordingly, CSAPR Phase 1 implementation is now scheduled for 2015, with Phase 2 beginning in 2017.

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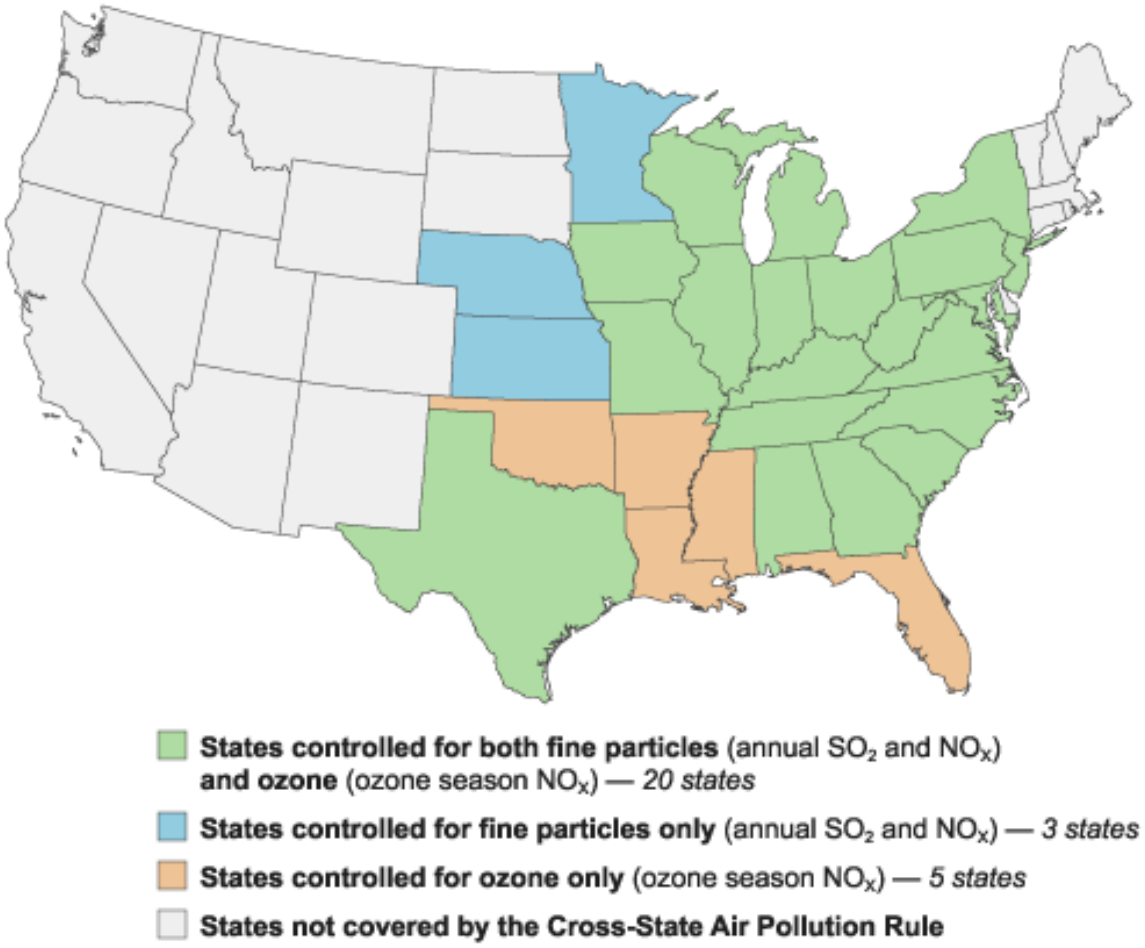
Program Map of Cross-State Air Pollution Rule States



Source: EPA, 2014

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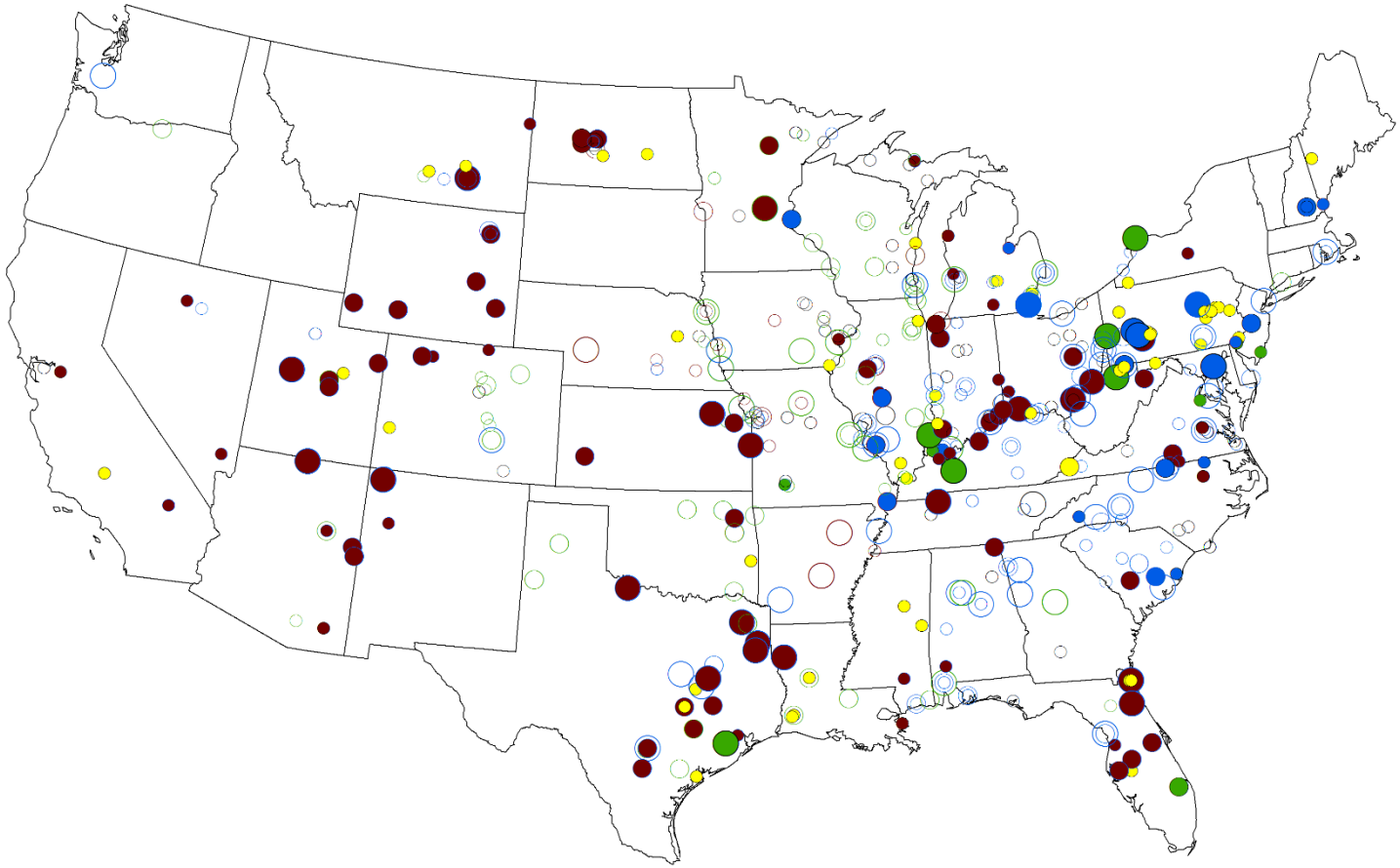
Results and Progress

2000 Coal Controls for SO_2 and NO_X (Start of ARP Phase II)

United States Environmental Protection Agency



Scrubber and SCR/SNCR
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- 300 MW to 600 MW
- Over 600 MW

