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Research Report 195

Impacts of Regulations on Air Quality and Emergency Department Visits in the Atlanta Metropolitan Area, 1999–2013

Russell et al.

Additional Materials 1. White Paper: Attributing 20 Years of Electricity Generating Unit Emissions Reductions in Atlanta, GA to Specific Policy Actions

Note: Additional Materials may appear in a different order than in the original Investigators' Report, and some remnants of their original names may be apparent. HEI has not changed the content of these documents, only their numeric identifiers.
Additional Materials 1 was originally submitted as Appendix 2.

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APPENDIX 2. WHITE PAPER: ATTRIBUTING 20 YEARS OF ELECTRICITY GENERATING UNIT EMISSIONS REDUCTIONS IN ATLANTA, GA TO SPECIFIC POLICY ACTIONS

2.1 Abstract

Electric utilities and automobiles emit vast amounts of air pollutants. These sources, however, are heavily regulated, and their emissions have been curbed, particularly since the 1970 Clean Air Act Amendments in the United States. Previous studies have linked air pollution regulations to large changes over time; however, if the goal is to dissect emission changes and attribute reductions to *specific* regulatory actions to assess which previous regulations have been more effective than others and thus plan future regulations, a broad-brushed before-after comparison will not suffice. Other factors, such as fuel price, population shifts, are all linked, and should be considered in this type of assessment. This work inspects electricity generating unit emissions from the Environmental Protection Agency's (EPA) Air Markets Program Database and mobile source emissions modelled using EPA's Motor vehicle emissions simulator (MOVES) model in Atlanta, GA and the broader Southeast. The approach assesses emissions and demand changes, and links emissions changes to multiple regulations from each source type after 1990. The output is daily counterfactual (i.e., hypothetical scenarios assuming various regulatory programs were not implemented) time series for multiple regulatory programs. Counterfactuals show increasing effectiveness across years as programs are incrementally implemented, and varying impacts of different programs on various pollutants.

2.2 Introduction

The 1990 Clean Air Act Amendments (CAAA) marked a turning point in regulating air quality across the United States. The 1970 CAAA (which amended the original 1963 Act) gave the United States Environmental Protection Agency (EPA) the authority to regulate air pollutants using two specific tools: air quality standards and emissions limits (National Research Council, 2004). EPA sets National Ambient Air Quality Standards (NAAQS) for six "criteria" pollutants—ozone (O_3), particulate matter (PM), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and lead—at levels designed to protect public human health and public welfare. Each pollutant has both primary (health) and secondary (welfare) standards (the same for many species), and PM is regulated both as $PM_{2.5}$ (particle diameters less than 2.5 μm) and as PM_{10} (diameters less than 10 μm). NAAQS are written as concentrations averaged over a specific period and follow specific statistical forms unique to each pollutant. EPA designates areas in exceedance of the NAAQS as non-attainment areas (NAAs), and requires the encompassing state to develop a State Implementation Plan (SIP) for reducing ambient air quality concentrations below the standards. The 1990 CAAA clarified and expanded the EPA's previous authority related to NAAQS-setting and enforcement, mobile and stationary source emissions standards, emissions cap-and-trade programs, and permit requirements. The Amendments also established the EPA's jurisdiction to regulate air toxics (hazardous air pollutants) and chemicals related to the stratospheric O_3 depletion.

Emission standards aim to reduce the release of air pollutants from specific industries and source types, and are written either as emission rates (emission per activity, e.g., grams NO_X mi^{-1}) or as total allowable emissions over a specified amount of time. Some standards are applied to specific plants, while others are applied to a fleet, and some regulatory programs—e.g., the Acid Rain Program defined in the 1990 CAAA—set up trading markets that permit plant owners to buy and sell emission allowances (National Research Council, 2004). For mobile sources, recent regulatory programs—e.g., the Tier 2 Gasoline Vehicle Standards and the 2007 Heavy Duty Diesel Rule—set standards for both engines and fuel composition. Mobile-source emissions limits are set at a federal level; however, EPA allows one state—California—to set mobile emissions standards independent of the national levels (though they must be at least as stringent), and other states can adopt either the federal or California standards. States use other tools, such as limits on Reid Vapor Pressure in gasoline below federal limits and Inspection and Maintenance (IM) programs, to reduce emissions in NAAs.