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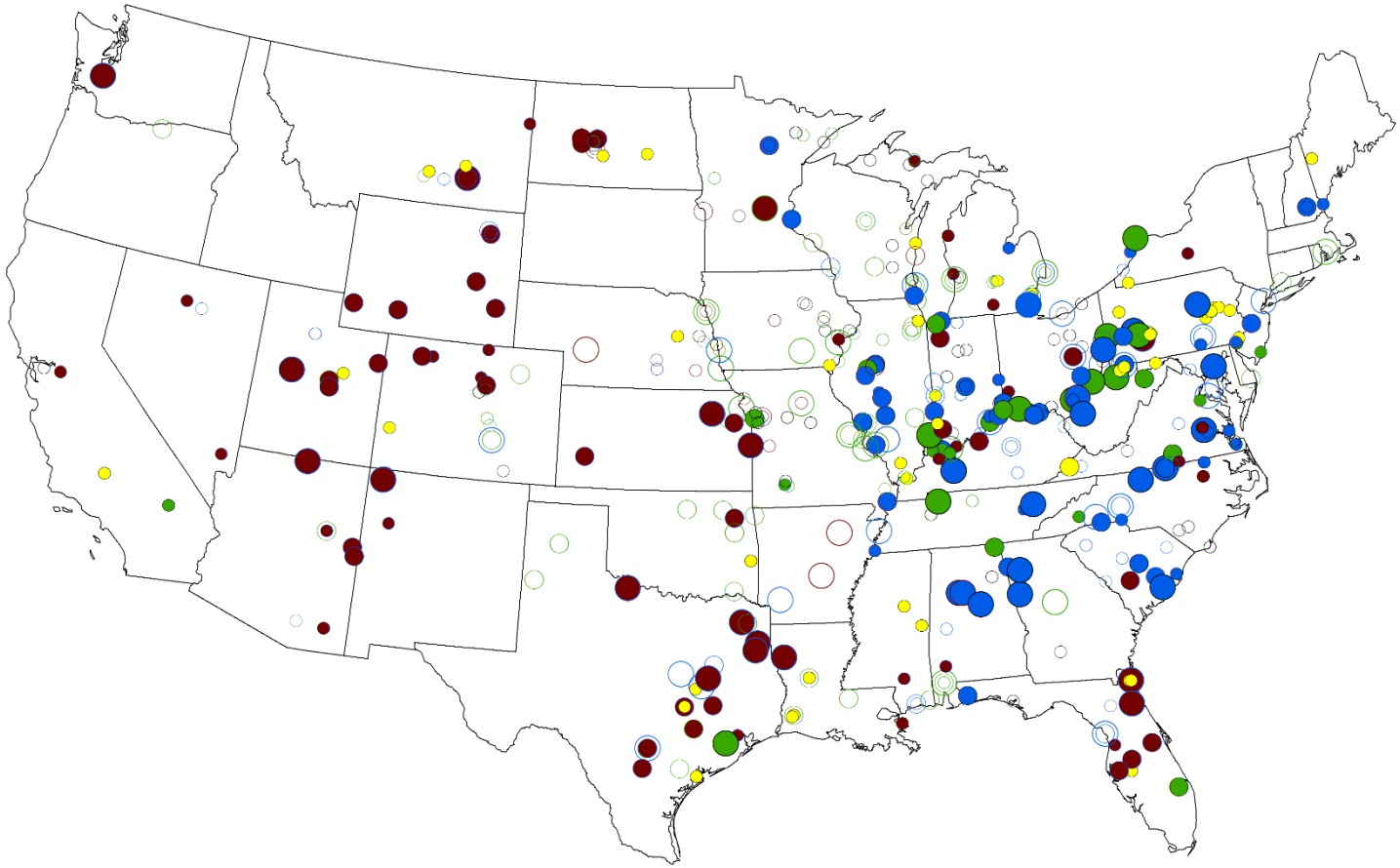
Virtually all coal-fired units have electrostatic precipitators, baghouses, or other advanced controls for high levels of particulate removal.

Source: National Electric Energy Data System (NEEDS 5.15) (EPA, 2015) and AMPD (EPA, 2016)

2005 Coal Controls for SO_2 and NO_X (CAIR Final Rule Issued)



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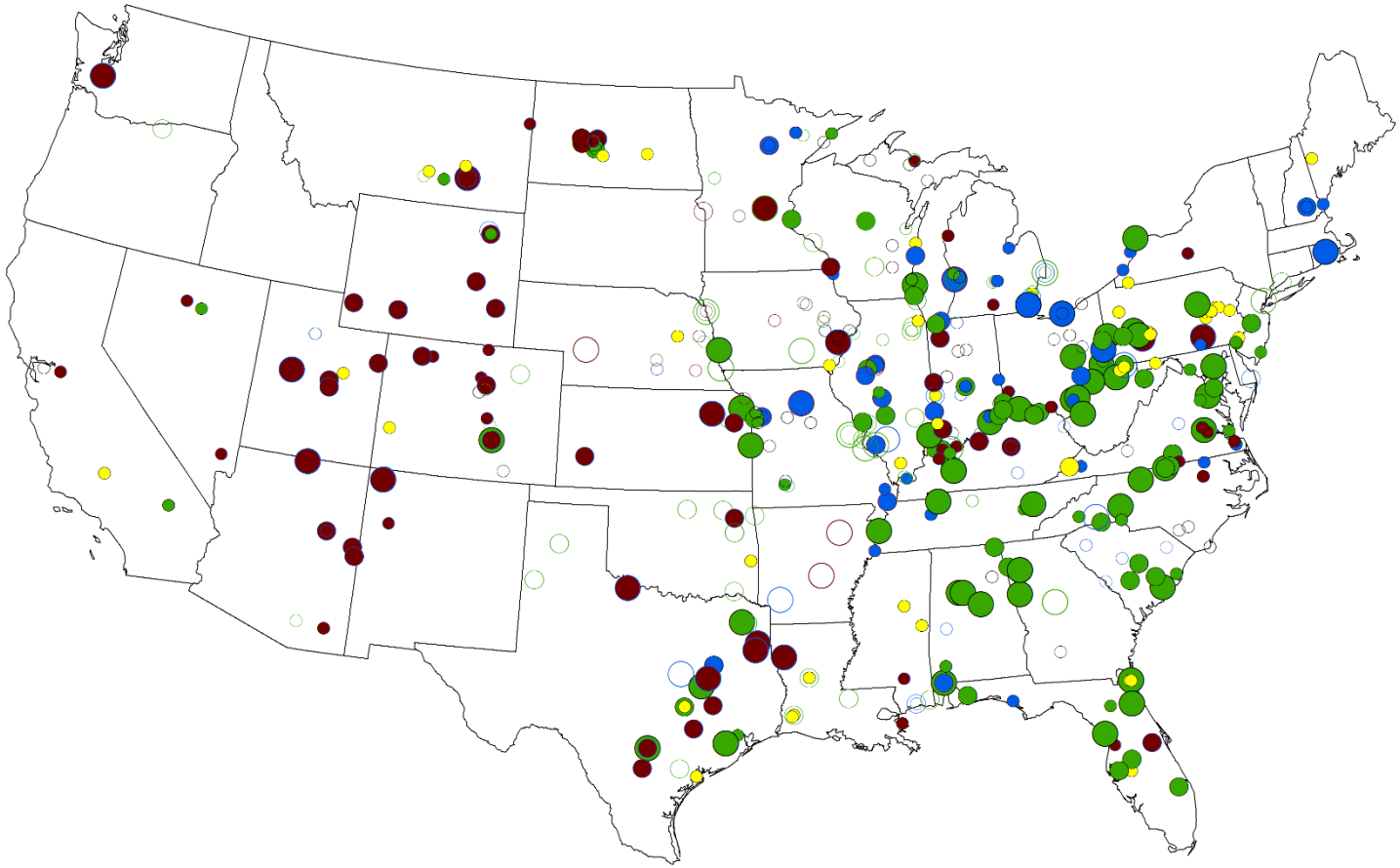
2010 Coal Controls for SO_2 and NO_X (CAIR SO_2 and NO_X Programs)

United States Environmental Protection Agency



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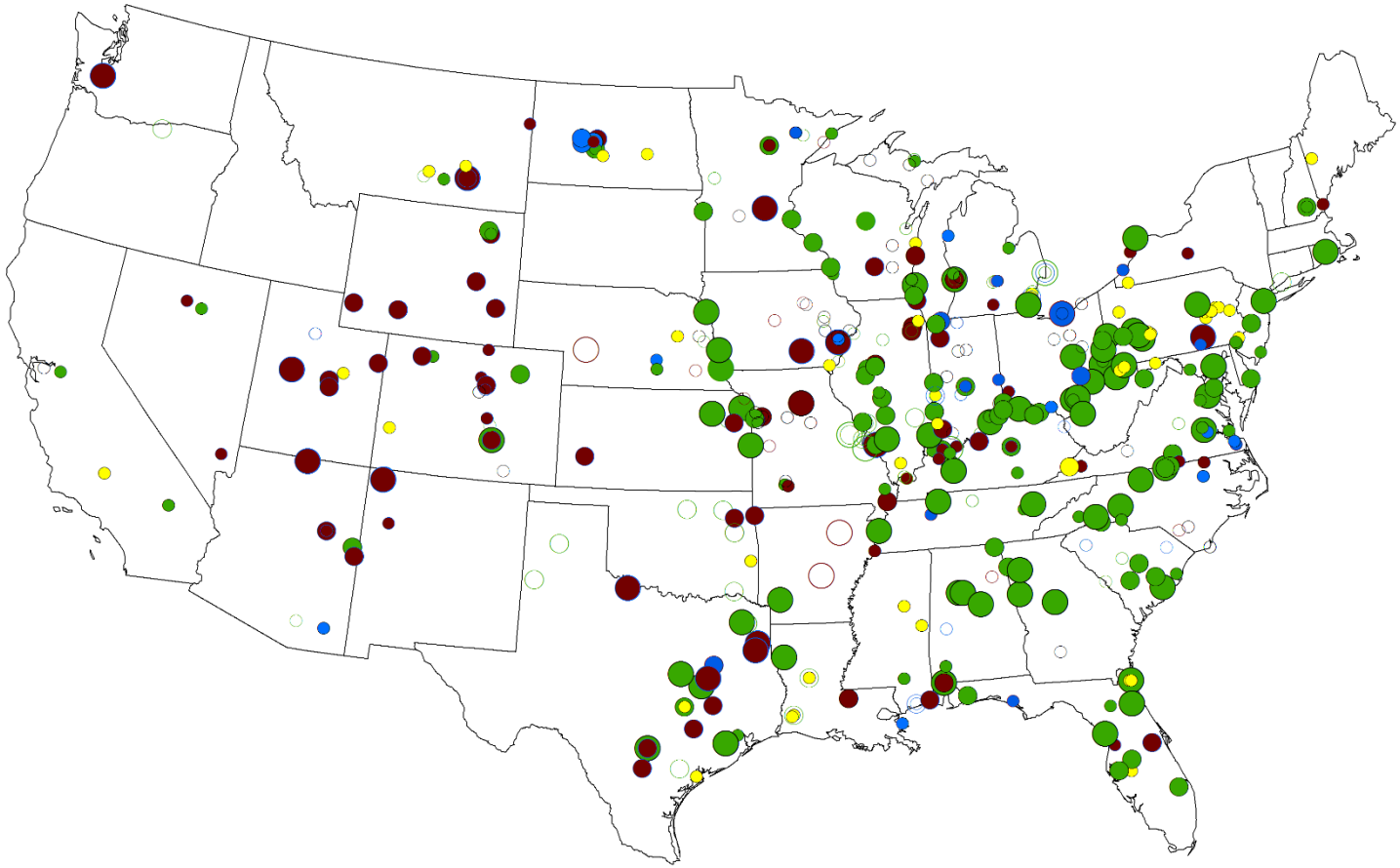
2016 Coal Controls for SO_2 and NO_X (Current)