In response to regulations contained in the 1990 CAAA, the EPA and the Georgia Department of Natural Resources' Environmental Protection Division (EPD) have applied various regulatory tools to improve air quality, with a focus on Atlanta, which frequently exceeds the NAAQS for O_3 and $PM_{2.5}$. Assessments of the effectiveness of specific regulations, however, are made difficult by the complex interplay between national regulations and their implementation at the state and local levels. For example, the EPD has implemented several emissions standards on stationary sources separate from national programs. Often, the state programs—codified in SIPs—are similar in approach and timing to national programs, and may be developed in negotiations between regulators, utilities, and public service commissions (PSC) that govern utilities. A state may promulgate a rule to achieve multiple objectives or meet multiple national standards (e.g., O_3 and $PM_{2.5}$ share precursors). Further, a utility, whose actions are subject to PSC rulings, may seek to identify the most cost effective measures to address multiple regulations. Such interconnected emissions policies affect air quality in varying ways depending on multiple factors such as source industry, location, and stack height, economic activity, and climate. Any assessment of the effectiveness of specific regulations implemented under the CAAA, therefore, must begin by acknowledging the intermeshed nature of air pollution regulations.

2.3 Power plant emissions

This section describes the emissions reductions of electricity generating unit (EGU) nitrogen oxides (NO_X = NO +NO_2) and sulphur dioxide (SO_2) over the 20-year period from 1995-2014 in Atlanta. EGU emissions are regulated under several policies, both national and state. It is of interest to regulators and stakeholders to assess the response of emissions to specific regulatory actions. This information can be used to link air quality and health improvements to regulations in and accountability framework (Health Effects Institute, 2003). This report investigates 20 years of emissions data and regulatory actions, and seeks to attribute emissions reductions to specific policies enacted over this period.

2.3.1 Decision-making by electric utilities under the current regulatory framework

Electric utilities are in a unique position. Many are public companies, meaning they are obligated to maximize shareholder value. However, their profit is limited by the amount that they can charge for electricity, which is regulated by the local Public Services Commission (PSC). Each investor-owned utility (Georgia Power is the only such utility in Georgia) submits an integrated resource plan (IRP) every three years to the PSC for approval. The IRP is the company's 20-year outlook, and includes information on electricity supply/demand projections, the regulatory outlook, control options, and options for commissioning/shuttering new/old plants.

There are four major drivers of these actions by major electric (Ewald, 2015):

Compliance. Units must comply with existing regulations to operate. However, utilities will work to ensure new regulatory actions are achievable.

Cost to the consumer. Utilities work with the PSC to create a pricing structure that is in the consumer's best interest.

Avoid new source review. The national new source review (NSR) program is a process that assesses the emissions from new sources. Repermitting occurs every 5-8 years, and can cover existing plants that show a 'significant modification,' which can include running the plant more. One way to avoid NSR is to show that a modification to a plant will result in reduced emissions.

Co-owners. Many plants are owned by multiple utilities (this is the case of multiple plants in Georgia). The other utilities are either electric membership corporations (EMCs) or municipalities, neither of which have their prices set by the PSC. The differences between the business models of the three types of electricity-producers creates difficulties in negotiating who will pay for controls, plant lifetimes, etc.

Profit. Utilities must make a profit to stay solvent. The PSC considers necessary controls (both the installation and the cost of running the control once it is installed), new plants, maintenance, etc. when setting the price.

Cost recovery is not an option when controls are not required under existing or anticipated legislation (Ewald, 2015; Huling, 2014). For this research, this means that controls on plants should all be able to be linked to individual actions by the state or federal governments. This is a key assumption in the following assessment.

Utilities face multiple time-scales of decisions making in terms of how to provide electricity to their clients. On the shortest scale, the grid needs to stay balanced (supply must equal demand). At this scale, decisions include when scale up/down certain plants to keep the energy supply consistent with the demand. At longer time scales, decisions are made regarding fuel switching, building new capacity, retiring existing plants, and adding controls.

Because of this, it is difficult to bound a group of plants into divisions based on the demand they serve. Utilities will produce, buy, and export power based on the total demand of the locations they serve, the cost of producing power in their own plants, and the cost of purchasing power from other utilities. Units across the fleet are `stacked'—in terms of their status as base, mid, or peaking load—in a way that minimizes the cost per kW-hr produced. With these in mind, utilities assign load across their fleet of plants. Depending on the price of different fuels and the availability of plants, load may be covered by plants that are nearby, in a different part of the state, or in a nearby state. In general, plants that are heavily controlled tend to run more.

As emission regulations have been put into place, the flexibility of being able to switch between plants has decreased (Ewald, 2015; Huling, 2014). Utilities create averaging plans that set a maximum emissions factor for a fleet of plans, allows for some flexibility for plant management. In non-attainment areas (NAAs), states designate specific plants for emissions reductions to meet NAAQS standards. Utilities may be forced to rely more or less heavily on these plants in order to satisfy fleet averaging plans or reduce emissions to standards set in the State Implementation Plan.

2.3.2 Power plants included in the study

To study the effects of regulatory actions that effect emissions from EGUs on in the Atlanta, GA region, we selected only the major (greater than 25 mega-watt equivalents (MWe)) plants within the 20-county Atlanta $PM_{2.5}$ non-attainment are (ANAA) that were in operation for all or part of the time span from 1995 - 2013. Reasons for selecting these plants (Atkinson, Bowen, Chattahoochee, Doyle, Harlley Branch, Hawk Road, McDonough, MPC, Tenaska, Walton, Wansley & Yates) are:

- Daily plant-level emissions are publically available in CEM data from the EPA
- Plants within the ANAA have been regulated most strictly over the study period compared with others in Georgia
- Emissions from these plants assumed to have a relatively larger impact on air quality on the central monitor in Atlanta (used for health analyses) than other facilities in the region (Muller, Tong, & Mendelsohn, 2009)
- Long-term emissions reductions reflect similar changes observed across the southeastern US (U.S. EPA, 2016)

CEM data, downloaded from the EPA Air Markets Database, includes notations on when certain controls went into operation on different plants. This information is synthesized for each of the plants that operated over the study period in the NAA (Table A2-1). Some of the plants were not online for the entirety of the study period, and some information in this section (including each plant's status as a base load or a peaking plant) is inferred from the record of load in the CEM data.

Table A2-1. Controls on plants used in the analysis.

Plant	Year Built	Primary Fuel	NO_x				SO_2		$PM_{2.5}$		Fuel Retrofit	Retrofit Date	Notes
			Control 1	Install Date	Control 2	Install Date	Control 1	Install Date	Control 1	Install Date			
Atkinson	1930	Coal											
Bowen	1975	Coal	Low NO_x burners	1995	SCR[1]	2001 (2 units) 2003 (2 units)	FGD[2]	2008-2010	Electrostatic precipitator	pre-1990			
Chattahoochee	2003	Natural Gas	SCR[1]	2003									
Doyle	2000	Natural Gas	Dry Low NO_x burners	2000									
Harllee Branch	1965	Coal	Low NO_x burners	2002 (2 units) 2003 (2 units)					Electrostatic precipitator	pre-1990			
Hawk Road	2001	Natural Gas	Dry Low NO_x burners	2001									
Jack McDonough	1963	Coal	Low NO_x burners w/ separated OFA	1995	Natural Gas Co-firing	1999			Electrostatic precipitator	pre-1990	Natural Gas	2011 (2 units) 2012 (4 units)	Retrofit included Dry Low NO_x burners and SCRs[1]
MPC	1999	Natural Gas	Water Injection	1999									
Tenaska	2001	Natural Gas	Dry Low NO_x burners	2001	Water Injection	2001							
Walton	2001	Natural Gas	Dry Low NO_x burners	2001									
Wansley (6052)	1976	Coal	Low NO_x burners w/ Closed-coupled/ separated OFA	1995	SCR[1]	2003	FGD[2]	2008-2010	Electrostatic precipitator	pre-1990			
Wansley (7946)	2004	Natural Gas	Dry Low NO_x burners	2004	SCR[1]	2004							
Wansley CC (55965)	2012	Natural Gas	Dry Low NO_x burners	2012	SCR[1]	2012							
Yates	1950	Coal	Low NO_x burners (4/7 units)	1994 (2 units) 1995 (2 units)	Natural Gas Co-firing	1999	FGD[2] (1/7 units)	pre-1990	Electrostatic precipitator	pre-1990			

[1] Selective Catalytic Reduction
[2] Flue Gas Desulphurization

2.3.3 EGU policies enacted, 1990-2015

The EGUs included in this study are governed under both national and state rules. Major national rules implemented under the 1990 Clean Air Act (CAA) Amendments since 1990 include the 1990 Acid Rain Program (ARP), the 1998 NO_X SIP Call and associated Budget Trading Program (NBTP) and associated SIP Call (U.S. EPA, 2009), the 2008 Clean Air Interstate Rule (CAIR) (U.S. EPA, 2005), and the 2011 Cross-State Air Pollution Rule (CSAPR) (U.S. EPA, 2015). State rules are established through State Implementation Plans (SIPs), which are required by the EPA for all areas that are in non-attainment under the National Ambient Air Quality Standards, which are established under the CAA.