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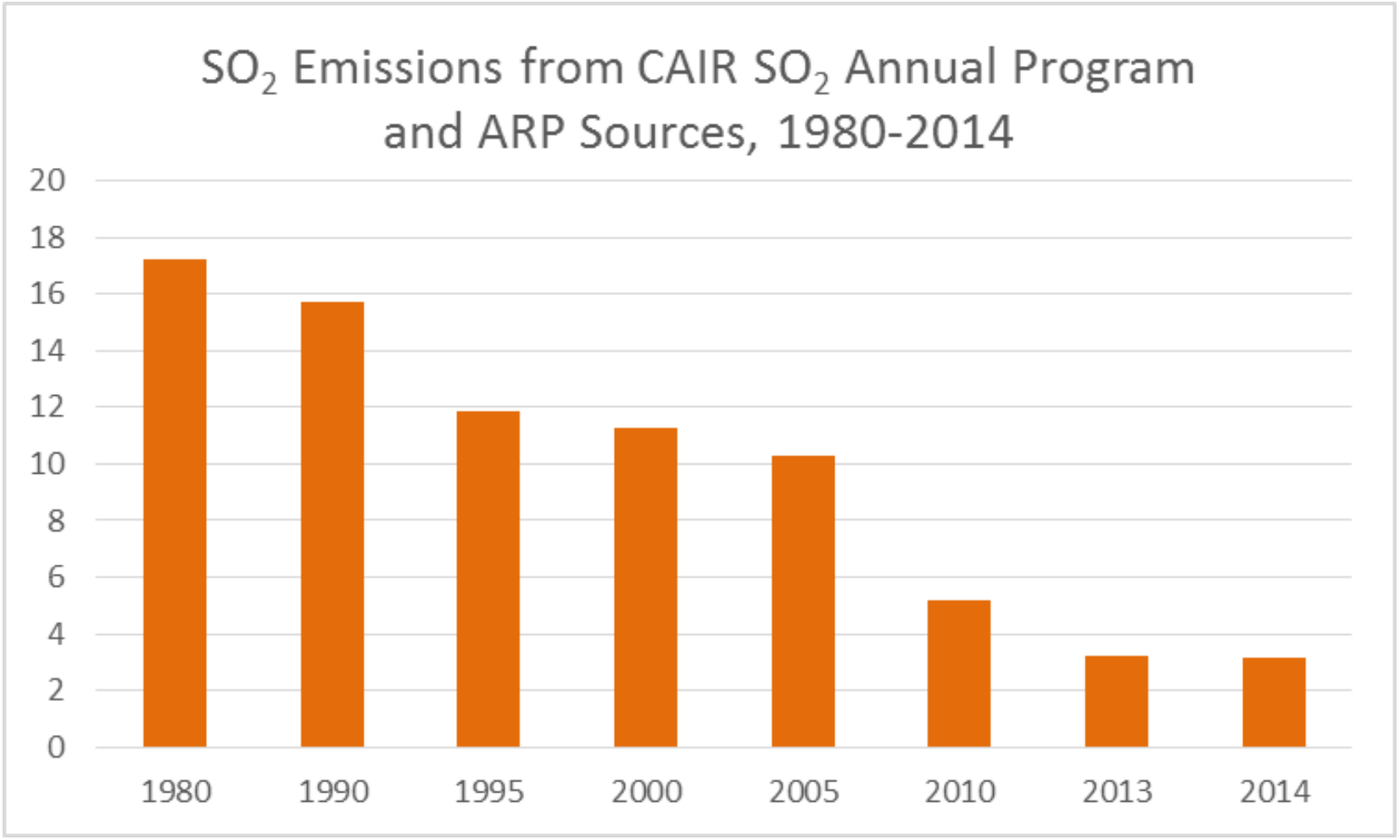
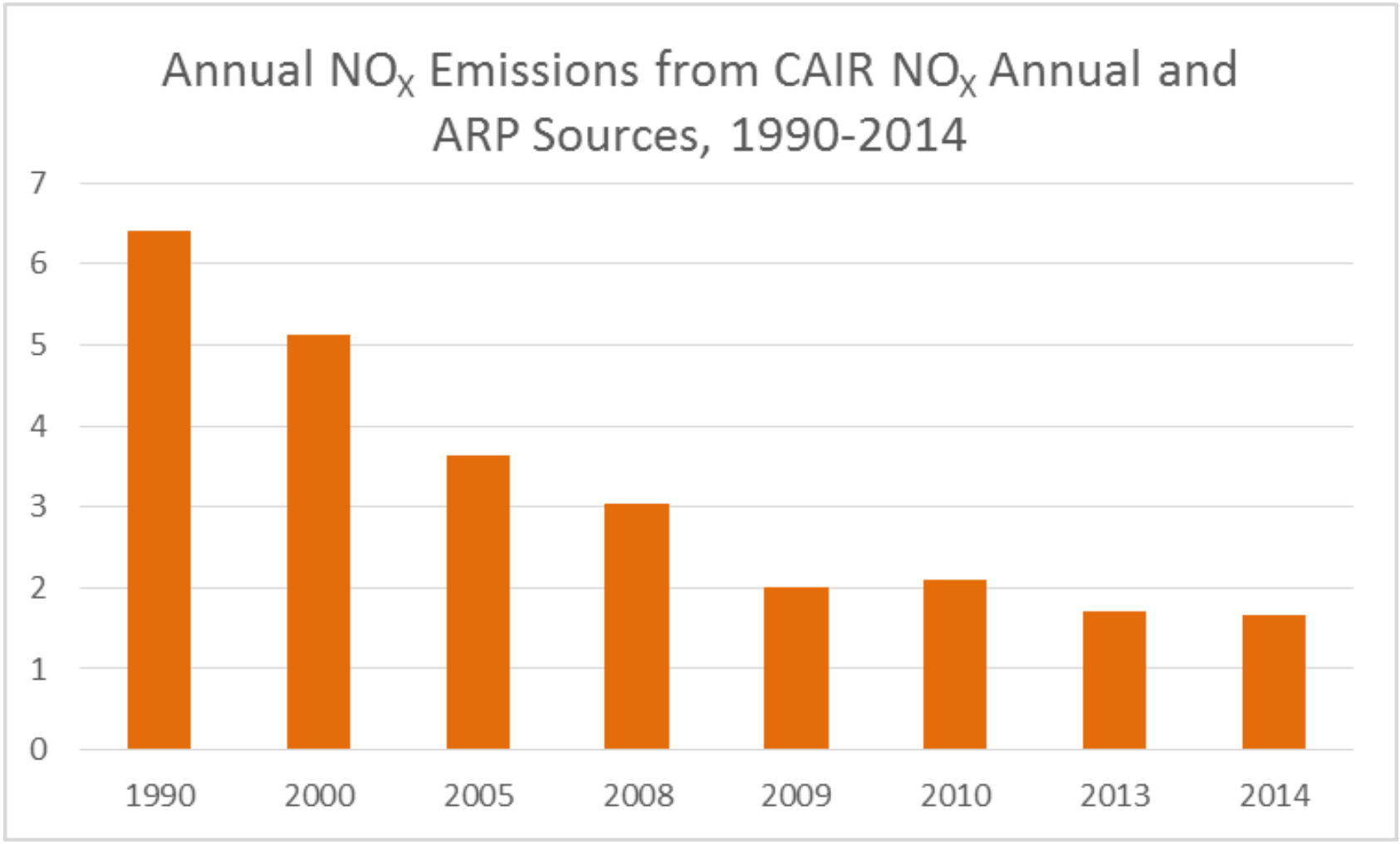
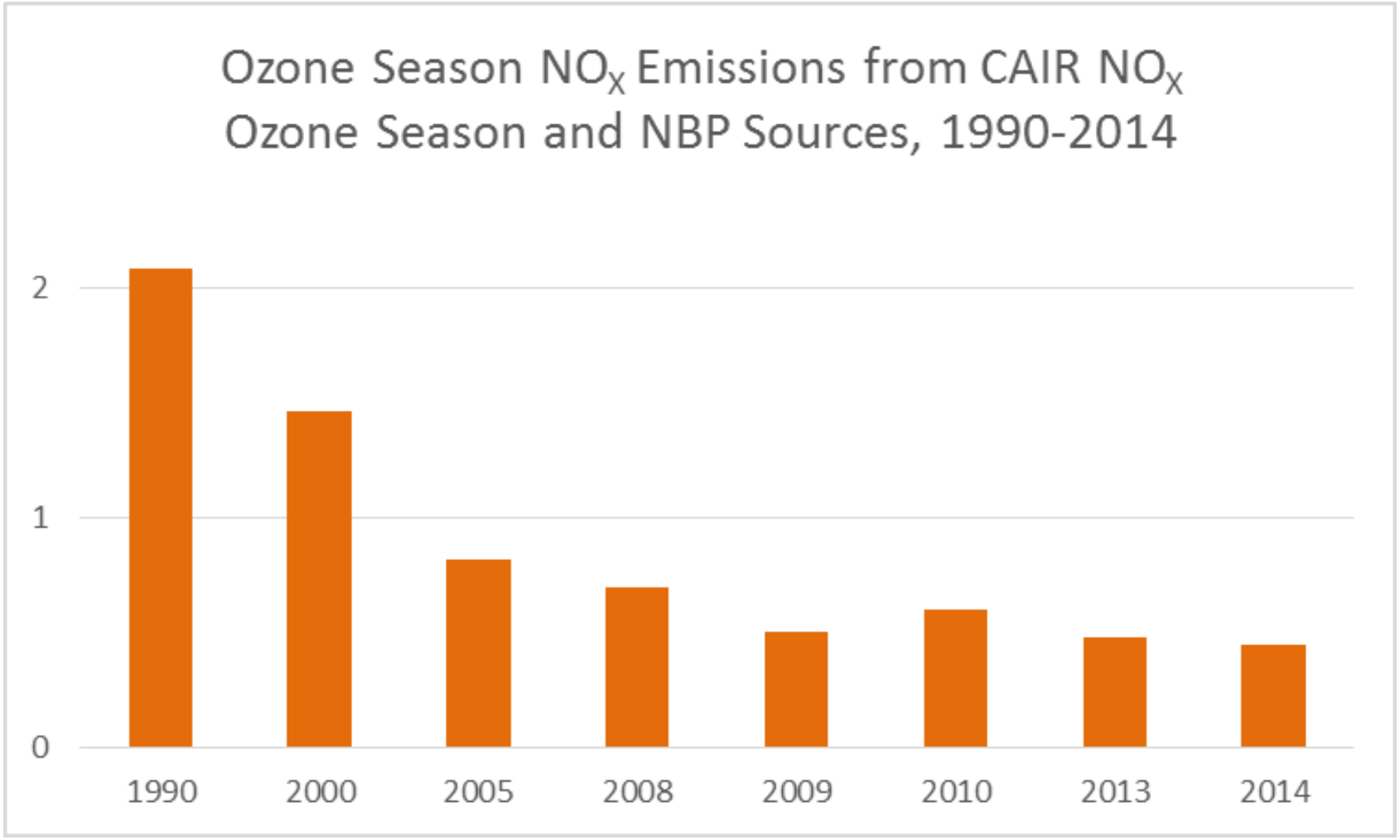
National Annual SO_2 Emissions from Regulated Power Sector Sources



National Annual NO_X Emissions from Regulated Power Sector Sources



National Ozone Season NO_X Emissions from Regulated Power Sector Sources



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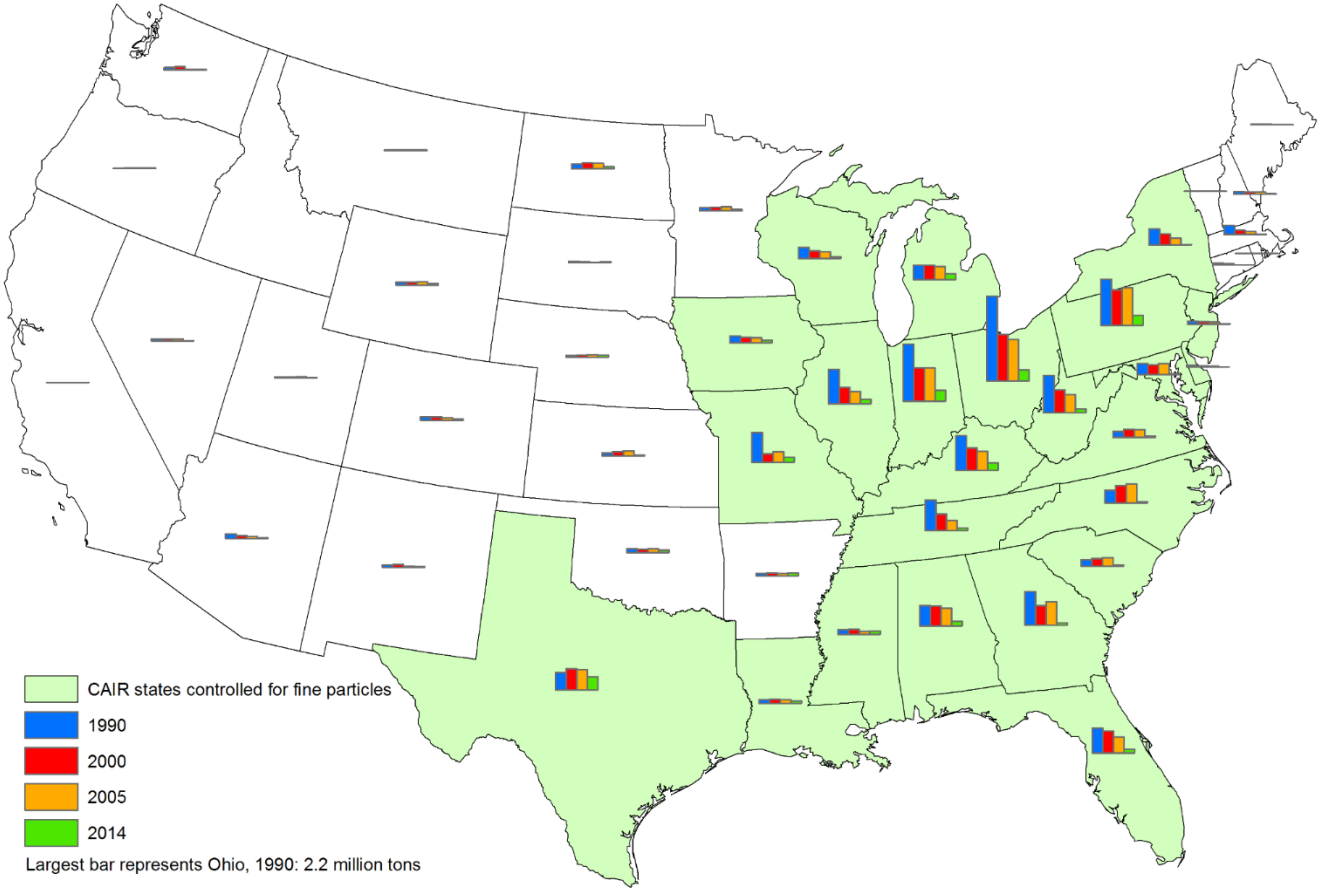
Annual SO_2 Power Plant Emissions 1990-2014



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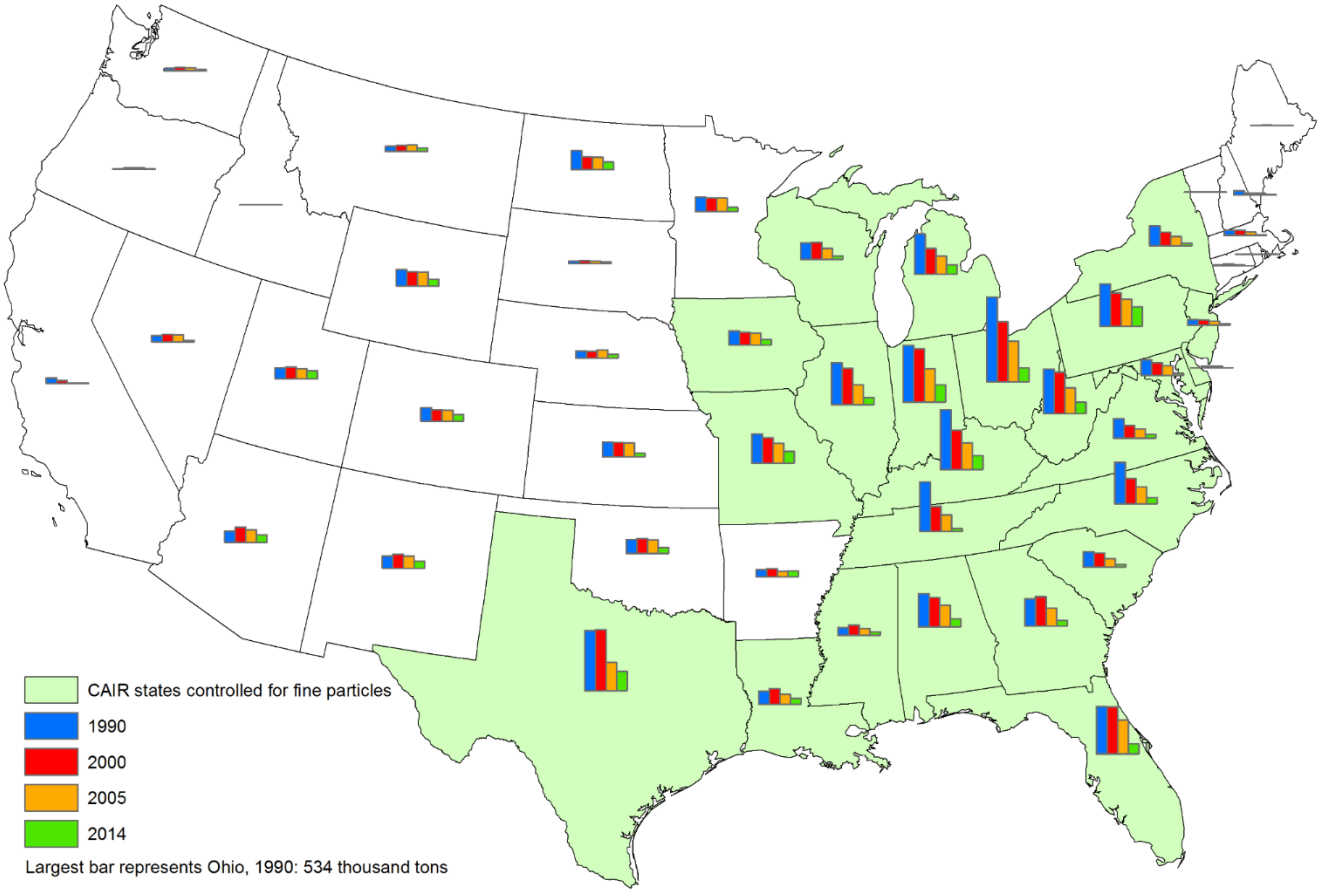
Annual NO_X Power Plant Emissions 1990-2014