Many of the state rules align with and are driven by the national rules, but can be more specific, e.g., specifying certain emission levels or controls on specific plants. For instance, when many plants were required to implement seasonal controls under Georgia rules, many other eastern states were required to implement similar seasonal controls under the NBTP. Similarly, when the Georgia Multipollutant Rule was implemented beginning in 2009 that required stricter, year-round controls on NO_X and SO_2, the first phase of CAIR, which also required year-round controls was implemented on a national level. In general, the Georgia state rules reduce utilities' flexibility---both in timing and by dictating the specific plants that require controls---in that they require specific controls on specific plants that contribute to elevated air pollution concentrations in NAA's.

This interplay between national and state rules contributes to a blurring of lines between emissions reductions attributable to specific actions. On one hand, the utilities must keep their emissions across their fleet below the national standards. On the other, the state may require multiple plants that impact air quality in its NAAs to install specific controls by certain dates. By installing the required controls, the utility can claim emissions reductions under the national program while simultaneously adhering to the rules in the SIP.

The following details major programs of interest to the current thesis. The list is not exhaustive of all programs impacting EGU sources in the Southeast, but covers major regulations.

2.3.3.1 National rules

National Ambient Air Quality Standards (NAAQS). The EPA is required to set NAAQS in the United States under the CAA. These are revisited and revised periodically by the EPA. Attainment of these standards in certain areas is based on observations, and the EPA designates certain places non-attainment status. Each state that includes a NAA much submit a State Implementation Plan (SIP) to the EPA that details the state's plan to reduce ambient pollution levels to concentrations below the NAAQS. The EPA sets NAAQS for ozone, particulate matter (both $PM_{2.5}$ and PM_{10}), lead, SO_2, nitrogen dioxide (NO_2), and carbon monoxide (CO) (National Research Council, 2004).

The Acid Rain Program (ARP). The Acid Rain Program was enacted in 1993 to combat increasing SO_2 and NO_X concentrations throughout the United States, and especially in the Eastern states. With the Clean Air Act Amendments on 1990, the EPA set out to reduce annual SO_2 emissions in the United States to 10 million tons less than they were in 1980 (U.S. EPA, 2002). To achieve these reductions, the EPA designed an approach that included two phases. Phase I, which began in 1995, targeted the largest existing power plants. Between 1990 and 1995, Georgia Power saw a dramatic decrease in SO_2 emissions (Ewald, 2015). Starting in 2000, Phase 2 required all other plants regulated under title IV of the CAA to achieve emissions reductions. To ensure reductions were being made, continuous emissions monitors were required for both SO_2 and NO_X on all regulated stacks (Harrington, et al., 2012).

The NO_X Budget Trading Program (NPB) and SIP Call. To address the problem of ozone precursors being transported across state lines in the East, the EPA issued the NO_X State Implementation Plan (SIP) Call in 1998. This Call was meant to improve the implementation of the controls established under the Acid Rain Program. The SIP Call did not place a limit on individual sources; instead, each state is required to reduce NO_X emissions during the ozone season to avoid non-attainment (U.S. EPA, 2009). The NO_X SIP Call only targeted coal plants during ozone season (5 months of the year) (Lloyd, 2014).

The EPA began the NBTP under the 1998 SIP Call to aid states in their effort to meet their emissions budgets. The NBTP was a cap-and-trade strategy that was optional; however, all 20 states and the District of Columbia used the program to help meet their NO_X SIPs by 2007. Georgia, which required seasonal NO_X controls on EGU sources in the NAA beginning in 2000, was not included under the NO_X SIP call or NBTP.

The Clean Air Interstate Rule (CAIR). CAIR, promulgated in 2005, was the regulatory approach to further reducing NO_X and SO_2 emissions adopted by the EPA after the Clean Skies Act did not pass Congress. The focus of CAIR is $PM_{2.5}$ transport across state borders. The regulation affected 28 eastern states, and set up three interstate emissions trading programs: the CAIR SO_2 annual trading program, the CAIR NO_X annual trading program, and the CAIR NO_X ozone season trading program. In effect, CAIR extended the ozone-season NO_X controls under the NPB to the entire year, and required large coal plants to install SO_2 controls or shut down. At http://www.epa.gov/airmarkets/programs/cair/ga.html (visited 3 September, 2015), the EPA reports that CAIR will lead to reductions of NO_X and SO_2 emissions of 37% and 54%, respectively, in 2015.

A 2008 court decisions kept CAIR in place, but instructed the EPA to develop an alternative rule that satisfies CAA requirements related to cross-state transfer of air pollutants.