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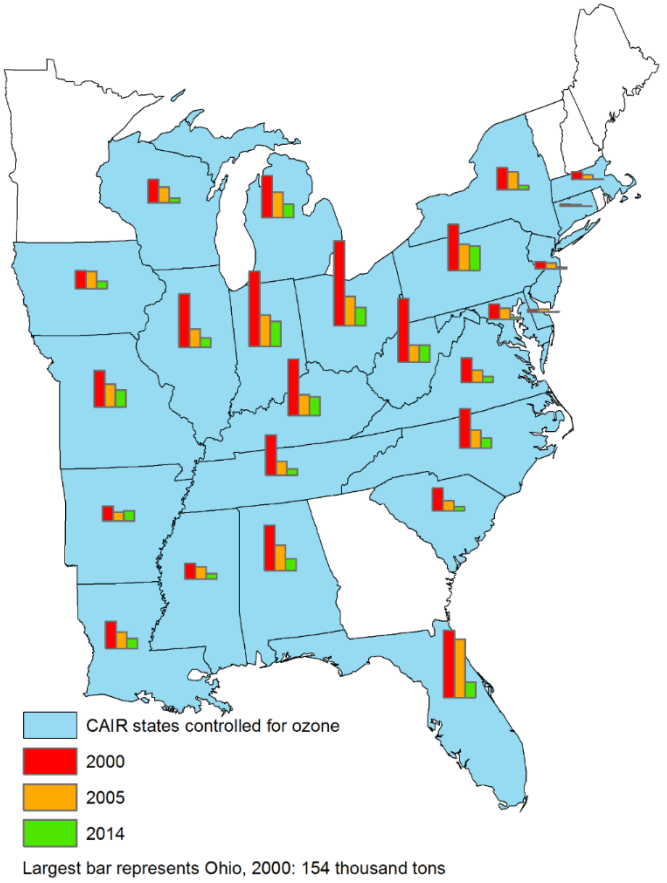
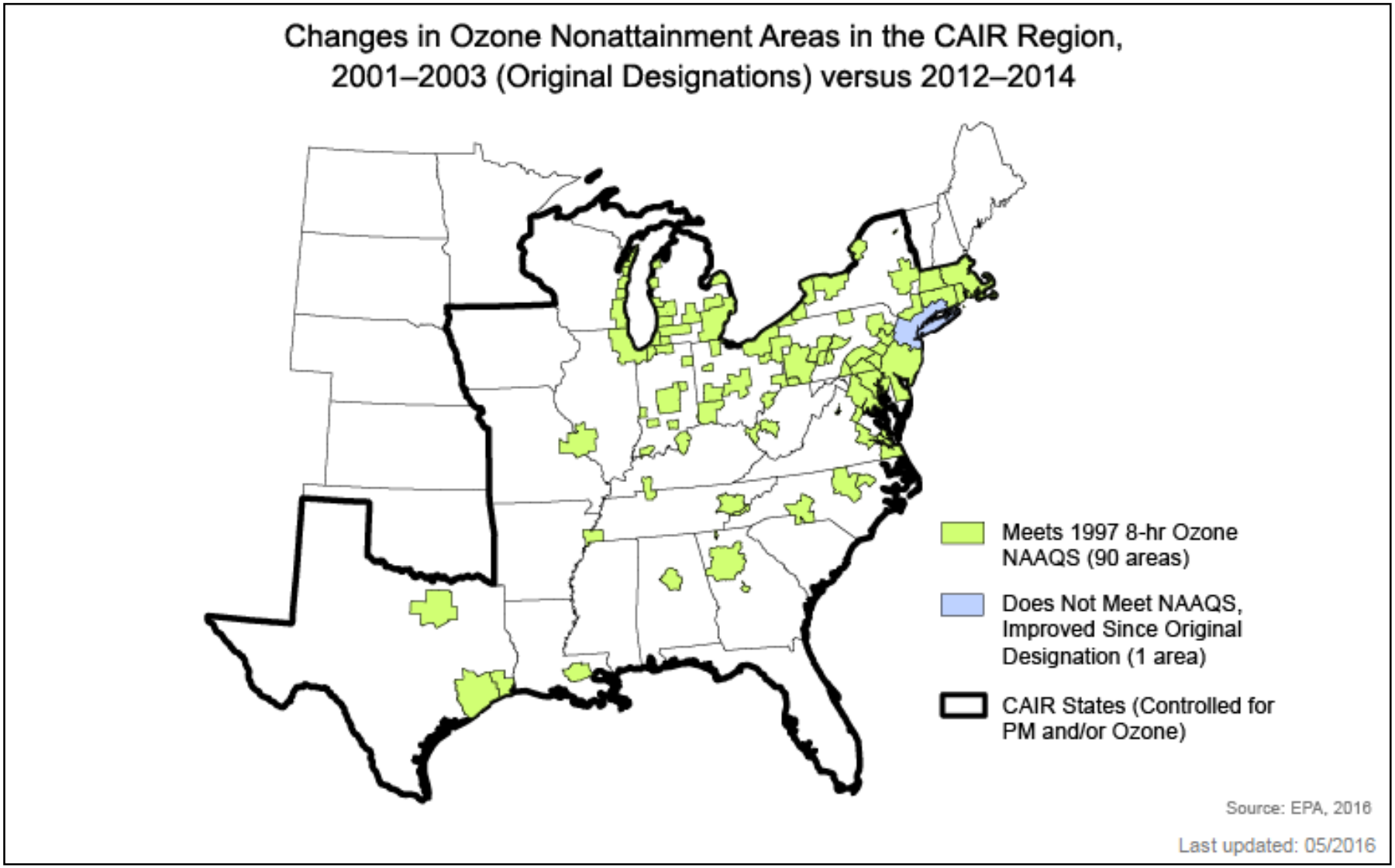
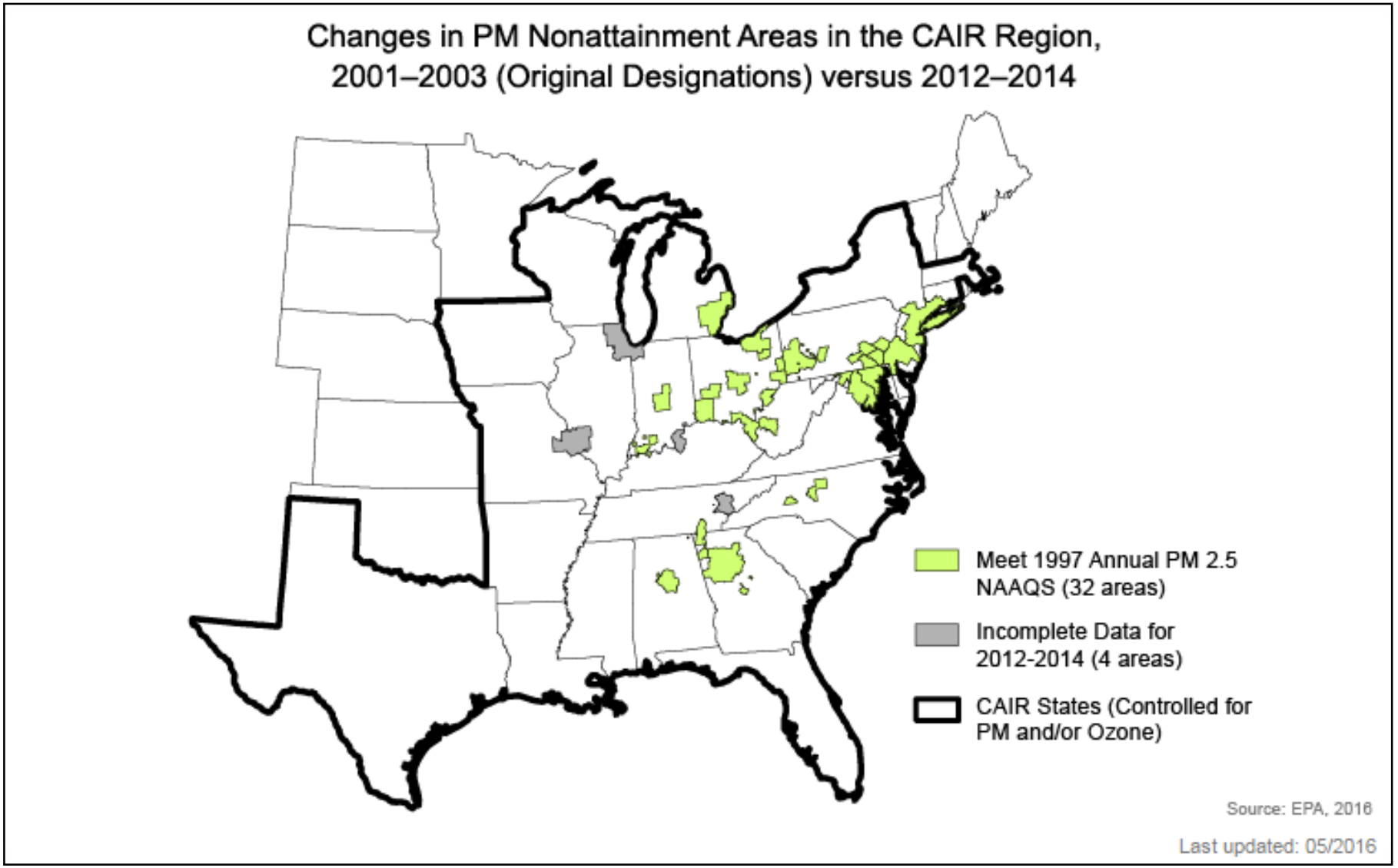
Ozone Season NO_X Power Plant Emissions 2000-2014