The Cross-State Air Pollution Rule (CSAPR). This rule was released by the EPA in July 2011 as the answer to the court ruling that reinstated CAIR. However, this rule was overturned by the courts before any parts of it were implemented, and CAIR remained in place. In October 2014, the D.C. Circuit issued a ruling that implementation of CSAPR would be delayed by three years, and the first phase replaced CAIR on 1 January, 2015.

2.3.3.2 State rules

The EPA requires states that contain NAAs to submit SIPs. These detail the state's plans for meeting NAAQS in the affected areas. In general, rules regarding EGUs in Georgia target only sources within or near NAAs, the largest of which is the Atlanta 20-County ozone and $PM_{2.5}$ NAA. The rules are documented in the Georgia Rules for Air Quality Control (GRAQC) and the SIPs submitted by the EPD to the EPA. In this section, reference will be made to both the GRAQC and the SIPs whenever possible. For rules in the GRAQC, we use the notation $GRAQC_*$ where * represents the rule section.

Emissions of Nitrogen Oxides from Major Sources ($GRAQC_{yy}$). Originally, the 13 counties of the ozone NAA region were included: Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinnett, Henry, Paulding, and Rockdale. Major plants in these counties were McDonough and Yates. The rule requires that plants in these counties install 'reasonally available control technology' (RACT), as approved by the Director (of the EPD). The date of compliance was 31 July, 1995. In 1999, the RACT requirement was expanded to 32 more counties. Newly covered facilities were required to be in compliance.

In 2000, all facilities that fell under rules $GRAQC_{jjj}$, $GRAQC_{lll}$, $GRAQC_{mmm}$, $GRAQC_{nnn}$ (which included most major NOX sources within the NAA, and some outside of it) were exempt from rule $GRAQC_{yy}$, since the new rules were more stringent. In 2005, the rule was further amended to include smaller plants (with a compliance date of 1 May, 2007). The EPD added a public comment opportunity after each RACT approval.

NO_X Emissions from Electric Utility Steam Generating Units ($GRAQC_{jjj}$). This rule was adopted in 1998, and applied to EGUs within the 13-county NAA. The rule established summertime (1 May - 30 September) emissions limits on a lb $mmbtu^{-1}$ heat input basis. Compliance was required by some units as early as summer 1999. More plants were added each summer between 2000 and 2002. In 2000, the rule was amended to include Putnam County, home of Plant Branch.

This rule aligns with EPA's NBTP and SIP Call. Neither program was not implemented in Georgia, partly because this rule accomplished the same goal (U.S. EPA, 2008).

NO_X Emissions from Fuel-Burning Equipment ($GRAQC_{lll}$). This rule, adopted in 1999, sets an emissions limit of 30 ppm NO_X @ 3% O_2, dry basis on medium-sized sources during the summer months in 45 Georgia counties. Compliance was required beginning on 1 May, 2000.

NO_X Emissions from Stationary Gas Turbines and Stationary Engines used to Generate Electricity ($GRAQC_{mmm}$). Promulgated in 1999, this rule sets emissions limits on smaller plants (0.1 MWe to 25 MWe) beginning in May 2003.

NO_X Emissions from Large Stationary Gas Turbines ($GRAQC_{nnn}$). Promulgated in 2001, this rule sets emissions limits on large gas turbines, 45 counties. Old turbines (permitted before April 2000) were required to comply by May 2003.

Multipollutant Control for Electric Utility Steam Generating Units ($GRAQC_{sss}$). This rule was promulgated in 2007, and established dates of compliance that specific plants needed to install selective catalytic reduction (SCR) and flue gas desulfurization (FGD) on specific units. Further, the rule specifies dates of operation of the control systems (e.g. the SCR on Scherer is only required to be run in the summer), however, all plants in the NAA are required to run their controls year-round. The rule specifically mentions NO_X, SO_2, and mercury as the target pollutants of the rule.

This rule overlaps both in date and purpose with CAIR, in that it required year-round controls on NO_X, and strict controls on SO_2 on coal-fired power plants. However, the targeted approach on specific EGU units had the effect of reducing the overall flexibility of utilities to meet their limits under the CAIR cap-and-trade programs.

Mercury Emissions from New Electric Generating Units ($GRAQC_{ttt}$). Promulgated in 2007, the rule states that new units (permitted after 1 January, 2007) must install best available control technology (BACT) for mercury, as determined on case-by-case basis by the Director (of the Georgia EPD). The rule was later removed.

SO_2 Emissions from Electric Utility Steam Generating Units ($GRAQC_{uuu}$). This rule establishes SO_2 emissions limits on coal-fired power plants, including all of the plants in the current study plus Plants Hammond and Scherer. The dates of compliance correspond to the dates from the Multipollutant Control Rule ($GRAQC_{sss}$).

2.3.4 Attributing EGU emissions to specific policies

Reductions in NO_X emissions compared to the counterfactual (i.e., hypothetical scenario assuming various regulatory programs were not implemented) show several distinct periods in which daily emissions dropped in Atlanta (black dots in Figure A2-1). A value of zero on the graph represents no change from the counterfactual, and a value of -1.00 represents a 100% reduction compared to the counterfactual.

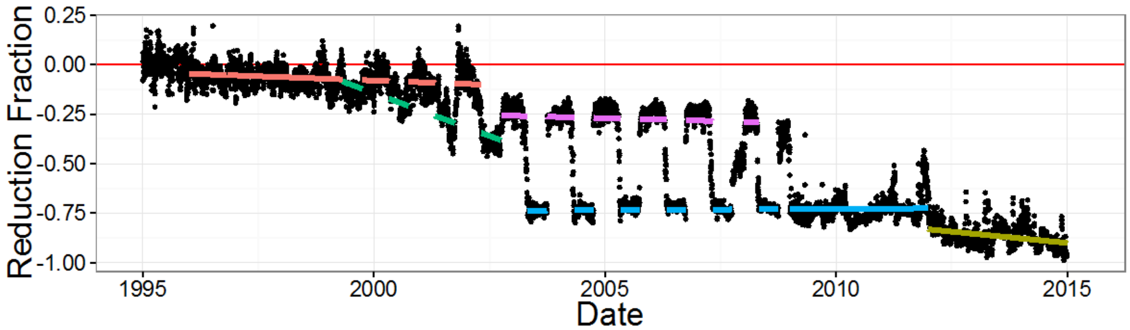


Figure A2-1. Fraction reduction in NO_X emissions normalized to the counterfactual (red line). Thicker lines correspond to time periods used to fit lines for quantifying reductions related to specific regulatory actions.

Five separate lines were fit to the graph in Figure A2-1. Each represents a different period (not always continuous) that is associated with a particular regulation. Lines indicate the time periods used to fit the lines, not the total period that the benefit of each control will be counted in the final analysis (this is discussed below). The lines were formed by fitting a linear regression to specific periods identified as dates of known control actions. Six dominating features of the graph are:

Orange (1996-2015). A 4.7% reduction is observed in the total average emissions factor in Atlanta for all EGUs during 1995. The line was only fit during the winters in the early 2000's because of the start of summertime NO_X controls in 1999.

Green (Summers 1999-2002). This period represents the beginning of the implementation of summer controls under $GRAQC_{jjj}$. The large negative slope of this line is due to the increasing number of units with SCR's at Bowen, Yates, and Wansley.

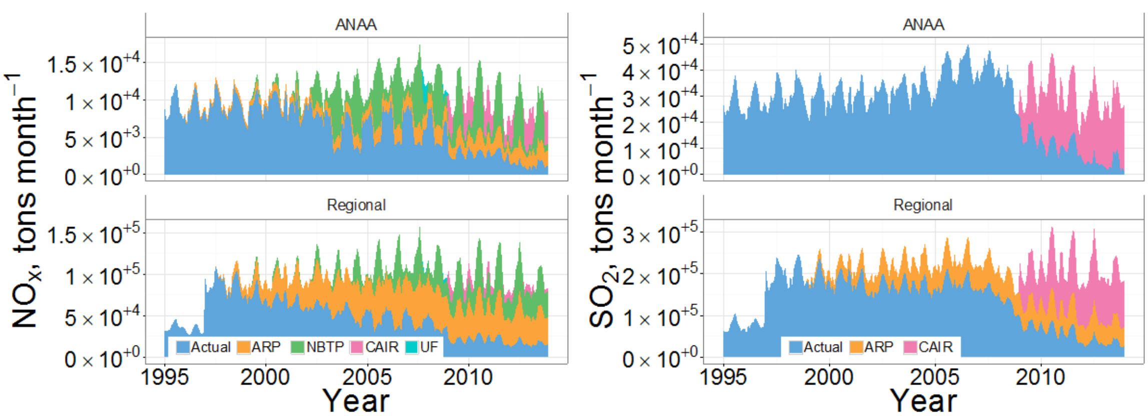
Purple (Winters 2002-2008). Under $GRAQC_{jjj}$, plants were required to control ozone during the ozone season. Since Plant Harllee Branch achieved this by installing low NO_X burners—which cannot be turned off like SCRs can—in 2002, the plant achieved emissions reductions year-round.