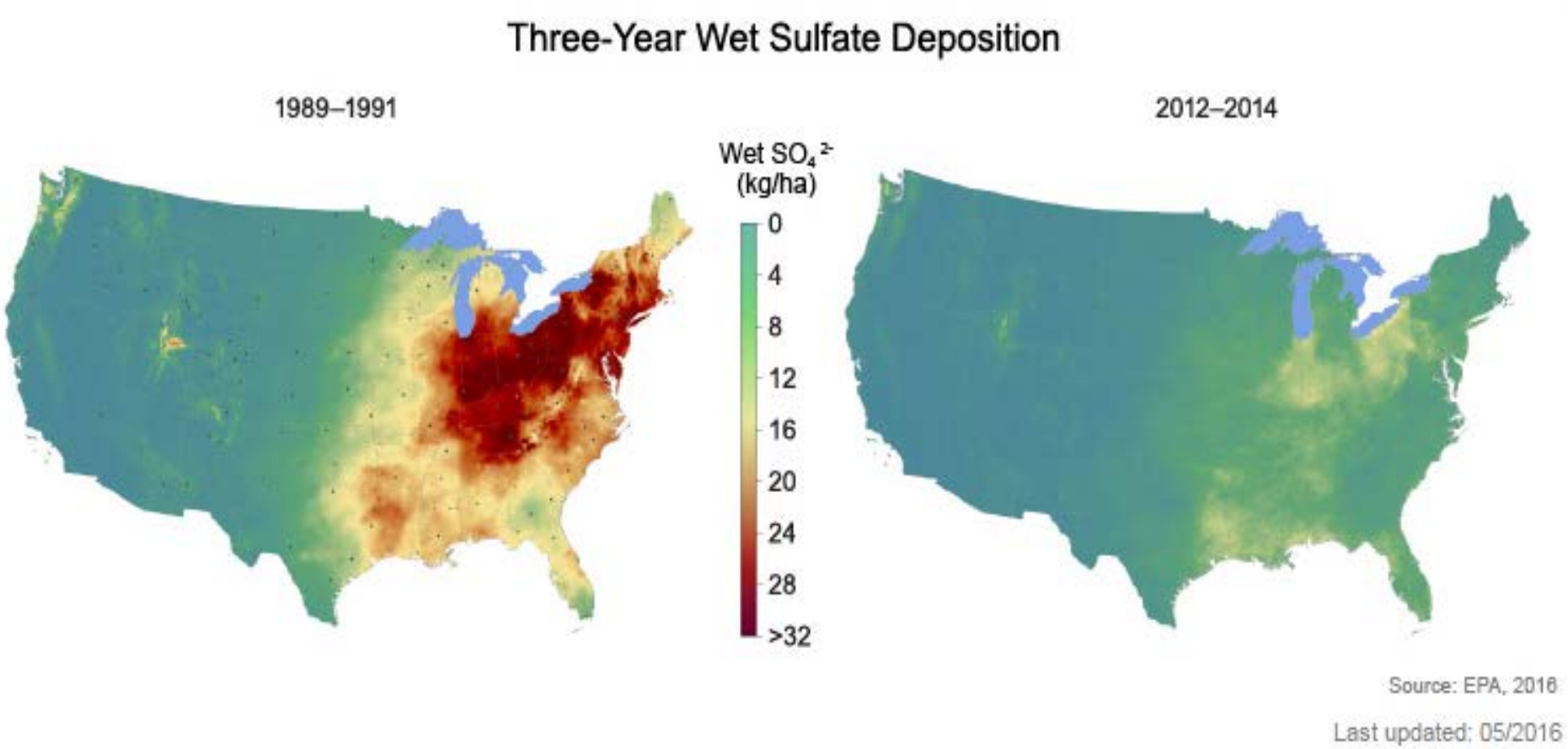
Air Quality – Ozone NAAQS Attainment



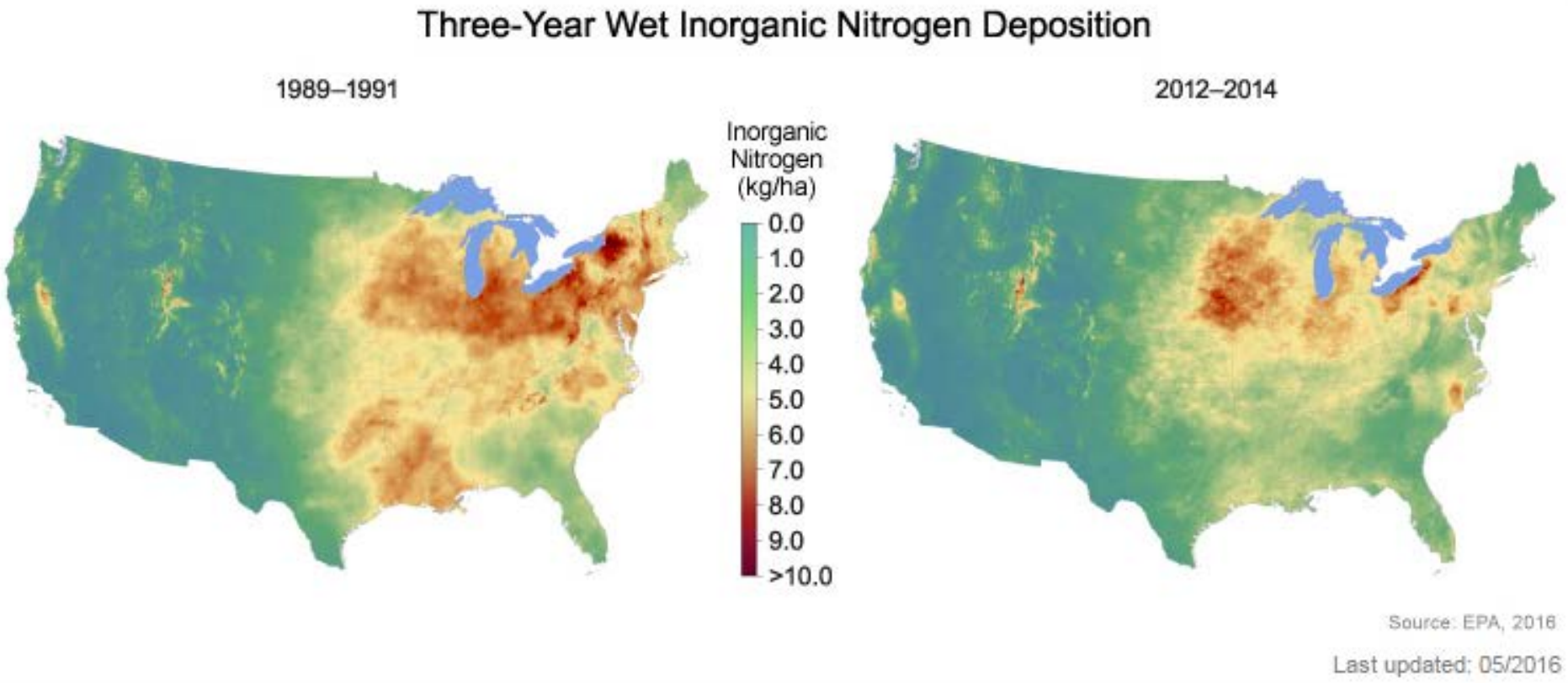
Air Quality – PM2.5 NAAQS Attainment



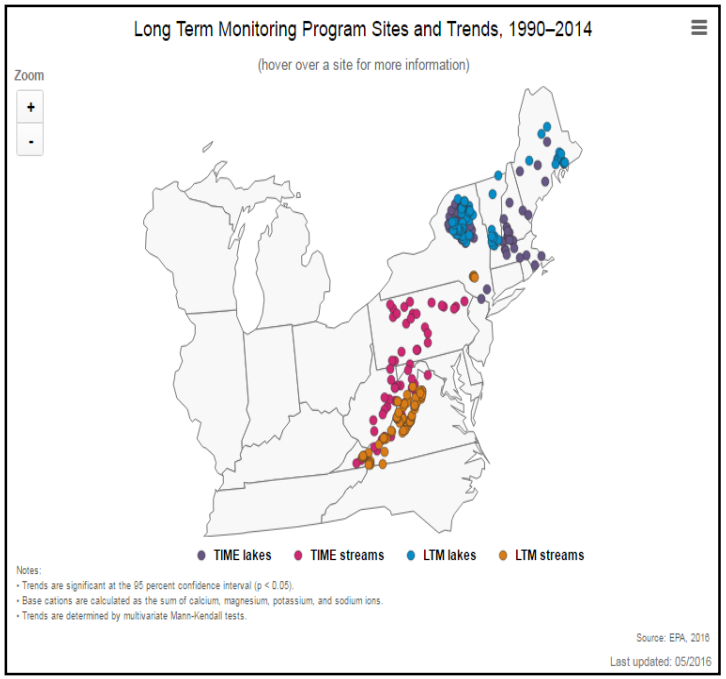
Acid Deposition Trends – Wet Sulfate



Acid Deposition Trends – Nitrogen



Environmental Response – Surface Water Chemistry in Sensitive Lakes & Streams



Regional Trends in Sulfate, Nitrate, ANC, and Base Cations at Long-term Monitoring Sites, 1990–2014

Region	Water Bodies Covered	% of Sites with Improving Sulfate Trend	% of Sites with Improving Nitrate Trend	% of Sites with Improving ANC Trend	% of Sites with Improving Base Cations Trend
Adirondack Mountains	38 lakes in NY*	100%	42%	87%	92%
New England	26 lakes in ME and VT	100%	21%	58%	76%
Catskills	4 streams in NY	100%	0%	50%	100%
Central Appalachians	66 streams in VA	100%	52%	14%	23%

Notes:
- Trends are statistically significant at the 95 percent confidence interval ($p < 0.05$).
- Base cations are calculated as the sum of calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na) ions.
- Trends are determined by multivariate Mann-Kendall tests.
- *Trends are based on a new subset of 38 lakes in New York.

Source EPA, 2016
Last updated: 05/2016

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Mercury and Air Toxics Standards

Mercury and Air Toxics Standards: Overview of Action

- On December 16, 2011 EPA finalized the Mercury and Air Toxics Standards, *the first national standards* to reduce emissions of mercury and other toxic air pollutants from new and existing coal- and oil-fired power plants
  - Published in the Federal Register on Thursday, February 16, 2012
- Standards were intended to reduce emissions of:
  - Metals, including mercury (Hg), arsenic, chromium, and nickel
  - Acid gases, including hydrogen chloride (HCl) and hydrogen fluoride (HF)
  - Particulate matter
- Air toxic pollutants are linked to cancer, IQ loss, neurological damage, heart disease, lung disease, and premature death
- Standards create uniform emissions-control requirements based on proven, currently in-use technologies and processes
- For more information on these Mercury and Air Toxics Standards: http://www.epa.gov/mats

MATS Timing

- EPA expected most facilities would comply with this rule through a range of strategies, including the use of existing emission controls, upgrades to existing emission controls, installation of new pollution controls, and fuel switching.