Blue (Summers 2003-2009, October 2009-December 2011). $GRAQC_{jjj}$, in full effect by summer 2003, required summertime NO_X controls. After 2008, $GRAQC_{sss}$ and CAIR required year-round NO_X controls, meaning the SCRs at Bowen, Yates, and Wansley were used both in the summer and the winter.

Yellow-green (2012-2014). Beginning in 2012, large portions of the load were generated with natural gas. A large portion of this was from Plant McDonough, although other coal plants were retrofitted during this period (Wansley), and existing smaller natural gas plants ran more as well.

There are a few sections in the graph in Figure A2-1 that do not match up with dates in the GRAQC. In the fall of both 2007 and 2008, it appears that some of the summertime controls remained active. 2008 is described by the EPA as a CAIR 'training year,' so it is possible that there is some connection here. Many of the deviations later in the time series (2010 and later) may be caused by startups and shutdowns and maintenance operations.

The linear approximations of known controls and specific dates from regulatory actions in Figure A2-1 were used to attribute emissions reductions to specific controls in FigureA 2-2. The assumption was made that controls would continue to yield the same reduction in NO_X emissions after new regulations were put into place. This ensures that regulations are only attributed *additional* reductions on top of those realized under previous actions. A similar approach to that described above was applied to assess regional emissions (made of seven states—Alabama, Georgia, Mississippi, North Carolina, South Carolina, and Tennessee) reductions.



FigureA 2-2. Changes in EGU emissions attributable to specific regulatory actions for NO_X (left) and SO_2 (right) in the ANAA (top) and Southeast Region (bottom). Regional CEM data was not completely reported until 1997, so all controls were assessed after this year. Labels: Actual—reported NO_X emissions, ARP—$GRAQC_{yy}$ and the ARP, NBTP–$GRAQC_{sss}$ and NBTP, CAIR—$GRAQC_{jjj}$ and CAIR, and UF—reductions that are not linked with specific controls. UF reductions may be related to test periods for controls that were not required by law. No UF periods were found for SO_2.

Actual NO_X emissions are measured at the source and reported by the EPA (U.S. EPA, 2016). Total NO_X emissions in the Atlanta area in 2014 were 89% less than in 1995 (Table A2-2).

Table A2-2. Emissions changes for various species and sources between reference year (y^*) and 2013.

Source (y^*)	Emissions in y^* (tons)	Emissions in 2013 (tons)	Percent change
EGU (1995)			
NO_X	303	43	86%
SO_2	920	142	85%
REG (1997)			
NO_X	2710	475	82%
SO_2	5604	943	83%
MOB (1993)			
NO_X	567	127	78%
SO_2	15	1	93%
$PM_{2.5}$	30	10	67%
CO	4306	1421	67%
VOC	326	123	62%
EC	12	4	61%
OC	18	7	67%

The first round of changes in Figure A2-1 and 2-2 aligns well with $GRAQC_{yy}$ and the Acid Rain Program. Many plants reduced their emissions slightly over the course of 1995, including Harllee Branch (2.5% reduction in emissions factor) and Wansley1 (2.6% reduction in emissions factor). Other coal plants reduced their emissions factor as well, resulting in a 4.7% reduction in the emissions factor across all plants. The negative slope of the corresponding fitted line in Figure A2-1 yields the increasing benefit of these regulatory programs over time.

The second group of reductions begins in 1999 with the onset of summertime NO_X controls. Beginning in Fall of 2003, the reductions include the year-round controls at Harllee Branch, since these are listed under the same rule ($GRAQC_{jjj}$). As discussed earlier, these reductions are attributed to both $GRAQC_{jjj}$ and the NBTP/SIP Call. Plant Bowen began operation of Selective Catalytic Reduction (SCR) control on 1/4 units in 1999, and completed the installation of SCRs on the three remaining units by 2003. Plant Wansley completed installation of its SCRs by 2003. These controls were only run in the summer months for the years 1999-2008.

The third major set of reductions began at the beginning of 2009 with the year-round controls required under $GRAQC_{sss}$ (The Multipollutant Control Rule) and CAIR. Because ozone-season controls were already in place, the benefits of these rules are restricted to the wintertime. Most the NO_X emissions reduction due to this rule comes from running the SCRs that were already installed at plants around Atlanta.

Around the time that the Multipollutant rule was beginning to take effect, natural gas prices in the United States began to fall (Figure A2-3). This, along with the price of the controls required under the multipollutant rule (for instance, under sections 7 and 8 of the rule, plant McDonough would have been required to install SCRs on and FGD on both units by May 2012), made the economics of converting much of the coal load to natural gas preferable to the alternative. (Figure A2-1, green line)

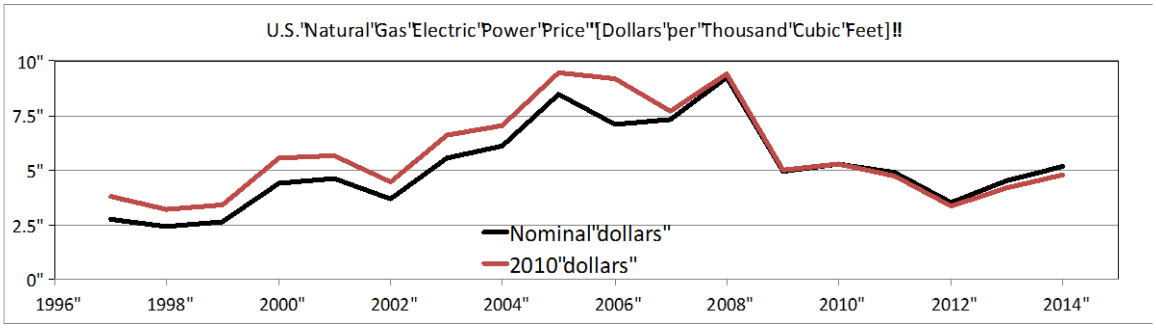


Figure A2-3. Price of natural gas in the United States. Source: U.S. Energy Information Administration. http://www.eia.gov/dnav/ng/hist/n3045us3a.htm Accessed 8 August, 2015.

The major retrofits to natural gas occurred at plants McDonough and Wansley. Further, many smaller natural gas that were constructed between 1999 and 2002—including Chattahoochee, Doyle, Hawk Road, MPC, Tenaska, and Walton—were online a larger percent of days in the later years compared to the years after they were first built. At the time these smaller plants first went online, they were mainly used in the summers when demand is highest.

Because a change to natural gas cannot be attributed solely to either regulatory actions or a reduction in the price of natural gas, the reductions achieved through a switch to natural gas are counted along with the $GRAQC_{jjj}$ and NBTP/SIP Call group in the summer and $GRAQC_{sss}$ and CAIR in the winter.

Uncategorized Controls. Two periods--the Falls of both 2007 and 2008--show lower than expected NO_X emissions based on the assessment of regulatory programs. It is possible that during these time periods one or more plants kept their SCR's turned on for one reason or another, but it is not immediately obvious why they would do this (since controls would have to be shown to be necessary to the PSC for cost-recovery).

SO_2 counterfactuals were developed in the same way as NO_X counterfactuals. Figure A2-4 shows the fraction of reduction in SO_2 emissions over time compared to the counterfactual. For most of the study period, the actual emissions stay near the counterfactual. Beginning in

2008, however, the installation of FGD controls at Bowen and Wansley reduced SO_2 emissions substantially. After 2010, the reduction fraction remained relatively constant until 2012, when the switch to large portions of the load being produced via natural gas caused the emissions to fall even further.

Because of the relationships between the Georgia Multipollutant Rule ($GRAQC_{sss}$), CAIR, and the emissions changes due to the economics of natural gas discussed above, all of the reductions in SO_2 seen in Figure A2-4 are attributed to $GRAQC_{sss}$ and CAIR.

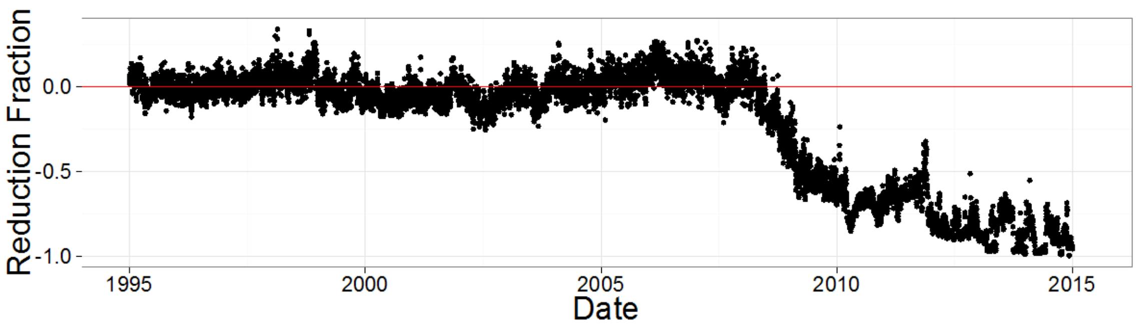


Figure A2-4. Fraction reduction in SO_2 emissions normalized to the counterfactual (red line).

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