- Existing sources generally had up to 4 years, if needed, to comply with MATS.
  - This included the 3 years provided to all sources by the Clean Air Act.
  - Under the Clean Air Act, state permitting authorities could also grant an additional year as needed for technology installation. EPA expected this option to be broadly available.
- EPA also provided a clear pathway for reliability critical units to obtain a schedule with up to an additional year to achieve compliance.
- April 16, 2016 was the final compliance date and all power plants are now expected to be in full compliance with the MATS requirements.
  - A very small number of reliability-critical sources have received extensions via Administrative Orders.

Lessons From Existing Programs

- *The Clean Air Act Works.*
  - Power plants have cut emissions that cause acid rain and harm public health.
  - The Act has prompted deployment of clean technologies, and has helped provide impetus for technology innovations that reduce emissions and control costs.
- Emissions trading *complements other approaches*.
  - Acid Rain Program and interstate air pollution transport programs were intended to achieve broad regional reductions.
  - CAA Title I provisions address local concerns.
- Well-crafted *legislation* makes program implementation and compliance more straightforward and timely.
  - CAA's 1990 Title IV Acid Rain Program vs. litigation experience with NO_X SIP Call, CAIR & CSAPR.
- *Simplify* rules and obligations as much as possible.
  - Complexity increases administrative and compliance burdens for both regulators and the regulated community.
- *Accountability and* information *transparency* are keys to program success.
  - Emissions monitoring, environmental assessment, and accessible data are essential for implementation.

Visit the Clean Air Markets web site to view emissions data, allowance transfers, program rules and guidelines, and program progress reports

Clean Air Markets: www.epa.gov/airmarkets

Cross-State Air Pollution Rule: www.epa.gov/crossstaterule

Mercury & Air Toxics Rule: www.epa.gov/mats

Carbon Pollution Standard for New Power Plants: www.epa.gov/carbonpollutionstandard

Climate Change: www.epa.gov/climatechange

Energy Efficiency: www.epa.gov/cleanenergy/index.html